THE EFFECTIVENESS OF COMPUTER-AIDED TEACHING ON THE QUALITY OF LEARNING DATA HANDLING IN MATHEMATICS IN GRADE SEVEN

BY

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ABSTRACT

The purpose of the study was to investigate the effectiveness of computer-aided teaching on the quality of learning data handling in mathematics in grade seven. The rationale for this study was based on the information that, preceding the introduction of curriculum 2005 in South African schools, statistics education received little or no formal importance. At tertiary institutions in South Africa and in many other countries, very few learners choose to major in statistics. Coupled with this was that the effective integration of technology into the teaching and learning of mathematics remains one of the crucial challenges facing mathematics, which has been slow to respond to technological innovation.

A review of the literature provided the basis for the study of grade seven learners to determine the use of technology in data handling, their views on the use of computers in mathematics and the effect of computers on the achievement of the set mathematics goals. Responses to the questionnaire, interview and the test scores as well as factors identified in the literature, are used to catalogue the effectiveness of integrating technology in mathematics. The study identified three defining characteristics, each with a number of associated elements. The first being that learners who engaged in technology activities in mathematics have shown a greater conceptual understanding of mathematics as indicated in the pre-test and post-test scores. The second was that technology intensive instruction through the use of the Excel tool helped learners to gain a better understanding of data handling concepts. Thirdly, research result of this study showed that integrating technology into mathematics instruction can be a positive influence on mathematics learning as evident in the interview as well as the test scores. The study concludes that effective integration of technology in mathematics requires recognition and comprehensive attention. This will provide effective quality learning in mathematics education.

DEDICATION

This study is dedicated to my parents; my late dad, Subramanian Solakrishnan Achary, who aroused in me a love for reading and my mum, Cherry Achary, for her love, support and constant encouragement.

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- The National Research Foundation for funding this study.

- Finally to The Almighty for providing the strength.

DECLARATION OF ORIGINALITY

I, Sarasvathie Achary, declare that this dissertation on:

The effectiveness of computer aided-teaching on the quality of learning data handling in mathematics in grade seven

is my own work and that it has not been submitted for any degree at another Tertiary Institution.

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LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS PAGE

APPENDICES

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

Motivation for the study arose from the researcher's interest in the use of computers to support mathematics teaching with a view to improving the quality of learning. Increasing calls for educational institutions to show greater responsibility and commitment to the improvement of the quality of education have resulted in studies being carried out by a number of government and non-governmental organizations both in South Africa and internationally (Texas Instruments by the Centre for Technology in Learning: Research Note 8: 2007:2-3; Lee and Hollebrands, 2008:326-330; Dwyer; Ringstaff & Sandholtz (1991:45-50).

There have been significant attempts by the South African government and the relevant departments such as the Department of Communications to promote the use of computers in schools so as to improve the quality of teaching and learning. The background of the role played and the attempts made by the Department of Education (DoE) and the Department of Communications are highlighted below:

- In 1996 the Department of Education initiated an investigation into technology-enhanced learning (Department of Education, 1996)
- In 2001 the Departments of Education and Communication jointly issued a plan for the use of technology (Department of Education and Department of Communications, 2001)
- In 2003 the Draft White Paper on e-Education was published (Department of Education, August 2003)
- To date the White Paper has been accepted as the policy document for technology-enhanced learning (Department of Education, 2004)

A paradigm shift is taking place in education and the drive towards the use of technology in mathematics education is gaining momentum. Driven by these changing expectations of teaching, the learning environment has to be designed such that it meets with these demands for changes. The former minister of education, Mrs Naledi Pandor (Address by the Minister at the Mathematics Centre Partners in Performance Lunch, 2008:1-6), launched the Quality Learning and Teaching Campaign in October 2008. The campaign called on all individuals and organisations to assume responsibility for improving the quality of education. The need for such a campaign is of significance as it makes the nation aware of the importance of providing learners with a sound education that is based on good qualitative principles. The Executive Director of the Human Sciences Research Council (HSRC, 2009: 1)), Dr. A. Kanjee of the Human Sciences Research Council in his explanation of the work carried out by the Centre for Educational Quality Movement has stated that:

> The quest for the improvement of education quality has been recognised as one of the most significant challenges facing the South African government.

This statement is of significance as it places the responsibility of quality education on the priority list of challenges. Ms Angie Motshekga (2009:1), the Minister of Basic Education, at the Quality Learning and Teaching Campaign business breakfast in 2009 has endorsed this statement by reporting that ensuring quality education is regarded as the key priority of the department.

A number of eminent scholars and researchers have attempted to define the term “quality”. The most suitable is that mentioned in The Education for All Global Monitoring Report (2003:5) which defines quality education as being significant, resourceful and distinctive. Recent developments in the field of mathematics and technology have resulted in the enhancement of educational standards through a qualitative framework (Harwell, Gunter, Montgomery, Shelton and West, 2001:259–286; Keong, Horani, and Daniel, 2005:41-42; Association of Mathematics Teacher Educators, 2006:1-2).

1.2 RATIONALE FOR THE STUDY

The last decade has seen an upsurge in debate about the standard of mathematics in South African schools as reported by the Trends in International Mathematics and Science Study (TIMSS, 2003:1). Therefore development and improvement of the quality of teaching and learning is an issue that needs to be highlighted. According to Kilpatrick (1992:21) qualitative approach will endeavour to provide a better understanding of the problems faced by learners and educators and thereby create a positive mathematical learning environment.

The University World News (MacGregor, 2009:2) reported in August 2009 that university results were a great cause for concern in South Africa. University vice-chancellors formulated a report which highlighted the poor state of mathematics education at school level which resulted in the high failure rate at university level. The report by MacGregor (2009: 2) stated that:

> South African vice-chancellors warned the government last week to expect more students to drop out, as the shocking results of pilot national benchmark tests revealed that only 7% of first-year students are proficient in mathematics, only a quarter are fully quantitatively literate and fewer than half have the academic literacy skills needed to succeed without support.
>
> MacGregor (2009: 2)

The quality of school mathematics needs to be addressed so as to provide a pivotal background for further education. The National Benchmark Tests Project formulated a report for the Vice-chancellors' Association, Higher Education South Africa (HESA) which concluded that “The challenge faced by higher education institutions in relation to mathematics is clearly enormous” (MacGregor, 2009:3).

Prior to the introduction of curriculum 2005, statistics education received little or no formal importance. North and Zewotir (2006:1) state that at tertiary institutions in South Africa and in many other countries, very few learners choose to major in statistics. There are many reasons for this: firstly the previous attempts at statistics education were merely a cursory attempt to read graphs; secondly, educators were not trained sufficiently in teaching statistics (North and Zewotir, 2006:1); thirdly, there is the notion that statistics is difficult to understand and fourthly, mathematical anxiety leads to statistical anxiety (Garfield, 1999:4-5).

It is widely acknowledged that proficiency in statistical skills enables people to become productive and participating citizens in an information rich society. It has helped to develop scientific and social inquiry skills (Ben-Zvi, 2002:1). In response to this need, calls for reform in mathematics education have advocated a more pervasive approach to statistics instruction at all levels. Researchers examining the development of learners' statistical understanding are beginning to produce a coherent body of knowledge that can inform instruction (Chance, Ben-Zvi, Garfield and Medina, 2007: 3; Garfield, 2002; Higazi, 2002:1-3).

The importance of the role of statistics in the educational process has now been recognised and is confirmed by the introduction of the discipline in school curricula at all levels. The Revised National Curriculum Statement (RNCS) (2002:6) has introduced Statistics (or Data Handling) as one of the five dimensions of primary mathematics. This evolution in the educational process is also justified by the awareness that in a modern society statistics is an everyday occurrence. Therefore this study will provide the basis for those involved in the education arena to understand the rationale behind the importance of the study of data handling. The best educational stage is the primary school level.

Using technology to transform the learning of statistics in mathematics will provide for effective learning (Chance, Ben-Zvi, Garfield and Medina, 2007: 2). It has been noted that technology enhanced lessons can also help learners to reflect and understand about various mathematical problems. The aim of the researcher is to empower learners to undertake mathematics learning using modern technology as well as to encourage educators to embrace technology in their teaching.

Professor Kader Asmal in The Draft White Paper on e-Education: Transforming Learning and Teaching through ICT: Department of Education (2003:3) suggests that the advances in Information and Communications Technology (ICT) have significantly transformed the learning and teaching practice and it has also extended new learning prospects and contact to educational resources that was previously not available. This being the case the need for a detailed study in the field of technology in mathematics education would in some way help to highlight the importance of the research.

1.2.1 Research Findings: Technology and Data handling

The Association of Mathematics Teacher Educators (AMTE, 2006:1-2) contends that technology has become a necessary tool in modern day mathematics. Consequently it is fundamental for the teaching and learning of mathematics. Many studies have been carried out and numerous papers have been written which support the notion of the inclusion of technology in mathematics teaching and learning (Pea, 1985:167-180; Papert, 1996:5-11; Papert, 1980:3-18; Stables, 1997:2-11; Handal and Herrington, 2003:275-287; Cradler, McNabb, Freeman, and Burchett, 2002:50-65). Thus there is mounting evidence to support the use of computer-aided learning in mathematics.

It is important to note the growing trend towards the use of technology in the field of statistics. The support for the use of computers in learning statistics is qualified by Chance, Ben-Zvi, Garfield and Medina (2007:1) who suggest that it is difficult to envisage teaching statistics without the use of technology. Contributions by Chance and Rossman (2006:1), Mills (2002:1-2), Nicholson, Mulhern, and Hunt (2002:1-2), Ben-Zvi and Friedlander, (1996:1), Ben-Zvi (2002:5-6) and Rider (2006:1) have suggested that teaching statistics with technology, when used appropriately, can bring about benefits.

While it is advocated that we are at a time of great technological advance, the use of such technology must be able to transform education so as to improve the quality of teaching and learning. Computing power is more available and affordable than ever before, more so when dealing with statistics education. Donovan (2006:1-8) and Higazi (2002:1-3) are a sample of the multitude of researchers who have conducted studies using various software that support statistical learning. These proponents of the use of selected software in statistics education have seen its benefit. .

Ben-Zvi and Frielander (1996:45) conducted research amongst grades 7-9 learners using an interactive computerized environment. The study was conducted using three components: firstly statistics activities were developed; secondly, the activities were implemented in class and teacher development was carried out; thirdly, research was conducted on the learning process in relation to the role of the teacher and learner. This study concluded that the use of computers allows learners to make investigations, can make students less dependent on their teachers, cultivates cooperation amongst learners, and can provide students with feedback on the tasks. Further to this they mention that, computers have made the creation of graphs and tables suitable problem solving tools, together with the more traditional mathematical methods (Ben-Zvi and Frielander, 1996:45).

This research is founded on the notion that a lucid value of data handling and the related concepts will prove to be very useful. These will provide an aid for prospective mathematics learning.

1.3 PROBLEM STATEMENT

The topic to be investigated is the effectiveness of computer-aided teaching on the quality of learning data handling in mathematics in grade seven.

This research topic arose in response to the researcher's observations of learners' attempts to visualise the various types of graphs as required by the data handling aspect of mathematics. This led to further frustrations, when learners were required to draw graphs and answer questions related to the topic. Hoepfl (1997:47) mentions that not much research has been carried out in the area of technology education and that research in this field was necessary in order to improve the quality of education. Research studies on the integration of computers in schools in developed countries are well documented but there have been few studies carried out in developing countries.

Statistical skills are an outcome in seven of the nine learning outcomes in the General Education and Training Band (GET grade 4-7). The report by Timmet and Scheiber, (2009:2) gives details of the 2008 Grade Twelve Mathematics Paper Two examination results. Here it was found that data handling accounted for thirty four percent of the question paper. The examiners report highlighted the lack of insight and analytical skills of the learners. Timmet and Scheiber (2009:1-12) reported that the following were some of the conclusions made by the examiners:

1. Many of those who wrote the examinations found difficulties in interpreting the graphs.
2. Data handling was not taught in many schools, and this was the section that could have given candidates more marks.
3. The reasoning was poor, owing to a lack of training or even incorrect teaching.
4. Understanding of data handling vocabulary was very poor.

North and Ottaviani (2002:1) suggest that these problems could be remedied by placing the emphasis on the teaching of statistics principles rather than focusing on meaningless statistical calculations.

The summary of the findings of the South African grade twelve 2008 mathematics paper two examination by Timmet and Scheiber (2009:1-12), is that the most suitable approach for data handling is that it should be taught so as to develop the logic of gaining information and solving problems in an orderly manner. The second point to emerge from the findings is that most South African educators are not equipped to teach the statistics component of the syllabus.

It would therefore mean that statistic is an integral part of the school curriculum and its importance cannot be sidelined. The reasons for the poor results in mathematics in South Africa is well documented by the Trends in International Mathematics and Science Study (TIMSS) in 2003 as well as the Global Monitoring Report, Education for All (EFA) in 2005. Further to this is the report by the moderators who reported their findings regarding the 2008 mathematics examination.

1.4 AIM AND OBJECTIVES

1.4.1 Aim

The aim of the research is to study the effectiveness of computer aided teaching on the quality of learning data handling in mathematics in grade seven.

1.4.2 Objectives:

- To investigate if learners' mathematical skills can be improved through the use of computer-supported materials
- To explore and describe learners' experiences and perceptions of computer-supported learning

1.4.3 Key Questions

1.4.3.1 What are the learners' attitude towards conventional methods of data handling and computer-supported activities?

1.4.3.2. Do computer-aided lessons in data handling in mathematics improve the scores of learners?

1.4.4 Hypothesis

If computer-assisted teaching and learning takes place, then the learners will be able to improve their learning of data handling activities.

1.5 RESEARCH DESIGN

Among the broad array of research methodologies available it is important to note that "research approaches continually evolve and change in response to the complex, interconnected global communities and their needs in our world" (Cresswell and Garrett, 2008:321). Implicit in this statement is the element of suitability of the method. It is important to note that the emergent methodology will be dependent on its appropriateness to the study and the achievement of the aims and objectives.

The research design was based on the following:

1. Research Method

The research method was both quantitative and qualitative.

2. Target Population and Sample Size

The research was conducted in a selected primary school in a school North of Durban, South Africa. The study utilised 2 groups of grade seven mathematics learners, selected through purposeful sampling, with one group exposed to traditional teaching methods (control group) and the other using computer-supported learning (experimental group).

3. Data Collection

Research data are typically collected through quantitative and qualitative methods (Wolf, 2008:17). For the purpose of this study the data was collected as follows:

Table 1: Data Collection Matrix

Method	**Qualitative Method and Quantitative Method**			
	Questionnaire	Tests	Interview	Classroom exercise
Control group	x	x		x
Experimental group	x	x	x	x

4. Data Analysis

The quantitative analysis included frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference. The qualitative analysis recorded the actual opinions and thoughts of the interviewees by the use of direct quotations where necessary.

5. Preliminary Work

Preliminary work consisted of a questionnaire for mathematics educators. The purpose of the pilot study was:

- to establish if data handling lessons were being done in the mathematics class as per the RNCS document,
- to determine if lessons were being done the conventional way or whether technology was being used,
- to ascertain the level of competence of learners in dealing with data handling.

1.6 SCOPE OF THE STUDY

The study is limited to one primary school to the north of Durban in KwaZulu-Natal. The results of the study can only represent the quality of mathematics education relating to the use of computers, in this particular school.

1.8 STRUCTURE OF THE STUDY

Chapter One: Introduction- Background and Purpose of the study

Chapter One opens with the contextualisation of the study. It serves to introduce the study by delineating the area of focus. It then proceeds with an articulation of the aims of the study, the rationale and significance.

Chapter Two: Literature Review - Theoretical Framework of the study

Chapter Two gives a detailed account of the literature relating to the use of computers to improve the quality of mathematics education. This chapter is a review of the relevant international and national literature on the topic under investigation.

Chapter Three: Research Design and Process

Chapter Three provides the methodological procedures, instrumentation and analytical processes applied to this study. A qualitative and quantitative research method was employed, with the use of a questionnaire; observations and interviews. Different instruments of data collection (questionnaire; interview and observation) were employed to gather the empirical data.

Chapter Four: Data Analysis

Chapter Four reports on the analysis of the data and discusses the findings. It focuses mainly on the aim of the study and some issues that surface from the data.

Chapter Five: Summary and Recommendations

Chapter Five involved the researcher’s findings and conclusions as well as the implications of the study. Recommendations for future research will also be made.

1.9 SUMMARY OF THE CHAPTER

This chapter provided the introduction to the study. The background, rationale, aims and objectives, research methodology and design and scope of the study has been set forth.

The next chapter will present the literature review that forms the basis of the study. The theoretical and conceptual framework regarding technology in mathematics education will be discussed in detail. Various theories and approaches relating to mathematical thinking will be reviewed.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

The introductory chapter describes the development and trends in mathematics education from global as well as South African perspectives. Of special significance is the role of technology in improving the quality of mathematics learning. The main purpose of this chapter is to present the literature review as well as the theoretical and conceptual framework on the influence of computer-aided teaching in mathematics. Hart (1991) as cited in Levy and Ellis (2006:172) delineated literature review as “the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new” (Hart, 1991:1). Mouton and Marais (1998:35) states that integral to research is the “testing of existing models and theories”. Central to this review is the influence of the theory of constructivism in the teaching and learning process. A review of studies related to its use and the influence thereof in the teaching and learning of mathematics will be reported. Theories of and approaches to mathematics learning and teaching and the appropriate learning models are also discussed. The study further expands on education reform in mathematics education.

2.2 TECHNOLOGY AND MATHEMATICS EDUCATION

Scientific skills and problem-solving abilities have become crucial in every career. Improvement in mathematics can offer a strong educational background which would result in a skills-rich workforce of the future. At the same time as there is an increased focus on technical skills mathematics study has gained momentum. Internationally and locally, there is growing emphasis on the importance of the effective use of computers in mathematics. Computer-aided instruction in mathematics has become a key concept in the research literature, reflecting an attempt to understand the relationship between the curriculum and student achievement.

2.2.1 Global Trends

As we cross the threshold of the 21st century, there has been considerable international attention given to the role that Information and Communication Technology (ICT) can play in economic, social, and educational change. This role has been most pronounced in the world's developed countries where technology has permeated businesses, schools, and homes and changed the way people work, learn and play. The impact that ICT has had to date in the developed world and the potential yet for further dramatic changes is reflected in a range of multinational policy documents.

Laborde (2001), cited in Ahmed et al. (2004:326) carried out research in France and reported that "the role played by technology moved from being a useful amplifier or provider of data towards being an essential constituent of the meaning of tasks" as teachers developed their use of technology in the classroom. In Britain Becta (2008:2) mentions that the many young children of today are computer-literate and these skills are improving at a rapid pace. Therefore there is a strong argument for these youngsters to be taught ICT skills earlier.

2.2.2 South African Information and Communication Technology Scenario

In South Africa the Department of Education clarifies the inclusion of ICT in Education. There is a transition from e-Education being seen as merely the acquisition of computer-literacy skills to a more integrated approach (DoE, 2004:14). The Department of Education (2004:14) qualifies the development of the ICT policy as:

- apply ICT skills to access, analyse·, evaluate, integrate, present and communicate information

- create knowledge and new information by adapting, applying, designing, inventing and authoring information
- function in a knowledge society by using appropriate technology and mastering communication and collaboration skills

In 2002 the Department of Education published the survey commissioned to establish the ICT situation in schools across the country, the findings of which was published in 2004 (DoE, 2004:12). The information which is presented in table 2 tabulates the following:

- number of schools that have computers
- the number of schools that use computers for teaching and learning

Table 2: Schools with Computers by Province

Provinces	Schools with computers	Schools with computers for teaching and learning
Eastern Cape	8.8%	4.5%
Free State	25.6%	12.6%
Gauteng	88.5%	45.4%
KwaZulu-Natal	16.6%	10.4%
Mpumalanga	22.9%	12.4%
Northern Cape	76.3%	43.3%
Limpopo	13.3%	4.9%
North West	30.5%	22.9%
Western Cape	82.4%	56.8%
National	39.2%	26.5%

(DoE, 2002:14)

The document published many findings, but for the purpose of the study the relevant issues will be mentioned:

- There was an average growth rate of 59 percent of schools that acquired computers between 2000 and 2002. Secondary schools showed a greater increase than primary schools.

- There were marked differences in the availability and use of computers in the various provinces.
- Schools were using e-mail services to a great extent for administrative work and to a lesser extent as a teaching and learning tool.
- Computer literacy and basic computer skills formed the most important element in the teaching process in both primary and secondary schools. The use of computers in the actual teaching and learning process was limited

Figure 1 is a graphical representation of Table 2 which provides an overview of the information of Table 2. The graph represents the availability of computers in provinces ranging from the province with the largest number of computers available in schools to those provinces that are poorly resourced. Further to this Figure 1 represents the actual use of computers in each province for teaching and learning. The availability of computers in a province does not correlate to its use in the classroom.

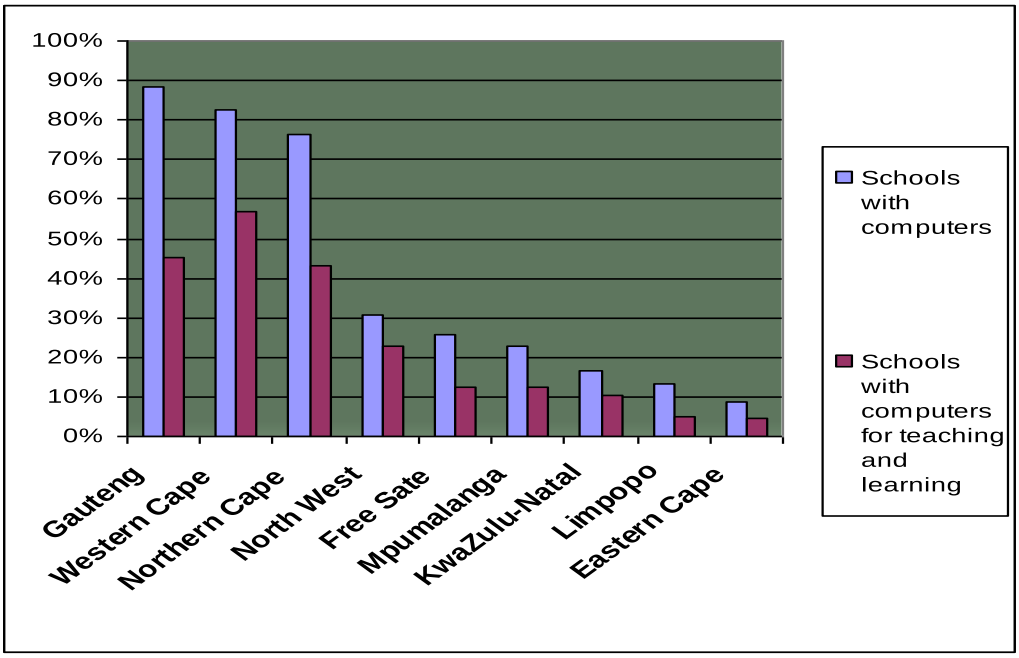


Figure 1: Availability of Computers and Use of Computers by Province (Adapted from: DoE, 2002:14)

The study found that schools in Gauteng, Western Cape and Northern Cape have a better ICT infrastructure than those in other provinces. This situation is not in accordance with the policy of the Department of Education in its call for the integration of ICT in schools. The disparities among all provinces are evident in figure 1.

2.2.3 The Role of Technology in Education

It has been suggested that technology plays a more meaningful role in the educational situation in view of the fact that adept use of technology sustains the "development of process skills such as higher order skills, adaptability, critical thinking, problem solving and collaboration that are essential to succeed in our rapidly changing information age" (Turkmen, 2006:1). Papert (1980:83) provoked this idea of the use of computers in education by making reference to the two important research themes that he proposed. "Children can learn to use computers in a masterful way, and that learning to use computers can change the way they learn everything else" (Papert, 1980: 83).

One issue raised by Papert (1990:1-3) in his keynote speech at a World Conference on Computers in Education in Sydney, Australia was his views on the approach to computers in education. He stated that the computer is not regarded as an instrument that will decide the direction of change; it is seen as a means through which diverse forces for change can be expressed. Extending on this view Papert (1990:11-18) agrees with the theories of Dewey, Montessori and Piaget that children learn by doing and thinking about what they do.

2.2.4 The Role of Technology in Teaching and Learning Mathematics

With the advent of the new era in technology and a realignment in the philosophy and theory of learning there is the view that a paradigm shift in teaching and learning mathematics with the use of information and computing technologies (ICT) is taking place. The existence of increasingly resourceful ICT tools such as the computer, internet, digital video disk (DVD) recorder, lends support to the view that the learning environment in school mathematics is changing into a more technological one. Teachers are aware of current changes and are involved in the processes of these changes in their schools. Lee and Hollebrand (2008:326) mentions that “Whether technology will enhance or hinder students’ learning depends on teachers’ decisions when using technology tools, decisions that are often based on knowledge gained during a teacher preparation program.”

Although the focus on technology in mathematics education has received increased attention in recent years there has been considerable debate about its use. Many proponents of technology use in education contend that technology should not replace the learning of the basic concepts but instead supplement the curriculum to encourage deeper and more substantial explorations of the mathematics concepts. Pea (1985:4-5) proposes that technology be used to help students cognitively reorganise mathematical knowledge.

Computers are frequently believed to transform how effectively we perform traditional tasks. Pea (1985: 5) is of the view that the key role of computers is changing the tasks we do, not by merely amplifying but by reorganising our mental functioning. This is a critical point made by Pea in assessing the role of computers in education from being merely a tool to make tasks easier to understanding and reorganising the learning experience. This view is supported by Sir Jim Rose, an education authority, in his independent primary curriculum review where he mentions that "In maths, primary children are advanced enough to use technology to improve their learning rather than just play computer games, for example” (Becta , 2008:3).

Ahmed, Clark-Jeavons and Oldknow (2004:324) have proposed two questions that one should take into account when advocating the use of technology in education:

1. How do the technological tools enhance the teaching and learning processes?
2. How do teachers perceive the technology in relation to the mathematics that is being learned?

2.2.5 The Importance of Computers in Mathematics Education

2.2.5.1 Rationale for the Use of Computers

The main rationale for the use of computers in mathematics education can be summed up by Yoder and Elias who state that “The immediacy of the feedback, the ability to analyze student errors and remediate, and the one-on-one individualization of an integrated computer-assisted learning program are valuable features that influence the incorporation of computer assisted learning in mathematics” (Yoder and Elias, 1998:3). This view is supported by the Mathematics Sciences Education Board (1990:2-5) in their observation of the profound impact of computers on mathematics and the paradigm shift of mathematics learning from pen-and-paper mathematics to the full use of calculators and computers.

2.2.5.2 Influence on learning

Of interest are the studies carried out by Yoder and Elias (1998:1) on computer-assisted learning in adults who were taught all subjects using computer-based activities. They had come to the conclusion that mathematics was distinctively compatible to computer-assisted learning.

A plethora of research has been carried out on the effect of using computers in the teaching and learning process and there are many views on its effect on mathematics learning. Yoder et al (1998:1) makes reference to this and concludes that mathematics is indeed the subject where the use of the computer has been most successful.

2.3 THEORIES AND APPROACHES TO MATHEMATICS LEARNING AND TEACHING

Amongst the clamour of shifting paradigms, a theory that used to dominate and still dominates the field of education is that of constructivism. Constructivism can be traced to aspects of sociology, philosophy, psychology, and education. A number of studies and many philosophers and educationalists have studied the constructivism framework for learning and observed its importance in education. For the purpose of this study the constructivist theory of Piaget will be used.

The essential idea of constructivism is that a person's learning is constructed, that learners build new knowledge upon the basis of previous learning (Thanasoulas, 2007:2; Ojose, 2008:26). There are two key perceptions that relate to the idea of constructed knowledge. The first is that learners construct new knowledge based on previous knowledge. This means that learners' past experiences will influence the learning situation. The second view is that learning is active rather than passive. Learners are active throughout the learning process: they apply current understandings and modify new learning.

This outlook of learning distinguishes itself from one in which learning is the mere transmission of information from one individual to another. According to Ackerman (2008:2) many theorists have made distinctive contributions towards understanding cognition concerning the following:

- How to re-evaluate education
- Gain insights into new developments
- Encourage the use of the latest equipment, media, and technologies that are available for children to use
  (Ackerman, 2008: 2).

Against this backdrop, the cognitive paradigm of constructivism has been influential in shifting the accountability for learning from the teacher to the learner, who is no longer seen as submissive or helpless (Thanasoulas, 2007:4; Ackerman, 2008). The student is regarded as an individual who is active in constructing new knowledge and understanding, while the teacher is seen as a facilitator rather than a figure of authority.

The essential thinking of Piaget’s theory (1970: 5-25) is that of cognitive structure. Cognitive structures are patterns of physical or mental action that underpin specific acts of intelligence and correspond to stages of a child’s development. The stages of cognitive development identified by Piaget are associated with specific age groupings, but they could vary from one individual to another. Piaget indicates that cognitive structures are not stable and they change through the processes of adaptation, being assimilation and accommodation. For Piaget the development of human intellect proceeds through adaptation and organisation. Adaptation is a procedure of assimilation and accommodation, where, on the one hand, external events are assimilated into thoughts and, on the other, new and unusual mental structures are accommodated into the mental environment (Piaget, 1970:8).

The next theory guiding the study is the theory of deep and surface learning. All learners display varying methods of learning. The idea of deep and surface learning was used by Marton and Säljö (1976) cited in Kember, Charlesworth, Davies, McKay and Stott (1994:3-4) as a method of understanding how learners approach a particular task. The deep approach to learning is the ability of the learner to understand, explore, relate to, interact with, and go beyond the basic; the surface approach involves content learning, memorising and rote learning (Lublin, 2003:3-4)

2.3.1 Overview of Theories

There have been various learning theories and studies carried out dealing with how children learn and the complexities of the human mind. As with any categorisation of this sort the divisions are a bit arbitrary: there could be further additions and sub-divisions to the scheme and there are various ways in which the orientations overlap and draw upon each other. Table 3 based on the four main learning theories by Merriam and Caffarella (1991:138) sums up the gist of these theories.

Table 3: Four Orientations to Learning

Aspect	**Behaviourist**	**Cognitivist**	**Humanist**	**Social and situational**
Learning theorists	Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner	Koffka, Kohler, Lewin, Piaget, Ausubel, Bruner, Gagne	Maslow, Rogers	Bandura, Lave and Wenger, Salomon
View of the learning process	Change in behaviour	Internal mental process (including insight, information processing, memory, perception)	A personal act to fulfil potential.	Interaction/ observation in social contexts. Movement from the periphery to the centre of a community of practice
Locus of learning	Stimuli in external environment	Internal cognitive structuring	Affective and cognitive needs	Learning is in relationship between people and environment.
Purpose in education	Produce behavioural change in desired direction	Develop capacity and skills to learn better	Become self-actualized, autonomous	Full participation in communities of practice and use of resources
Educator's role	Arranges environment to elicit desired response	Structures content of learning activity	Facilitates development of the whole person	Works to establish communities of practice in which conversation and participation can occur.

Manifestations in adult learning	Behavioural objectives Competency - based education Skill development and training	Cognitive development Intelligence, learning and memory as function of age Learning how to learn	Andragogy Self-directed learning	Socialisation Social participation Associationalism Conversation

(Merriam and Caffarella 1991:138)

From the above discourse it can be noted that the theories project some similarities as well as many contrasting ideas regarding how children learn. Cognitive theory concentrates on the conceptualisation of the learning process. It focuses on the exploration of the way information is received, organised, retained and used. Against this background, the cognitive paradigm of constructivism is important to understand that responsibility of learning and teaching.

2.3.2 A Constructivist Perspective on Teaching and Learning

The basis of this study will be seen from a constructivist perspective. Empirical research has uncovered a great number of philosophers and educationists who have propounded the theory of constructivism in education (Ernest, 1991:184-185; Huitt & Hummel, 2003:1-12; Pea, 1985; Shaughnessy, 1992; Guba and Lincoln, 1994). This is certainly not a new theory, but it has in recent times seen resurgence. The earliest works by Jean Piaget, John Dewey, and Jerome Bruner have made vital contributions towards understanding the thinking behind constructivism and its effects on teaching and learning.

Learning is seen as hierarchical (Ernest, 1991:238) which refers to the stages of a child's development. According to Huitt & Hummel (2003:1-4) Piaget studied the idea of how children think and concluded that there was a great deal of difference in the thinking of young children from that of older children. Thus these stages of development form the basis of his study and are also used by many teachers in their classrooms. Blejec (1994:193) has found that graphical presentations and statistical calculations of data are crucial components of statistical practice. Therefore he contends that as computers can greatly help the teaching of appropriate graphical presentation, teachers can now devote more time to the discussion and understanding of statistical concepts. This view is explained by Pereira-Mendoza and Mellor (1990:150) who state that it is not sufficient for learners to just be able to only read information from a graph.

There is an increased emphasis on drawing inferences from data present in various forms. Pereira-Mendoza and Mellor (1990:151) conducted a study that examined the effects of various characteristics of graphical displays on students' ability to read, interpret and predict from such displays and discuss the results within Davis's Frame Theory (1984:6-12). The results of the study was that while there were very few problems with the literal reading of graphs, most problems were encountered when dealing with interpretative questions and questions requiring prediction. In close examination of the findings it can be suggested that as calculations and visual representations can be easily done using computer software, learners and teachers can devote more time to understanding the concepts related to graphing.

2.3.2.1 The Stages of Intellectual Development As Defined By Piaget

According to Piaget (1970:4-8), the development of thinking passes through a number of consecutive stages, each of which is characterised by its own distinctive processes. Based on the constructivist approach to learning the stages are delineated as follows:

Table 4: Stages of Cognitive Development

STAGE	MENTAL AGE RANGE	SCHOOL PHASE	THINKING
1. Sensori-motor	0-2 years		The child experiments with things and situations within his/her environment by trying out different actions to see what results ensue.
2. Pre-operational			
2.1 Pre-conceptual thought	2-4 years	Junior Primary	The child uses language to express his/her thoughts, but his/her reasoning is transductive, i.e. It involves a kind of logic that proceeds from one particular to another.
2.2 Intuitive thought	4-7 years		Although the child's reasoning becomes more elaborate, it is still based on a naïve form of perception in which only one relationship is grasped at a time.
3. Operational			
3.1 Concrete operational thought	7-11 years	Junior & Senior Primary	The appearance of proper logical thinking takes place. The child builds up for himself/herself the various concepts of everyday situations.
3.2 Formal operational thought	11-16 years		The child is now no longer dependent upon concrete experiences for his/her thinking and learning.

Ernest (1991:184-185) makes reference to experience and thought development as being central to the constructivist view of Piaget. This is a learning theory based on the principle that new learning is based upon what has previously been learnt. Focusing on this notion it is evident that experience is vital to learning and that new learning is based on what the child has experienced in the past (Richardson, 2003:1625).

All forms of constructivism accept the view of assimilation and accommodation. Bartolini Busi (1994:124-125) makes reference to the difference in approaches between Piaget and Vygotsky (1978) in relation to these two concepts. According to Piaget assimilation is regarded as the child's interpretation of new material in relation to what is already known and accommodation is the modification of the concepts in relation to the child's experience. Vygotsky further modified this and concluded that knowledge is defined through a social context (Laborde, 1994:147). This refers to knowledge that emanates from the social environment which leads to the idea that a child's thinking is influenced by others more competent than him/her.

The constructivist perspective on learning assumes that concepts are not taken directly from experience, but that a person's ability to learn from and what he/she learns from an experience depends on the quality of the ideas that he/she is able to bring to that experience. This is again the same idea about the role of theory: observation is driven by theory, so the quality of the observation is determined by the quality of the pre-existing theory. It is noted that knowledge does not merely transpire from experience. Rather, it arises from the interaction between experience and our current knowledge structures (Sugarman, 1987:6). With reference to the quality of the theory a suitable cognitive theory needs to be used so as to guide the process of learning. There is the need for a style of thinking that recommends just changes to the curriculum and the valuable use of technology is regarded as an integral element. Therefore the use of constructivism would be a suitable theoretical framework as it falls into the cognitive domain of affording the learners the opportunity to construct new knowledge and new meaning from authentic experiences.

2.3.2.2 Vygotsky's Zone of Proximal Development

The social cognition learning model of Vygotsky (1962:12-56; 1978:19-91) declares that culture is the leading determinant of a person's development. It has been determined that cognitive skills and patterns of thinking are not primarily established by inherent factors, but are the products of the activities practised in the society in which the individual grows up.

One vital precept in Vygotsky's theory is the notion of the existence of what he called the "Zone of Proximal Development" (Vygotsky, 1978:19-25). Zone of Proximal Development is the difference between the learners' capacity to solve problems on his own, and his capacity to solve them with assistance. This refers to all the functions and activities that a learner can perform independently without the help of anyone else and the level of competence that a learner achieves because of the support of others more competent in the task at hand.

2.3.2.3 Pre-Mathematical Frames of Davis

According to Davis (1994:177) human beings are bestowed with the ability to manipulate and use representations in a more abstract manner. This is founded on the cognitive "collages" process, based on what children learn in their early years. Hereafter the procedure of assembly takes place, meaning that collages are developed further which help in understanding modern mathematics. The pre-mathematical frame theory is based on the process of accommodation as developed by Piaget. The progression is from the early knowledge to one based on collages, to the assembly of such collages and eventually the redefining of thinking plays a major role in the education process. It has been disclosed by Davis (1994:188) that cognitive collages are constructed from the pre-mathematical frames learned in early childhood.

2.3.2.4 Constructivism in Mathematics Education

The impact of technology-aided learning in mathematics from a constructivist perspective has become one of the basic building blocks towards a quality education. Higazi (2002:1) refers to the impact of technology on college students by noting that:

- It improves the quality of instructions

- motivates the learning process
- encourages students' active learning in the form of participations and feedback at their own pace
- provides students with the psychological incentives they need to work hard

Cradler, McNabb, Freeman, and Burchett, (2002:47) cited research and the subsequent findings by the Center for Applied Research in Educational Technology (CARET) about how technology influences learners' achievement and academic performance in relation to three primary curricular goals:

1. Achievement in content area learning
2. Higher-order thinking and problem solving skill development
3. Workforce preparation

The results of the research and evaluation illustrated that technology can facilitate the development of critical thinking skills when students use technology to present, publish, and share results of projects. (Cradler et al., 2002:49)

Further insight into the creation of a technological learning environment in mathematics in primary school is explained. Stables (1997:3) has had much dialogue with teachers and mentions that primary school teachers who have used technology into their classes often comment that technology activities are a valuable means of expression for all types of learning. These include general skills such as collaborative learning and problem solving or specific development of mathematics concepts.

According to Molefe, Lemmer and Smit (2005:50) there is an increase in the number of schools in South Africa that have encouraged teachers to become computer literate. Statistics provided by the Department of Education in 2000 revealed that about 40 percent of South African schools had access to at least one computer (Molefe et al, 2005:50). This being the case there seems to be a positive trend towards integrating technology into the school firstly to the teacher and later to the learners.

2.3.3 Learning Cycle Model for Learners: 7E Model

Turkmen (2006:7) is of the opinion that the "Learning cycle approach asserts that learning is the active process of constructing rather than passively acquiring knowledge directly from teacher and using technology can increase instructional effectiveness, can reduce time and costs needed for learning." The learning cycle model is relevant to the study as it merges in with the constructivist approach of thinking. This view is supported by Eisenkraft (2003:57) who mentions that recent research in cognitive science has revealed that understanding the level of previous knowledge is an indispensable element of the learning procedure. With this in mind a learning cycle (Figure 2) model will be discussed and its effectiveness evaluated. This is referred to as the 7E learning model.

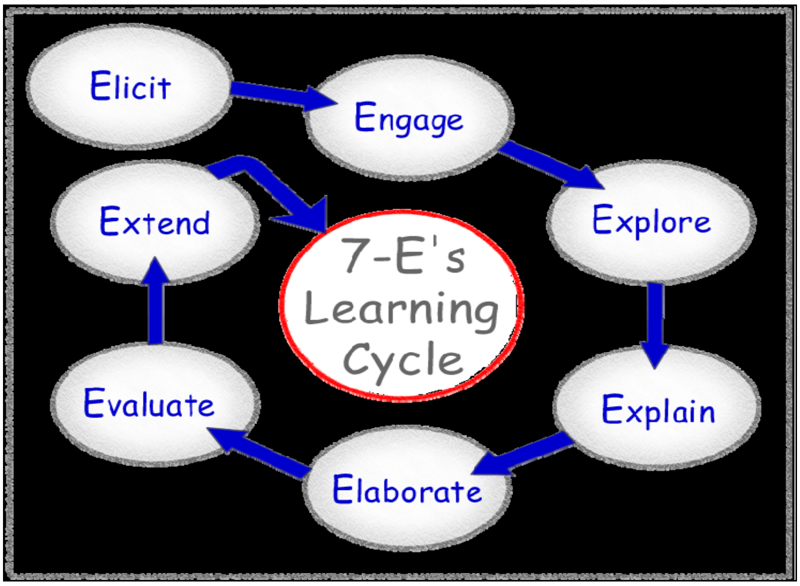


Figure 2: Learning Cycle Model (Eisenkraft, 2003:56-57)

As discussed previously, constructivism learning leads to individuals formulating their own mental construction of information and thus establishing meaningful connections, rather than by internalising mere facts to be regurgitated later on. By using the 7E learning cycle it could be argued that constructivism emphasises the importance of the world knowledge, beliefs and skills an individual brings to bear on learning. Since new knowledge is seen as an amalgamation of prior knowledge as well as the willingness of the recipient to learn, the 7E model allows the learners to make informed choices regarding their learning.

The collaboration of both the teacher and learning in the education process is presented in Table 5. Clearly defined roles are presented for each person in the process as well as what transpires at each stage of the model.
According to Eisenkraft (2003:59) the 7E model is essential and provides the teachers with the basis for student-centred learning. Further to this the aim of the 7E learning model is to stress the increasing significance of obtaining knowledge that was previously learnt and to expand, or reassign such knowledge to the learning of new concepts.

Table 5: Understanding the 7E Model

MODEL	**TEACHER**	**LEARNER**
Excite . . . stimulates the learner's curiosity.	Creates interest. Generates curiosity. Raises questions; Elicits responses that uncover what the students know or think about the concept/topic	Shows interest in the topic by asking questions.
Explore . . . to satisfy curiosity.	Encourages co-operative learning with minimum supervision. Observes and listens to the students. Asks probing questions to redirect the students' investigations when necessary. Acts as a facilitator.	Uses inquiry to explore and investigate and satisfy curiosity about the chosen concept/topic. Thinks freely, but within the limits of the activity. Tests predictions and hypotheses. Forms new predictions and hypotheses. Experiments with alternatives and discusses with others.

Explain . . . the concept and define the terms.	Encourages the students to explain concepts and definitions. Asks for justification (evidence) and clarification from students. Formally provides definitions, explanations, and new labels. Uses students' previous experiences as the basis for explaining new concepts.	Uses various resources, group discussions and teacher interaction to derive definitions and explanations. Explains possible solutions or answers to others' explanations. Listens critically to others' explanations. Questions others' explanations. Refers to previous activities.
Expand . . . discovering new applications	Expects the students to use formal labels, definitions and explanations provided previously. Encourages the students to apply or extend the concepts and skills in new situations. Reminds students of the existing evidence and data.	Applies new labels, definitions, explanations and skills in new, yet similar situations. Uses previous information to ask questions, propose solutions, make decisions and design experiments. Draws reasonable conclusions from evidence. Records observations and explanations.
Extend . . . the concept into other content areas.	Looks for concepts connecting with other concepts/topics and/or with other content areas. Asks probing questions to help students see relationships between concept/topic and other content areas.	Makes connections and sees relationships of the concept/topic in other content areas. Forms expanded understanding. Makes connections of concept/topic to real world situations.
Exchange . . ideas, lesson plans, or experiences.	Shares information about the concept/topic with others via cyberspace. Collaborates by sharing interest and/or activities with others.	Shares information about the concept/topic with others via cyberspace. Collaborates by sharing interest with others via cyberspace.
Examine . . . the student's under-standing.	Observe students as they apply new concepts and skills. Assess students' knowledge and skills. Looks for evidence of changes in thinking or behaviours. Allows students to assess own learning and group skills.	Answers open-ended questions by using observations, evidence and previous accepted explanations. Evaluates own progress and knowledge. Uses alternative assessments to demonstrate understanding.

(Adapted from Eisenkraft (2003:3)

2.3.4 Deep and Surface Learning

Learners display differences in their approach to learning. There are a variety of approaches to learning that have gained popularity over the years but the two common approaches are that of deep and surface learning. Marton and Säljö (1976) cited in Kember, Charlesworth, Davies, McKay and Stott (1994:3-4) recognised and defined two distinct methods of learning: The deep approach to learning involves a student focusing on significant issues in a particular topic while the surface approach to learning takes place when students focus on key words or memorization.

The research carried out by Chomsky in relation to the deep and surface aspect of learning is seen in context to language acquisition but it holds true for mathematics too as mathematics is often regarded as a language for learning numbers. According to the view of Chomsky (1977:98) the instrument of language acquisition originates from innate processes. D'Agostino (1986:174-175) qualifies this by explaining the acquisition of linguistic knowledge and ability as a product of a universal innate ability that enables each child to construct systematic grammar and generate phrases. This theory brings to the fore the idea that children acquire language skills quicker than any other skill. Here reference is made to the two aspects of structures that children are faced with. The first is the underlying logic, or deep structure, which determines that all languages are the same and that human mastery of it is genetically determined, not learned. The second is those aspects of language that humans have to study, known as surface structures.

Lublin (2003:2) posed a question to teachers of undergraduate students, asking them how they wanted their students to approach learning in their subject area. The response to this was "they want students to become enthusiastic about the subject, to be engaged and involved, to understand and appreciate it, to put effort into it, to value it and be able to operate in it - in short, most staff would like students to get to understand and love the subject as they themselves do" (Lublin, 2003:2). This response is in accordance to the deep approach to learning. In order to gain an understanding of the two approaches a glance at Table 6 and Table 7 would help to formulate a clear perspective.

Table 6: Deep Approach to Learning: High Quality Learning

DEEP LEARNERS:
Look for meaning in their studies
Examine evidence critically
Actively relate new information to previous knowledge
Want to know the underlying principles of what they are
Are interested in what is being learned for its overall sake

(Ramsden; Beswick and Bowden (1989:152-154)

Table 7: Surface Approach to Learning: Low Quality Learning

SURFACE LEARNERS:
Regurgitate material and relies on rote learning, which can become a boring and tedious way to learn
Restrict learning to the defined syllabus
Is not prepared to look for relationships between ideas and makes few links between or within subject areas
Lacks confidence and fears failure

(Ramsden; Beswick and Bowden (1989:152-154)

Drawing upon the theory of deep and surface learning significant and meaningful contribution have been made dealing with the question of errors made by learners.

2.3.5 The Nature of Errors

According to Donaldson (1963:183-185), there are three types of errors made by learners when they deal with problem-solving in mathematics. The first is arbitrary error, meaning that the learner frequently applies concepts from real life experiences which fail to take into account the constraints of the problem. Here the learners overlook a part of the available information, while working on the rest (Donaldson, 1963:201) and the learner behaves randomly and fails to take account of the limitations laid down in what was given (Orton, 1983:4).

The second type of error is executive error whereby the learner fails to perform the required manipulations. It refers to those involving the inability by the learner to carry out manipulations, though the learner may have understood the theory (Orton, 1983:6).

The third type of error is structural error which occurs when learners fail to understand the basic principle of a problem. It arises from a false expectation about the structure of a problem and a fundamental failure to understand the relationships concerned in the problem or to grasp some essential rule to solution (Donaldson, 1963:185). Structural errors happen when there is a lack of understanding of topics (Orton, 1983:7).

The critical goal in understanding the notion of errors is to support the learner in becoming an effective thinker. It could be argued that changes in the way teaching and learning are conceptualised and the understanding of errors made by learners would lead to a significant transformation of the education process.

2.3.6 Technological Pedagogical and Content Knowledge Model for Educators

In considering how learners learn and the models of such behaviour as discussed above, it would therefore be worth considering the role of the mathematics teacher in this learning process. Teacher knowledge of the subject and specifically that of the use of technology in the mathematics classroom impacts on learners' approach and attitude to the learning process. Although the core component of this study is the learner, nevertheless the impact of the teacher cannot be ignored.

In the discussion that follows question two will be considered. Following Mishra & Koehler's (2006:1017-1054) explanation of how Technological Pedagogical and Content Knowledge (TPCK/TPACK) lies at the core of teaching with technology, Niess (2005:1-6), Lee and Hollebrands (2008:325-330), Angeli and Valanides (2008:2-15), Bull et al (2008:2-6), Koehler and Mishra (2006:1019) have made a concerted effort in explaining and supporting the inclusion of technology in education. Mishra & Koehler (2006:1017) put forward the thinking that "thoughtful, pedagogical uses of technology require the development of a complex, situated form of knowledge we call *Technological Pedagogical Content Knowledge*" .The use of the TPCK model has been recommended for teachers as a means of effectively using this knowledge to understand how to use technology successfully to teach a variety of subjects. Pedagogy means the science of teaching, content is the subject matter and technology refers to the equipment or devices.

Educators are constantly trying to find new and innovative ways of teaching so as to make a meaningful contribution to the education of the learner. Figure 3 is a representation of the three important components that shape education (Lee and Hollebrands (2008:327). The understanding of each component is necessary so that the three components do not work in isolation but as an interactive process (Mishra and Koehler, 2006:1024). Marks (1990:9) reiterates the development of this process by stating that it is of vital importance to teachers who believe in innovation. This is further enhanced by the constructivist perspective as discussed earlier.

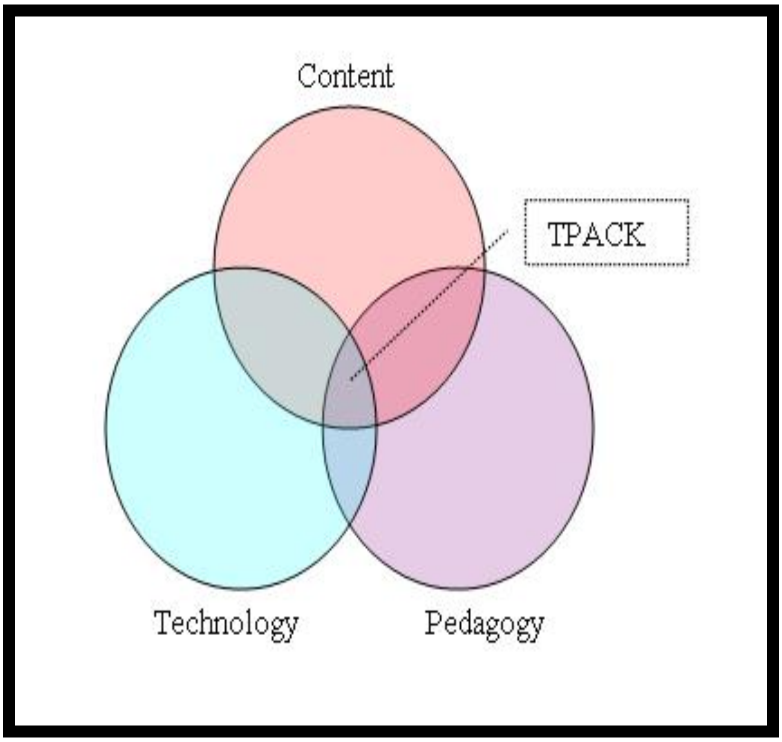


Figure 3: Components of Technological Pedagogical Content Knowledge.
(Lee and Hollebrands (2008:328).

The focal point of the three aspects of technology, content and pedagogy leads to the formulation of the main cog of the model which is the intersection. Lee and Hollebrands (2008:327) propose four different aspects that make up teachers' TPCK:

1. An overarching conception of what it means to teach a particular subject integrating technology in the learning process.
2. Knowledge of instructional strategies and representations for teaching particular topics with technology.
3. Knowledge of learners' understanding, thinking and learning with technology.
4. Knowledge of curriculum and curriculum materials that integrate technology with learning.

The important role of the educator in the implementation of technology in education is further emphasised by the use of the TPACK framework as illustrated in Figure 4.

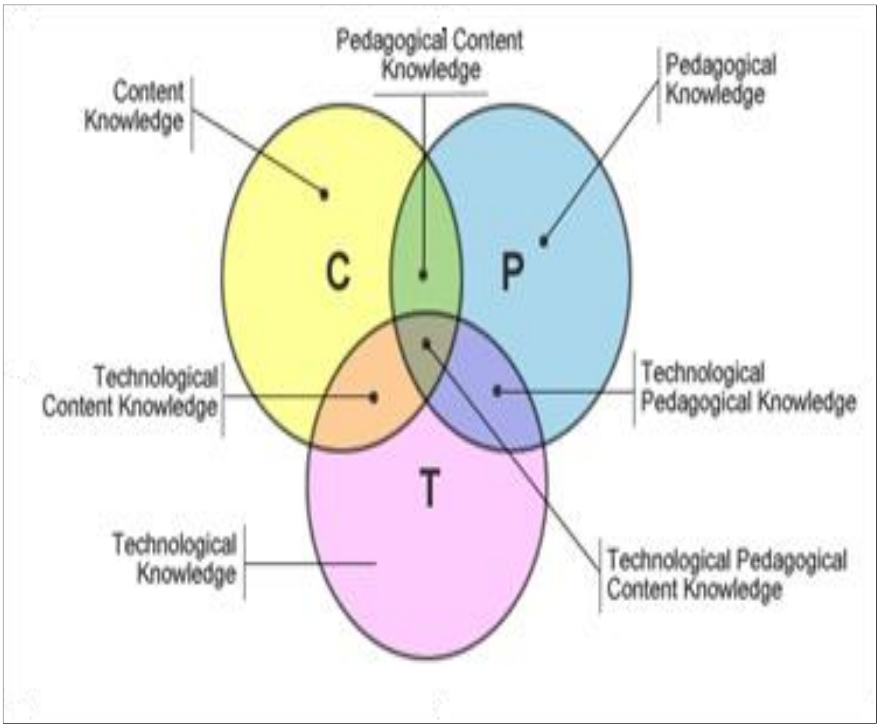


Figure 4: Technological Pedagogical Content Knowledge Framework (Kohler et al., 2007:4)

Angeli and Valanides (2008:15) contend that in addition to the importance of TPCK to the teacher is the development of the process to include the learner. Theoretically it is evident that Pedagogical Content Knowledge (PCK) is the cornerstone of TPCK. The assumption therefore is that the educator must not only be aware of the subject content and the means of teaching but also of importance is the learners' abilities. Based on this analysis of the model Angeli and Valanides (2008:15) have developed a more inclusive representation of TPACK as represented in Figure 5.

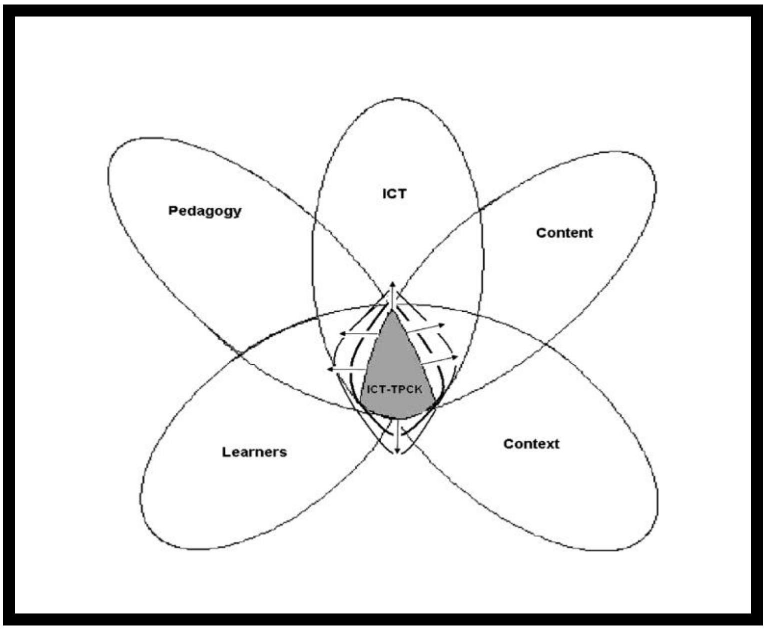


Figure 5: New Technological Pedagogical Content Knowledge Model. Angeli and Valanides (2008:15)

This new development is of interest as it leads to the realisation that TPCK development efforts are rooted in constructivist ideas because it was found that useful interaction takes place when learners learn new concepts. Angeli and Valanides (2008:16) also argued that the prominence should not only be on learners' cognitive progression but also on their holistic growth taking into account other aspects related to their personal development that goes beyond mere cognition.

It is generally agreed that technology can help create a rich learning environment but there is still a real concern as to how teachers implement the technology in the classroom. Teachers' attitudes toward technology appear to be in a constant state of change, but the potential for its use as an aid to learning is useful. This potential depends upon the teachers' ability to integrate the technology into everyday classroom activities. Integration requires a great deal of effort by the teacher. However, used appropriately, it can reinforce, supplement and extend student skills. Although technology poses many challenges for teachers, it also provides powerful tools for supporting the teacher's work.

2.3.7 Statistics and Mathematics Education

Calculators and computers have been found to be valuable aids for mathematical explorations, computations and graphing functions. Given that these devices can handle most of the routine statistical computations, suitable use of them can facilitate students' experimentation and exploration when learning statistical concepts. Langrall, Nisbet, and Mooney (2006:1) having studied the implementation of statistics education in various countries believes that there is a need for change in mathematics education which proposes an all-encompassing approach to statistics education.

Subsequent to the extensive use of computers in education there has been an increase of educational software resulting in many textbooks also including software packages. Therefore it has become necessary to evaluate these software packages and choose those that can assist the learners in their learning process. Moore (1997) as cited in Chance, Ben-Zvi, Garfield, and Medina (2007:3) supported a restructuring of statistics education and curriculum after having considered the correlation among content, pedagogy, and technology. Further to this he suggested that suitable technology be chosen so that the awareness is on teaching the subject and not the tool that is used in the process (Moore, 1997:135) as cited in Chance, Ben-Zvi, Garfield, and Medina (2007:3).

Many software packages are available that aid in teaching statistics using the computer. For example, spreadsheet software such as Excel can be used effortlessly to produce different graphical representations for the same set of data. When different diagrams can be plotted very rapidly, students can focus on understanding and discussing the choice of an appropriate diagram to represent the data. By manipulations on columns of data, the same software can also be used easily to explore the effect on the central tendency when changes are made to the data. Other software can be very useful for the exploration of probabilities.

“A clear purpose for using the graph is to solve a problem: this enables children to experience active use of graphs as problem solving tools rather than seeing them as illustrations” (Ainley, Nardi and Pratt: 2000:1). The approach suggested by Ainley et al (1995:1) in Figure 6 is a representation of the approach that advocates active participation by learners. The graph is now used as a means of analysing information and the more mundane application of data collection, drawing graphs and interpreting information is enhanced by plotting information into a programme and relating to this information. Learners are now encouraged to provoke their critical thinking skills and develop further data needed to draw meaningful conclusions and make further predictions.

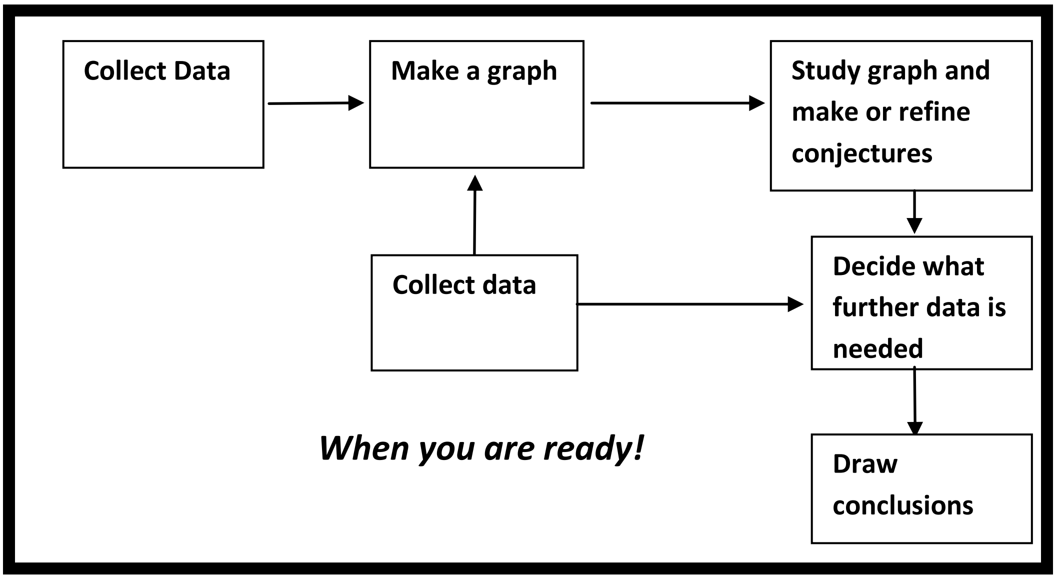


Figure 6: A Schematic for the Active Graphing Approach. (Ainley et al 1995:1)

By explicitly directing attention to the nature of data, alternative representations and prediction, the focus of a graphing activity changes from the activity of drawing and tabulating data to underlying elements. These elements are critical in developing an understanding of what graphs mean and how they can be used in society. They help develop critical skills in analysing graphical information.

It is essential to emphasise the understanding of graphing in the teaching of data handling. The following are some of the reasons as to why a computer intervention is important in the teaching of data handling:

- New advances in technology
- Importance of visualisation
- Ease in drawing
- Sustaining interest
- Learning new concepts

Advances of technology make available new tools and opportunities for the teaching of statistical concepts including the use of various graphical representations. These new technological tools aid in facilitating the visualisation of statistical concepts and thereby help in making statistical thinking easier to understand. Drawing graphs by hand can be a tiresome and intricate task, but when done using the computer it can lead to active learning. Use of technology in data handling tasks facilitates learners' interest and offers the means for them to focus on understanding statistical concepts.

There is the need to concentrate on the key concepts, not just in isolation, but also by demonstrating the way that the components link together. The traditional lessons on teaching graphs and data handling concepts do not lend itself to an active learning process. Learners who are over reliant on traditional learning methods would not be able to develop skills that are necessary for the technological era that they live in. It is therefore envisaged that computer intervention is necessary when learning data handling concepts.

2.3.8 Rationale of Attitude

Recent advances in technology have promoted changes and brought about advances which have provided new ways to learn. The past decade has brought an explosive growth in both the number and the variety of applications of computers and other technologies used in schools which has led to questions being raised about the issues of attitude. A synchronized learning occurs when the learner is introduced to a new experience with a view to promoting a positive attitude towards the learning experience as well as the learning tool. The attitudes and feelings involved with the human-computer relationship are difficult to identify. Fennema and Sherman (1976:324-326) suggest that apprehension toward a subject area may influence the learning process; negative or indecisive attitudes toward computers exist and could be a restraint to using computers in the learning environment. It seems likely that students' attitude toward and acceptance of computer technology, as well as learning about computers, may be important in the integration of electronic technologies in the classroom, workplace and home.

2.4 SUMMARY OF THE CHAPTER

Chapter two has reviewed the literature relating to the mathematics curriculum, both generally and from a technological perspective. Theoretical issues involving the curriculum design and technology were examined and the position of technology within the proposed models of the mathematics curriculum was considered. A variety of theories were reviewed which sought to challenge the traditional methods of mathematics teaching and learning and set out the theoretical framework of this study. Here the researcher has noticed that there was fundamental change in pedagogy when dealing with the use of modern technology to enhance the mathematical learning environment. Against this background the cognitive paradigm of constructivism as proposed by Piaget has a great deal of relevance. This is the Piagetian model of human cognition based on active participation of learners in the learning process. It has been noticed that Piaget's theory provides a solid framework for understanding a learner's thinking at different levels of development. Reference to the experience that a learner brings into a learning situation and the stages of development of the learner has been used in this study as a starting point. Of special interest to the researcher is the view that Constructivism learning leads to individuals formulating their own mental construction of information and thus establishing meaningful connections, rather than by internalising mere facts to be regurgitated later on. Building on this the researcher found that Davis' development of Pre-mathematical Frames is closely linked to Piaget's process of accommodation. This process is defined as new knowledge is constructed from previous experience. The social cognition model of Vygotsky and the zone of proximal development process identify the range of potential each person has for learning, with that learning being shaped by the social environment in which it takes place. The study is also based on the deep and surface approach to learning which helps to gain insight into the level at which learners' are in relation to their learning.

Chapter three will concentrate on the research design and methodology. The various processes involved in the design of the study will be addressed.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Chapter three presents the research design and process for this study.

> "Research is a way of knowing based on systematic and reproducible procedures that aim to provide knowledge that people can depend on. It is, however, a somewhat expensive way of knowing since it demands that people who engage in research follow particular canons that usually require the use of special procedures, instruments, and methods of analysis"
> (Wolf, 2008:5).

Schoenfeld (2000:641) contends that the rationale behind research in mathematics is two fold: one pure and one applied. He defines these as follows:

- Pure (Basic Science): To understand the nature of mathematical thinking, teaching and learning
- Applied (Engineering): To use such understandings to improve mathematics instruction

It was found that the two aspects are equally important and complement each other. According to Schoenfeld (2000:642) the reason for this is "without a deep understanding of thinking, teaching, and learning, no sustained progress on the "applied front" is possible". Further to this is the view of Creswell and Garrett (2008:321) who acknowledge that research is persistently surfacing thereby enabling researchers to design fresh new methods in order to reach substantial conclusions.

This view is extended on by Hoyles and Noss (2006:1) who mention that their research objective is to "bring the field of research with and on computationally-based technologies in mathematical learning closer to the broader field of mathematics education research".

3.2RESEARCH DESIGN

3.2.1 Introduction

Mouton and Marais (1998:33) contend that "The aim of a research design is to plan and structure a given research project in such a manner that the eventual validity of the research findings is maximized." The process and procedure of the research is based on appropriate and effective decision making. Process is described as chronological steps of procedural activities (Levy and Ellis, 2006:172). Creswell and Garrett (2008:321) suggest that in order for the researcher to be able to make substantive progress in the study, a large "toolkit of methods and designs" needs to be understood. A rich array of different methods would lead to a better understanding of the study. Therefore for the purpose of this study a variety of approaches were used in order to formulate a good research study. The two most popular types of research method are the qualitative and quantitative methods.

According to Neill (2007:2-6) quantitative research is an investigation into a recognised problem, based on testing a theory, determined by numbers, and evaluated using statistical techniques. Contrary to the quantitative approach, the qualitative process leads to the understanding of a person in a social context.

The research design stems from the research problem. In an attempt to answer the research question the research design was based on a multi-method approach to collecting the relevant data.

The research was grounded primarily upon the theory of constructivism (Piaget: 1970). Further to this the model of Vygotsky (1978:24-36) and his concept of social cognition as well as the pre-mathematical frames of Davis (1984:167-177) was included in the design.

3.2.2 Research Approach

Mouton and Marais (1998:51) suggest a research strategy (Table 8) that can be carried out in three different ways. The first research strategy is the exploration of an area of research where not much research has been carried out. The second strategy is the descriptive research which engages a number of research strategies most notably that of the categorisation of variables. The third strategy is the explanatory research the aim of which is to explain a phenomenon in terms of specific causes.

Table 8: Research Strategy

RESEARCH STRATEGY		
RESEARCH GOAL	**Contextual interest (internal validity)**	**General interest (internal and external validity)**
Exploratory Research	Overview of phenomena by means of case studies and in-depth interviews.	Overview of phenomena means of exploratory surveys
Descriptive Research	Case studies, in-depth interviews, participation observation.	Sample surveys.
Explanatory Research	Contextual explanations by means of case studies, historical analysis.	Experimental and quasi-experimental studies.

(Mouton and Marais, 1998:51)

3.2.3 Research Method

The research method employed was both quantitative and qualitative. Wolf (2008:17) defines these two approaches:

> Quantitative approach can establish relationships among variables and Qualitative studies do play a useful role in attempting to understand the mechanisms by which relations among variables are established.
> (Wolf, 2008:17)

Marshall and Rossman (1980:23-24) maintain that human behaviour is considerably manipulated by the situation in which it occurs; thus one must study that behaviour in situations. Quantitative study tends to quantify data and generalise results from a sample population by measuring the incidence of various views and opinions in a chosen sample. The qualitative research is used to gain an understanding of underlying reasons and motivations in an attempt to uncover prevalent trends in thought and opinion (Hoepfl, 1997:48). Strauss and Corbin (1990) cited in Hoepfl (1997:48) maintain that qualitative approach to research can be utilised to trends that is not well documented as well as to garner new understanding on work that is well documented. As mentioned previously the qualitative and quantitative methods were used in this study. In modern social research study triangulation of the theories was espoused so as to validate the findings. “Triangulation is defined as the mixing of data or methods so that diverse viewpoints or standpoints cast light upon a topic” (Olsen, 2004:3). It was found that the merging of the qualitative and quantitative methods of data collection would result in a more insightful research. For the purpose of this study the researcher wanted approach the study using a flexible design so as to gain significant knowledge.

3.2.4 Sampling

Sampling refers to the process of selecting the participants of the study, the number of participants in each category of the research and the site where the study is conducted.

3.2.4.1 Target Population

The research study was conducted in a selected primary school in a school north of Durban, South Africa. The school population was 850 learners and the school caters for learners from Grade R (Reception class or Pre-primary class) to grade seven. The socio-economic status of the learners was diverse; with a large number of the school population coming from a low socioeconomic background. The school learners were introduced to computer literacy in 2008 when a business corporation had set up a computer centre at the school. Forty new computers were donated to the school and basic computer literacy is being taught to all learners from grade R to grade seven. Computer literacy is the most basic aspect of computer use but it is important to note that the basics orientation to computers is vital for further development.

The study utilised 2 groups of grade seven mathematics learners, selected through purposeful sampling, with one group exposed to traditional teaching methods (control group) and the other using Computer-supported Learning (experimental group). There was a wide range of technology ability in the class from children with very limited computer knowledge and no Internet access at home to those who use technology and the Internet daily. None of the participants had used spreadsheet software prior to the study. There was no special selection process for the participants. All students in the class returned signed parental consent forms and were, therefore, included in the study.

3.2.4 Sample size

According to Wolf (2008:31) it can be difficult to study an entire population as it is expensive and difficult to sustain. Therefore a small sample of the population to be studied would be sufficient to prove the validity of the research. The control group of the research used randomly selected 20 grade seven learners from one class and the experimental group consisted of a group of randomly selected 20 grade seven learners from a separate class. The sample of this study was heterogeneous, so as to provide representation across ability levels and across the gender divide. In the case of the interview the sample size was much smaller because of the intensity of the process. Ten learners formed the basis of the interview group, which was smaller by contrast to the other focus groups because of the in-depth nature of the interview.

3.3 EMPIRICAL INVESTIGATION

3.3.1 Classroom Activities

Activity 1: Learners in both the control group and the experimental group were taught lessons dealing with bar graphs and pie graphs. Learners were asked to conduct a survey about the types of books that other learners in the school enjoy reading. The following steps were followed:

Step 1: a. Mind map of book types.

b. Prediction of the most popular and the least popular book.

Step 2: Conduct a survey.

Step 3: Organisation of information in tally charts.

Step 4: Represent the data.

Step 5: Drawing conclusions.

The control group and the experimental group were involved in all 5 steps of the lesson. Steps one and two were conducted by both groups in the same manner. The control group worked manually on steps three, four and five while the experimental group worked on the computer. The lesson for the experimental group was modified by using the data analysis excel programme. Learners were introduced to the excel programme (Figure 7) and after explanation on how the programme operates learners were allowed to draw graphical representation of their survey and discuss findings of these. Hereafter a sample of the learners were involved in an observation and interview session dealing with the data handling and with special reference to pie graphs as set out in Appendix H.

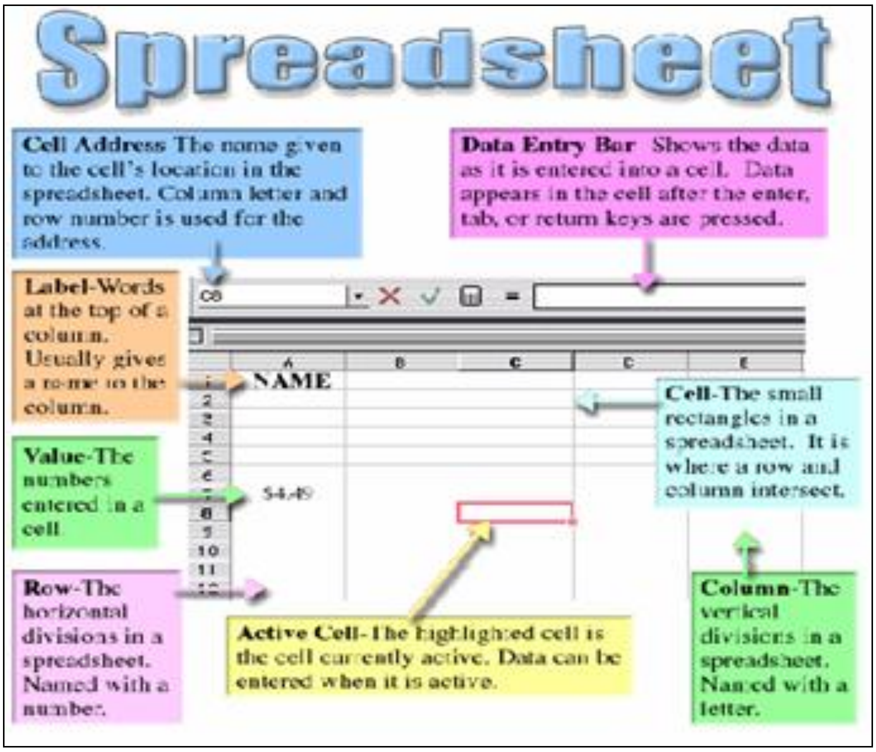


Figure 7: Snapshot of Excel Programme

During the classroom activities a sample of learners from the experiment group and the control group were chosen to acquire information on the nature of errors that were made by the learners as categorised by Kogan (1966:342-344) and Orton (1983:235). The learners were asked to perform a task and during the observation they were asked to explain their method of acquiring an answer. The following table (Table 9) served to set out the classification of errors as discussed in chapter two.

Table 9: Classification of Errors

Classification of items	**Structural errors**		**Executive Errors**		**Arbitrary Errors**	
	Experiment	**Control**	**Experiment**	**Control**	**Experiment**	**Control**

ITEM 1: Tally Chart and Frequency						
ITEM 2: Conversion to Angles and Fractions						
ITEM 3: Drawing of Pie Graph						
ITEM 4: Questions relating to Item 1						

Learners were asked to answer each question and as they recorded their answers they were asked to explain how they got to the answer. This served to explain the reasoning behind some of the errors that were noted. As learners explained their answers they were also encouraged to make the necessary changes if they felt that their answers were incorrect.

3.3.2 Questioning Techniques

Siniscalco and Auriat (2008:3) suggest that the aim of a questionnaire is to try to ensure that variations in responses to questions are construed as reflecting differences among respondents, rather than differences in the processes that produced the answers. There are two types of questioning techniques that can be used in questionnaires: closed questions and Open-ended questions. With respect to this study a section of the questionnaire dealt with the closed approach which closely resembles a multiple choice type of question.

According to Siniscalco and Auriat (2008:3) there are a number of advantages and disadvantages for the use of this method.

The main advantages of closed questions are:

- the respondent is restricted to a finite (and therefore more manageable) set of responses
- they are easy and quick to answer
- they have response categories that are easy to code
- they permit the inclusion of more variables in a research study because the format enables the respondent to answer more questions

in the same time required to answer fewer open-ended questions (Siniscalco and Auriat, 2008:26)

The main disadvantages of closed questions are:

- they can introduce bias, either by forcing the respondent to choose between given alternatives or by offering alternatives that otherwise would not have come to mind
- they do not allow for creativity or for the respondent to develop ideas,
- they do not permit the respondent to qualify the chosen response or express a more complex or subtle meaning
- they can introduce bias, where there is a tendency for the respondent to tick systematically either the first or last category, to select what may be considered as the most socially desirable response alternative, or to answer all items in a list in the same way
- they require skill to write because response categories need to be appropriate, and mutually exclusive

(Siniscalco and Auriat, 2008:26)

Related to this is the question of attitudes, opinions and beliefs of participants. Researchers in the past were reluctant to conduct interviews because of the cumbersome nature of analysing the data. Now however there is the school of thought who propose it is vital to understand the thought process of individuals when engaged in a one-to-one session (Siniscalco and Auriat, 2008:55)

3.3.3 Interview Design

> "An interview guide or "schedule" is a list of questions or general topics that the interviewer wants to explore during each interview. Although it is prepared to insure that basically the same information is obtained from each person, there are no predetermined responses, and in semi-structured interviews the interviewer is free to

> probe and explore within these predetermined inquiry areas. Interview guides ensure good use of limited interview time; they make interviewing multiple subjects more systematic and comprehensive; and they help to keep interactions focused”
> (Hoepfl, 1997:52)

Interviews were conducted with individual participants from the grade seven experimental group. The experimental group was chosen as the participants would be able to provide insight into their thoughts about computer aided learning in data handling. The control group would not have provided new insight as there was no new intervention in the learning process. Learners were selected using random sampling. Learners were allocated numbers and learners who were allocated odd numbers were selected. This was conducted after the official school hours so as not to disadvantage learners of normal classroom lessons.

The interview consisted of structured questions. The interview schedule took the following format:
Section A: Perception. Section A dealt with the participants’ choice of their favourite subject and their favourite section in mathematics. Also included here was their choice of their least favourite subject and their least favourite section in mathematics.
Section B: Questions on Mathematics Curriculum. This section engaged learners on specific questions dealing with their choice of the most interesting activity in mathematics, use of mathematics in daily life, mathematics in the work place and the use of computers in the choice of a particular career that they wish to follow. These questions although general in nature would be helpful in gathering information as to the learners’ perceptions of the use of computers in the work place.

Section C: Questions on Data Handling. These questions focused on a specific topic dealing with data handling. Given the question of assisting the school tuck shop make a selection of cool drinks to sell learners had to answer questions based on this.

Interviews were recorded using a recording device that captured the full interview on tape. This is an important aspect as it enhances the validity of the process.

3.3.4 Questionnaire Design

The design of the questionnaire for this study was based on areas that would lead to a clear understanding of the research question. The questionnaire was structured focusing on three parts so as to explore the various components that would lead to a clearer understanding of the objectives of the study.

Section A: Profile: This section deals with the general details profiling the participant in respect of gender and age.

Section B: Attitude to computers: Here the participants were asked to respond to questions relating to their attitude to computers as well their impressions about the importance of computers. A 3 point scale was used to gauge responses. Learners were asked to respond to three of the questions by explaining the choice of response for their answer.

Section C: Data handling: Firstly participants answered questions on their understanding of terms relating to data handling using a three point system. The second aspect dealt with whether they could carry out data handling functions. Thirdly participants were requested to state their thought about data handling. The last aspect was carried out with the experiment group only. The participants completed this section after their interaction with the computer activity.

3.4 Data Procedure

3.4.1 Reliability and Validity

A great deal of emphasis is placed on the aspects of reliability and validity in research because "without rigour, research is worthless, becomes fiction, and loses its utility" (Morse, Barrett, Mayan, Olson and Spiers, 2002:2).

In order to accept the findings of the research, the reliability and validity of the study has to be proven. Reliability as defined by Kirk and Miller (1986:41-42, cited in Hoepfl, 1997:59-60) refers to the degree to which a measuring procedure gives consistent results. That is, a reliable test is a test which would provide a consistent set of scores for a group of individuals if it was administered independently on several occasions (Hoepfl, 1997:59-60). Reliability is therefore equivalent to stability or repeatability. Validity on the other hand is concerned with the degree in which a test or other measuring device is truly measuring what it intended to measure (Golafshani (2003:602).

Validity therefore refers to the accuracy or truthfulness of a measurement. It asks the question of are we measuring what we think we are? Since it has been observed that there are no statistical tests to measure validity, it would therefore be found that all assessments of validity are subjective opinions based on the judgment of the researcher. The random sample that one selects inherently implies reliability and validity.

Proving the reliability and validity of the study will be conducted from a constructivist perspective. Golafshani (2003:604) has pointed out that constructivism deals with the idea that knowledge is constructed and changes can occur depending on certain circumstances. Therefore in order to acquire valid and reliable data different methods of research may be necessary. One can demonstrate consistency in the qualitative and quantitative results an example of which is learners scoring higher marks in quantitative score show deeper understanding in the concepts. A measurement that reveals constant results over a period of time is regarded as being reliable. This measurement, if prone to random error, discloses a lack of reliability.

3.4.2 Data Collection

Research data are typically collected through quantitative and qualitative methods (Wolf: 2008). For the purpose of this study the Data Collection Matrix as set out in table 9 below was followed.

Table 10: Methods of Data Collection

RESEARCH STEPS	METHOD	PARTICIPANTS
Step 1	Questionnaire	Experimental and control group
Step 2	Class exercises / pre-test on statistics/ nature of errors	Experimental and control group
Step 3	Post-tests	Experimental and control group
Step 4	Computer activities	Experimental group
Step 5	Interview	Experimental group

Step 1: The research questionnaire (Appendix D) was handed out to both the experimental group and the control group so as to garners responses of the participants prior to the study itself. The learners' attitude to mathematics, understanding of mathematics, technology use and data handling strategies and skills are vital to this study.

Step 2: In introducing the aspect of data handling both groups of participants were involved so as to assess prior knowledge and teach the aspects that are relevant to the grade seven syllabi (Appendix F).

Step 3: Tests (Appendix G) based on the lessons taught in step three were carried out to ascertain the learners' understanding of the topic.

Step 4: The experimental group was involved in the computer based exercises (Appendix H).

Step 5: The researcher conducted the interview with the experimental group (Appendix E). The aspects that were covered were attitude to mathematics, understanding of mathematics, attitude to technology and proficiency in data handling.

3.4.3 Data Presentation and Analysis

The quantitative analysis included frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference. The Qualitative analysis will record the actual opinions and thoughts of the interviewees by the use of direct quotations where necessary.

3.5 ETHICAL ISSUES AND LIMITATIONS

Trochim (2006:23) has proposed a data base of information that forms the basis for ethical consideration when conducting a research so as to protect the participants involved in the study. The following issues were prominently discussed:

- Voluntary participation- participants must enter the programme of their own free will
- Informed consent- participants must be aware of the study and its procedures
- Risk of harm- no participant should be exposed to any form of risk; physical or psychological
- Confidentiality- identity of all individuals during the study to be confidential

- Anonymity- personal details of the participants and responses must not be made public knowledge
- Right to service- the control group must be exposed to the same programme after the study

Based on the above the ethical issues related to the collection of data were seriously considered and adhered to. Arrangements were made to meet and talk with the class about the research, and to distribute the information sheets and consent forms. The learners were given the opportunity to ask questions about the research. This meeting occurred two weeks prior to the first lesson, so that the students had the chance to return the consent forms indicating whether or not consent had been granted by the parent or guardian. The participants and their parents were informed that participation in this project was voluntary and that even those who participated were free to withdraw from the research at any time. Assurance of confidentiality and anonymity is maintained when perceptions and experiences are used in the study. With regard to ethics from the selected school, permission from the Department of Education was sought.

3.6 SUMMARY OF THE CHAPTER

This chapter concludes an investigation into the research design and process of the effectiveness of computer aided teaching on the quality of learning data handling in mathematics in grade seven. A variety of aspects of the research design has been underlined. The research approach and sampling was highlighted. Discussion of the empirical investigation dealing with classroom observation, questionnaires and interviews was done. The procedure, data collection, presentation and analysis as well as the ethical issues and limitations were set out.

In the next chapter discussions of the findings will be conducted. The results and analysis of the findings will be examined in detail.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 INTRODUCTION

Chapter Four contains the results obtained from the various data collection methods. The results of the study are presented, the subsequent analysis carried out and discussions on the findings emerged. As presented in Chapter Three the research method at each stage was carried out and the two types of data being quantitative and qualitative were collected and analysed separately. Further to this the study was rooted in the theoretical framework of constructivism (Piaget: 1970) and deep and surface learning (Marton and Säljö: 1976 cited in Kember, Charlesworth, Davies, McKay and Stott: 1994:145-150) as set out in Chapter Two.

Chapter Three set forth the steps that the study followed; therefore the analysis will be indicated following this protocol. The questionnaire containing closed-type questions as well as open ended questions was administered to both the experimental group and the control group. Analyses of the questions were done through frequency counts and percentages. Presentation of the findings of the pre-test and post-test scores was followed using the statistical package. Graphic illustration was presented in the analysis of the tests. The interview aspect of the data was determined using direct quotation. Lastly the classroom observation and discussion on errors was carried out. In the conclusions section, statistical and qualitative inferences drawn from each source of data contribute in portraying the characteristics of the study.

4.2 ANALYSIS OF THE CONTROL GROUP QUESTIONNAIRE

The questionnaire was distributed to the control group and the experimental group comprising 20 learners each. Each section dealt with a specific aspect in relation to the study. The findings and discussions are discussed and analysed as it appears in the questionnaire. The process will unfold firstly by discussing the responses of the control group and thereafter the focus will move to the experimental group.

4.2.1 Section A: Profile of the Learners

Section A provided the biographical profile of the learners (Table 10). The reason for this is to determine the level of understanding of the learners in terms of the theory of Piaget (1970) as discussed in the research literature in Chapter two.

Table 11: Biographical Profile of the Control Group

AGE :	**11**	**12**	**13**	**TOTAL**
MALE	-	6	5	11
FEMALE	2	4	3	9
TOTAL	2	10	8	20

The questionnaire was answered by 20 learners with 55 percent of the learners being male and 45 percent female. The distribution was in keeping with the gender distribution of the learners who participated in the whole study.

4.2.2 Section B: Learners' Attitude to Computers

Section B was concerned with the learners' attitude to computers. Constructivists have proposed technology-enhanced learning, therefore before the actual learning can take place the attitude of the learners must be gauged. This section measured the responses of learners based on ten questions. The questions in this section are set out in Table 11 while the graphical representation is located in Figure 7. Learners were required to give an explanation for questions 6, 9 and 10. The feedback for these questions was crucial in assessing the attitude of learners towards the use of computers in the mathematics lesson. The process used was to firstly identify commonly shared opinions regarding a specific topic and secondly to classifying the responses according to the positive, negative and neutral aspects (Valenta, Therriault, Dieter, and Mrtek, 2001:120).

Table 12: Statements on Learners' Attitude to Computers

STATEMENT
1. Computers make work easier.
2. Learning about computers is worthwhile and necessary.
3. Working with computers makes me nervous.
4. It is important to know how to use computers in order to get a good job.
5. I wish I could use computers more frequently.
6. Computers can replace teachers.
7. A job using computers would be very interesting.
8. Most jobs need people to be computer literate.
9. Lessons done using a computer would be interesting.
10. I think mathematics lessons should be carried out using computers.

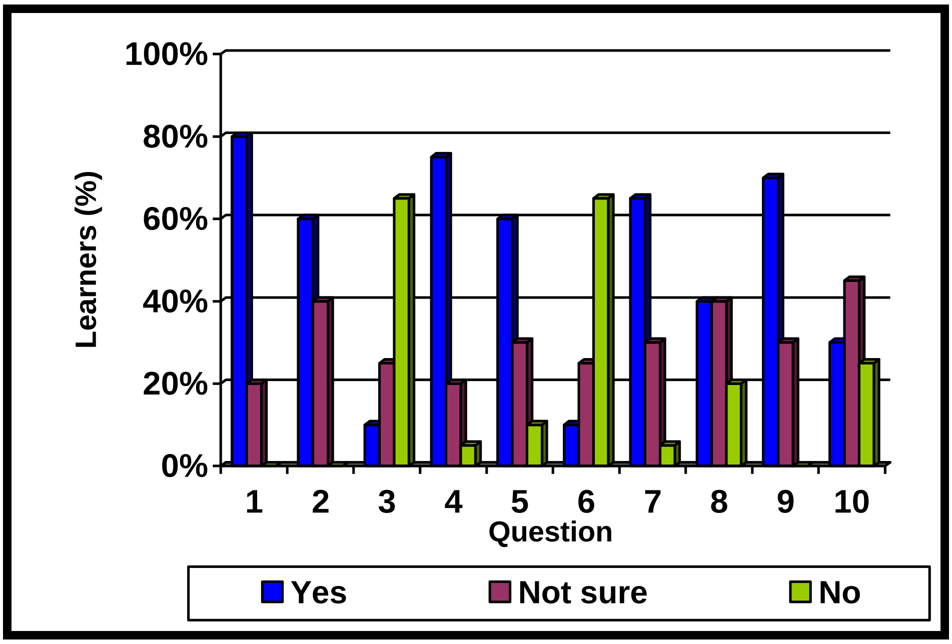


Figure 8: Statements on Learners' Attitude to Computers

Question 1: Computers make work easier.

It was found that 80 percent of the learners accepted that computers make work easier while 20 percent were not sure. The high percentage of positive responses indicated that learners were aware of the importance of computers while the 20 percent who indicated they were not sure did not categorically dispel the idea. This is in keeping with the research question.

Question 2: Learning about computers is worthwhile and necessary.

In response to this question 60 percent of the learners indicated that it was worthwhile to learn about computers while 40 percent signified that they were unsure. Once again none of the learners answered no. This is of significance as it again becomes evident that computers are seen as a worthwhile tool in the learning process.

Question 3: Working with computers makes me nervous.

A small sample of the learners (10 percent) found working with computers caused computer anxiety while 25 percent were not sure and a large proportion were not afraid of working with computers.

Question 4: It is important to know how to use computers in order to get a good job.

Analysis of this question revealed that 75 percent of the learners answered yes to the statement, 20 percent were not sure while 5 percent of the learners' response was negative.

Question 5: I wish I could use computers more frequently.

In response to this question 60 percent responded that they would like to use computers more often, 30 percent were not sure and 10 percent responded no. It is evident from the above information that although this group had not been exposed to the computer-assisted learning they were still aware of the positive effect of computers in education.

Question 6: Computers can replace teachers. Explain your answer.

This question was used to elicit the learners' attitude towards the replacement of teachers by computers. It was found that only a small number of learners agreed with the statement while a combination of the learners who stated that they were not sure and those who disagreed with the statement was 90 percent. The conclusion can be drawn that the human factor in the teaching and learning process is extremely important. The correlation can be made with question one where 80 percent of the learners stated that computers make work easier; learners still believe that the teacher is an important component in the education process.

- Teachers explain but computers do not.
- Computers can't control a class or explain like the teacher does.
- Computers are made by man and only man can teach a proper lesson.
- Computers cannot replace teachers because we humans have more knowledge than the computer.

Question 7: A job using computers would be very interesting.
It was noted that 65 percent agreed with the statement, 30 percent were not sure while 5 percent did not agree with the statement.

Question 8: Most jobs need people to be computer literate.
Learners were divided on the issue of the use of technology in the workplace. A combination of 60 percent (40 percent were not sure and 20 percent noted no) of the learners were not aware of the use of computers in the work place.

Question 9: Lessons done using a computer would be interesting. Explain your answer.
Of the responses obtained a large number of learners (70 percent) felt that lessons would to interesting if computers were use whereas 30 percent of the learners were not sure. None of the learners was adverse to the idea of using computers in lessons.

Most learners commented on the fun aspect of using computers and they mentioned how easy the activities are. These were some of the comments made by those learners who stated that lessons done on a computer would be interesting:

- It is easy to use a computer
- There are fun things to do on a computer

- It is fun to use and easier

Question 10: I think more mathematics lessons should be carried out using computers.

The statistics for this question revealed that 30 percent of the learners believed that lessons using the computer would be interesting, 45 percent were not sure and 25 percent did not think that computers would help in making the lesson interesting. Here too learners were asked to explain the reasons for their choice and these were some of the responses:

- No, we need to know all the methods, so it's better if we do not use computers
- We as learners have to learn how to work out answers by ourselves not rely on the computer
- Not all maths lessons can be done on a computer only some can
- Natural Science- I'm not sure about that. I think that my maths teacher is much more brilliant than the computer

4.2.3 Section C: Data Handling Aspects

Section C concentrated on data handling and the related aspects. It was divided into three sub-sections:

1. Understanding mathematics terms on data handling
2. I can do the following
3. Thoughts about data handling

Sub-section 1: Before the lesson on Data Handling what was your understanding of the following terms? Learners were asked to answer this question by providing a rating for each term. The rationale behind the choice of ratings is to establish the pre-knowledge framework of the learners. Frame is defined in accordance to Davis' cognitive science theory (1984).

The rating for each response was given as follows:

1= you could explain to someone easily.

2 = you think you understand, but might have trouble explaining to someone.

3 = you still do not understand the term well.

This section was proposed to determine the learners' pre-knowledge of data handling and its related concepts. Each of the terms in Table 13 is consistent with the data handling section as proposed by the department of Education in the Curriculum Statement document (DoE: 2002).

Table 13: Learners' Response to Understanding Terms

STATEMENT	YES	NOT SURE	NO
1. Tally chart	30%	40%	30%
2. Bar graph	50%	40%	10%
3. Percentage	10%	45%	45%
4. Pie graph	30%	30%	40%
5. Questionnaire	30%	20%	50%
6. Estimate	20%	40%	40%
7. Fractions	20%	55%	25%
8. Calculate	50%	40%	10%
9. Solve problems	10%	55%	35%
10.Angles	35%	50%	15%
11.Handling data	25%	30%	45%
12.Gathering data	20%	25%	55%
13.Surveys	30%	40%	30%
14.Analysing results	5%	40%	55%
15.Presenting results	20%	45%	35%

The table above revealed the percentage of learners' responses to each question. An evaluation of the responses to the questions revealed that there was a 50 percent affirmative answer for only two of the statements. The two concepts that the learners found simple enough to be able to explain is bar graph and calculate. The remainder of the terms received a 30 percent or less affirmative response. It therefore becomes apparent that the learners' pre-knowledge of the section on data handling is not up to the required standard and that their level of competence needed to be improved.

Sub-section 2: I can do the following.

This question was chosen to elicit the learners' responses to what aspects of data handling they are able to carry out Figure 9. Here too the idea of the aspect of learners' previous knowledge is important as it follows on from the literature review as propounded by the theory of constructivism (Sugarman: 1987:5-25).

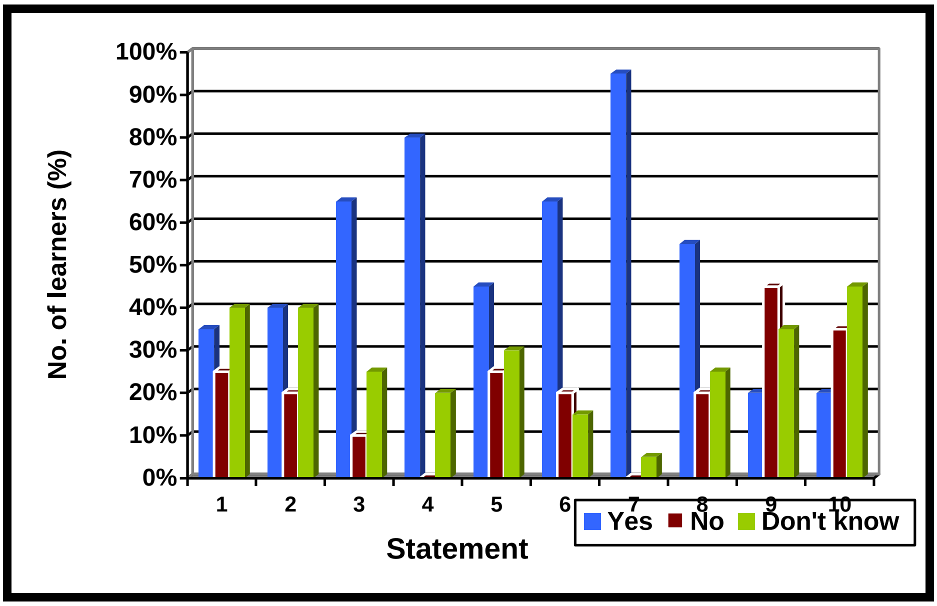


Figure 9: Statements on: "I can do the Following".

Question 1: Collect data. **Question 2:** Design a simple questionnaire in order to collect data.

These two questions were used to elicit the pre-knowledge of the learners. The first step in the understanding of data handling is the ability to collect data. Only 35 percent of the learners stated that they are able to collect data while 25 percent were not sure and a significant proportion of the control group (40 percent) were not able to collect data. A similar response was also noted for question 2 where 40 percent of the learners replied yes, 20 percent were not sure and 40 percent recorded a negative response.

Question 3: Record data on a Tally chart.

Being able to record information on a tally chart is the first step towards understanding the process of data handling. The results for this section conclude that 65 percent of the learners are able to record data on a tally chart which is a significant component of the data handling aspect of mathematics. Learners' understanding of recording information on a tally chart will enable them to use the information correctly in the application stage of the lesson.

Question 4: Draw a Bar graph and double bar graph; **Question 5:** Draw a Histogram; **Question 6:** Draw a Pie chart.
It is apparent from figure 9 that of all the graphs the bar graph is the easiest to draw with 80 percent of learners believing so. Less than half of the learners (45 percent thought that drawing of the histogram was easy while 65 percent believed that the pie graph was easy.

Question 7: Answer questions based on a bar graph; **Question 8:** Answer questions based on a pie chart.
It is apparent from figure 9 that there is a vast discrepancy in the percentage of learners answering yes to the two questions. In the case of answering question on bar graphs 95 percent (19 learners) responded in the affirmative whereas in the case of pie graphs 55 percent (11 learners) were in agreement. During the lessons observations were also made regarding these two issues and the findings collaborate what was observed during the lessons.

Question 9: I can draw conclusions from findings. **Question 10:** Make recommendations from findings.
In addition to being able to draw conclusions from findings learners were also asked if they could make recommendations from the findings. In both instances it was found that only 20 percent of the learners could draw conclusions or make recommendations from findings while 80 percent of the learners were either unsure or stated that they were unable to perform the said functions..

Sub-section 3: Thoughts about data handling.

This section of the questionnaire dealt with learners' views about data handling and the related concepts.

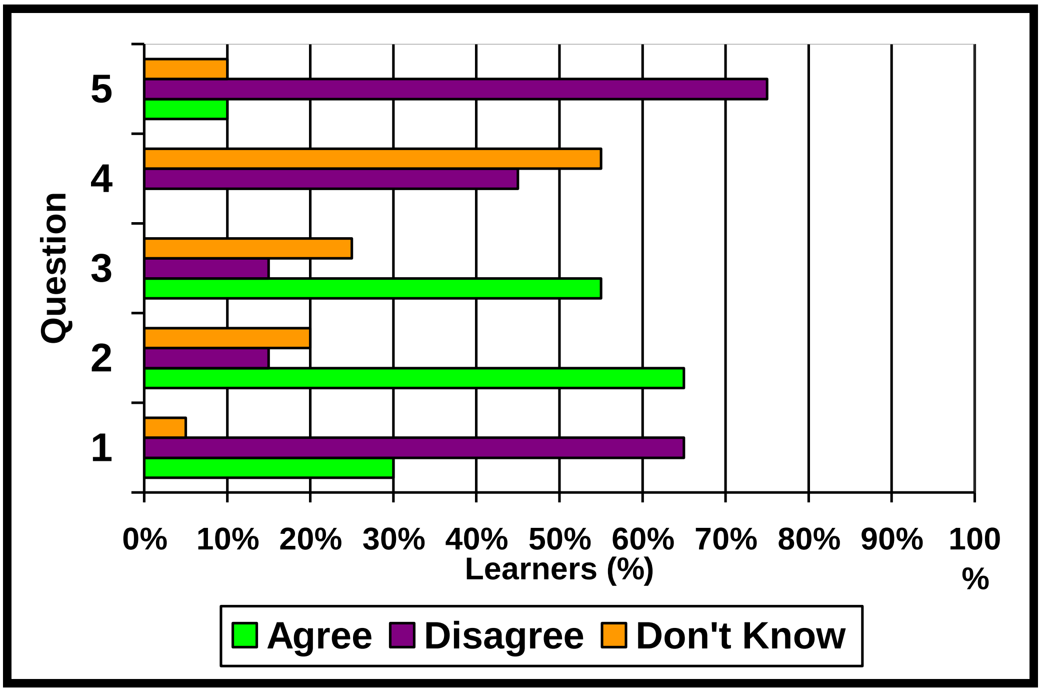


Figure 10: Response of Learners' Thoughts about Data Handling

Question 1: Drawing graphs are difficult.

The motivation for this question was to establish from the learners' response the idea of visualisation as a basis for understanding graphs. From the responses it is evident that learners did not have a serious problem with visualisation as 65 percent of them stated that drawing graphs are not difficult. Although this is not an overwhelming majority it is nevertheless significant.

Question 2: Graphs are easy to read. **Question 3:** It is easy to answer questions when it is in the form of a graph.

An evaluation of these two questions was done together as the response was the same. For both questions the learners' responded the same with 65 percent agreeing that graphs are easy to read as well as answer questions based on the graphs. This is still not the prescribed norm as 35 percent of the learners still need to achieve the set level of competence.

Question 4: I can predict what can happen in the future by looking at information in a graph.
It is evident from the graph (Figure 10) that learners are operating at the surface level of thinking when answering this question. According to Marton and Säljö (1976) cited in Kember, Charlesworth, Davies, McKay and Stott (1994:3-4) surface approach to learning happens when learners are intent on memorization rather than on issues. None of the learners felt that they could predict what can happen in the future by studying a graph.

Question 5: I must be able to draw well to be able to draw a graph.
The dominant thinking of the respondents was that they need not be able to draw well in order to be able to draw a graph (80 percent). Logically they realise that it is not their artistic ability that is of importance but it is essential to understand the information presented in a graph, draw inferences and make predictions.

4.3 ANALYSIS OF THE EXPERIMENTAL GROUP QUESTIONNAIRE

4.3.1 Section A: Profile of Learners

Section A presented the biographical summary of the learners (Table 13). The motive for this is to establish the stage of the learners understanding in keeping with the constructivism theory.

Table 14: Biographical Summary of Experimental Group

AGE :	**11**	**12**	**13**	**TOTAL**
MALE	1	4	6	11
FEMALE	1	7	1	9
TOTAL	2	11	7	20

As in the control group represented in figure 11, twenty (20) learners participated in this aspect of the study of which 55 percent were males and 45 percent females. The age distribution of the learners is presented in table 14.

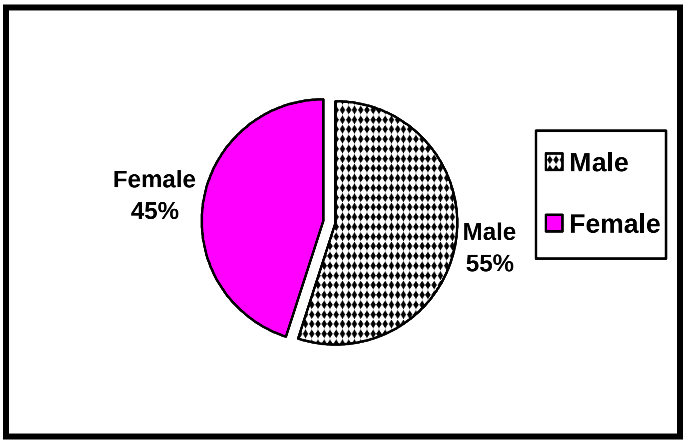


Figure 11: Gender: Experimental Group

4.3.2 Section B: Learners' Attitude to Computers

Section B measured the learners' attitude to computers and its use. The reason for the inclusion of the questions in this section is because these issues are relevant to the impact of computers upon the learning of mathematics. The response to the learners' attitude to computers can be examined in Figure 12. Further to this as in the control group learners were required to justify their responses for questions 6, 9 and 10. The views expressed by the learners in this question were essential in gauging the difference in learners' attitude between the control group and the experimental group. The researcher was able to gather data which would help in understanding the cognitive level at which the learners, were functioning. The supporting evidence reveals the importance of technology in the everyday lives of the learners.

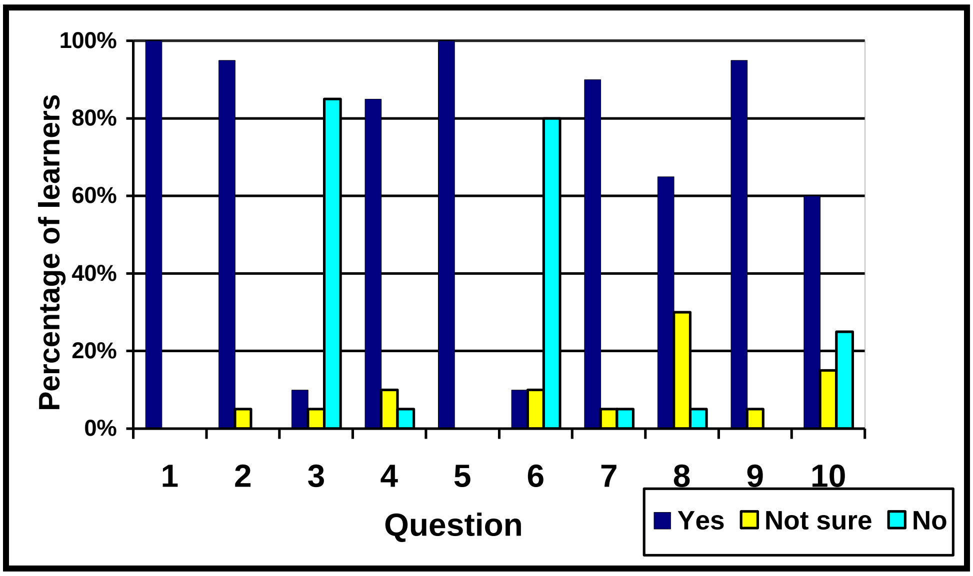


Figure 12: Learners' Attitude to Computers

Question 1: Computers make work easier.

It was noted that all the learners (100 percent) stated that computers make work easier. These results conclude that the lessons conducted using the computer was beneficial to the learners. Judging from the responses it is evident that the effectiveness of computer-aided instruction is apparent.

Question 2: Learning about computers is worthwhile and necessary.

The analysis of this question showed that 95 percent of the learners believed that computers are not only worthwhile but necessary as well. A very small percentage of 5 percent (1 learner) was not sure. These findings seem to indicate that learners have a positive perception of computers.

Question 3: Working with computers makes me nervous.

This question was used to determine whether learners were comfortable using computers in their mathematics lessons. It was noted that the majority of learners (85 percent) were at ease using computers while 5 percent stated that they were unsure and 10 percent were nervous when using computers.

The findings show that learners were comfortable using technology in the learning process.

Question 4: It is important to know how to use computers in order to get a good job.

It was noted that learners tended see the importance of computers in the workplace. The response to this statement is that 85 agreed with the statement, 10 percent were not sure while 5 percent disagreed. It is thus observed that learners acknowledged the significance of being technologically literate so as to secure a good job.

Question 5: I wish I could use computers more frequently.

All the learners (100 percent) of the experimental group stated that the frequency of the use of computers should be increased. The above results highlight the fact that the learners see the importance computers in education.

Question 6: Computers can replace teachers.

The dominant thinking of the respondents was that computers cannot replace teachers with 80 percent of the learners expressing this view while 10 percent each were either unsure or were in agreement. The positive influence of teachers is a thread that was echoed by most learners.

The actual extract of responses of the learners who disagreed with the statement is:

- There are some things a teacher can do and computers can't
- Computers may not know things or have experience of teachers. A teacher could make you understand something properly but a computer may not
- I think that it would be really difficult to replace teachers; you wouldn't get any feedback from a computer
- No, because you can't rely on computers, it can break or get a virus but a teacher will always be there

While most of the learners reflected on the importance of the teacher in the process of learning, an interesting explanation by one of the learners who agreed with the statement was the following response;

- In the future teachers will get old and forget the work but computers get old but still store all the information

Question 7: A job using computers would be very interesting.
According to 90 percent of the respondents a job that requires the use of computers would be exciting. The above results could also provide evidence that learner at times understand the importance and the use of computers in the workplace.

Question 8: Most jobs need people to be computer literate.
An evaluation of this question is essential as it can be inferred that learners were not quite aware of the use of computers in most jobs. This can be justified by the fact that although 65 percent of the learners agree with the statement there was still a high proportion of learners who did not know (30 percent).

Question 9: Lessons done using a computer would be interesting.
It is evident from figure 12 that 95 percent of the learners see the value of computer-assisted learning. This pattern appears to be consistent with the responses to many of the questions and statement posed to the learners in the analysis above.

- It would be interesting because nowadays children don't enjoy writing and computers make work easier to do
- You will be able to understand different section by using games, diagrams and programmes
- Yes, it would be because it is fun to use a computer and it will be much faster to carry out a task

- Yes, children would want to learn and lessons will be fun

Question 10: I think more mathematics lessons should be carried out using computers.

This question was proposed to determine if learners would be amenable to the inclusion of computer-assisted teaching and learning. A feedback of the responses reveals that a significant number of learners would welcome more lessons in mathematics being done using the computer. Learners' descriptions of the influence of computer-assisted learning are listed below:

- Yes. You understand the work better especially if the teacher doesn't explain to you properly and when you ask questions you don't get the proper answer
- A better understanding because there are many functions to use on a computer
- It would be better because it has a calculator and you can just type all the answers

In contrast to the above explanations learners who responded no to the statement gave the following reasons:

- No, maths is meant to be done by teachers and they explain better and make the work easier
- No, it would be difficult to understand because maths is an important subject and it has to be taught in away you will understand
- No, because it will be a lot of stress for people who are having different problems in mathematics

4.4.3 Section C: Data Handling Aspects

SECTION C provides an evaluation on the data handling aspect of the study.

According to Eisenkraft (2003:56) the 7E model is essential and provides the teachers with the basis for student centered learning. Further to this the aim of the 7E learning model is to stress the increasing significance of obtaining knowledge that was previously learnt and to expand, or reassign such knowledge to the learning of new concepts. Based on this section C was divided into three sub-sections:

1. Understanding mathematics terms on data handling
2. I can do the following
3. Thoughts about data handling

Sub-section 1: Before the lesson on Data Handling what was your understanding of the following terms? A rating scale was provided and learners had to select their response as per the given scale. This was a 3 point scale with the following explanation:

1= you could explain to someone easily.

2 = you think you understand, but might have trouble explaining to someone.

3 = you still do not understand the term well.

Learners had to rate their understanding of the terms related to data handling. The responses of the learners are set out in Figure 13.

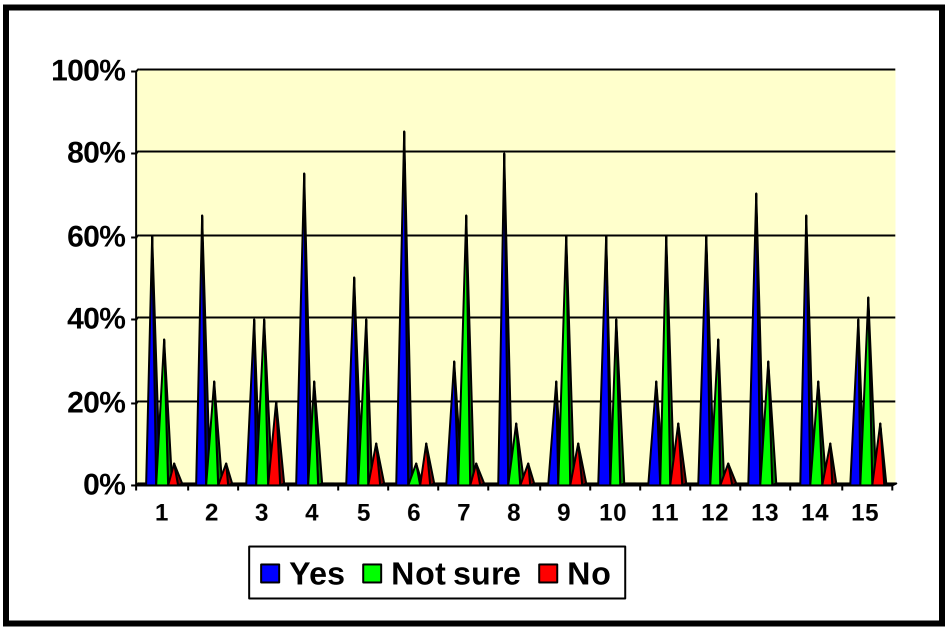


Figure 13: Learners Understanding of Data Handling Mathematical Terms

It can be inferred from the data above in Figure 13 that learners in the experimental group showed an increase in their understanding of statements relevant to data handling as compared to those in the control group. An assessment of the responses shows that there was a 50 percent and over score for ten of the concepts. This is a significant finding as it revealed that the learners in the experimental group were operating at a higher level of understanding than those of the control group. Another very interesting observation was the decline in the number of learners who did not understand the terms well.

Sub-section 2: I can do the following. ..

Based on the constructivist teachings of Piaget (1970) and Vygotsky (1978), learners build on previously acquired knowledge. It would therefore be important to understand the level at which the learners are functioning prior to new lessons being taught. Further to this being able to explain concepts and definitions is one level of the 7E model (Eisenkraft (2003:57). Responses to this section reflect learners' ability to carry out certain tasks on data handling. These skills are critical for appropriate interpretation of data when dealing with graphs. The ten questions sought to identify the learners' level of competence regarding data handling.

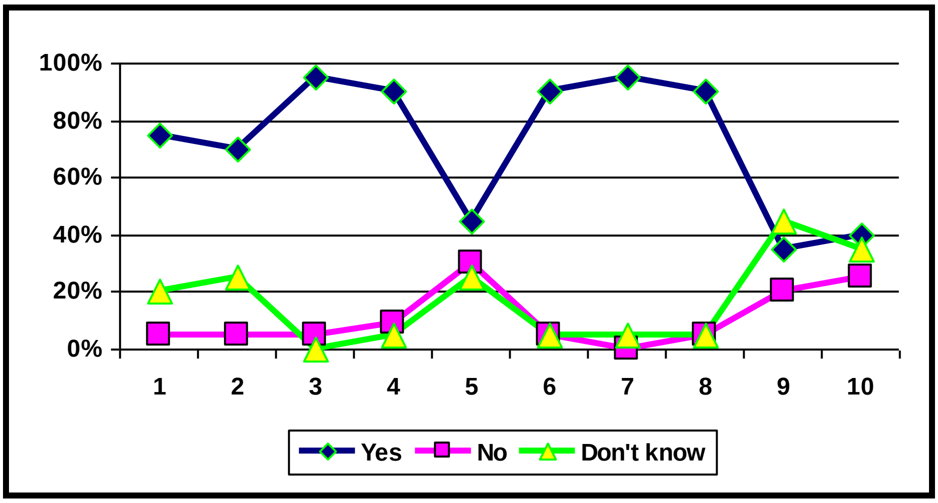


Figure 14: Learners' Response to: I can do the following…

Question 1: Collect data. **Question 2:** Design a simple questionnaire in order to collect data.
On the question of collecting data 75 percent of the learners responded that they could do the task and 70 percent agreed that they could design a simple questionnaire. This is a much higher percentage than that recorded by the control group. These findings meant that the experimental group was confident in attempting the two tasks.

Question 3: Record data on a Tally chart.
The findings show that 95 percent of the learners stated that they are able to perform this task. This is a relevant finding as it is an important component in the data handling aspect of mathematics.

Question 4: Draw a Bar graph and double bar graph; **Question 5:** Draw a Histogram; **Question 6:** Draw a Pie chart.
These three questions will be analysed together as it follows the same theme of the ability of the learners to draw a particular type of graph. Question 4 and question 5 received the same response of 90 percent of the participants being able to draw the graphs while 5 percent each were either unsure or could not draw the graphs at all. There was a marked difference in the response to question 6 as less than half (45 percent) of the learners felt that they could draw a histogram. These findings seem to indicate that learners had a strong pre-knowledge framework in dealing with bar graphs and pie graphs.

Question 7: Answer questions based on a bar graph.**Question 8:** Answer questions based on a pie chart.
These two questions were combined so as to establish learners' ability to answer questions based on two different graphical representations. Once again there was very little difference in the responses to the two questions with 95 percent and 90 percent respectively answering in the affirmative.

Question 9: Draw conclusions from findings; **Question 10:** Make recommendations from findings.

Question 9 and 10 focused on a deep level of understanding where conclusions can be drawn and recommendations made. Although the findings indicated that fewer than half of the learners could perform the two tasks; 35 percent could draw conclusions and 40 percent could make recommendations, this is still an increase in the percentage as compared to the control group.

Sub-section 3: Thoughts about data handling

This section is concerned with the learners' contemplations about data handling. The purpose of this section was to ascertain the pre-knowledge of the learners.

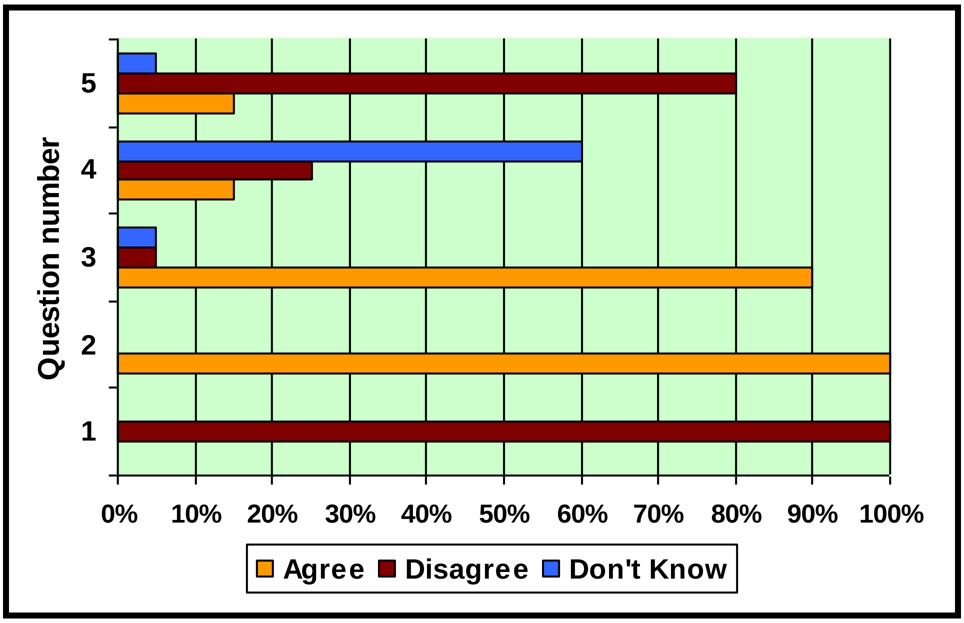


Figure 15: Learners Thoughts about Data Handling

Question 1: Drawing graphs are difficult; **Question 2:** Graphs are easy to read.

All 100 percent of the learners reported that they did not find drawing graphs difficult and that graphs were easy to read. Their choice of answer could be grounded in the fact that the learners were able to able to draw the graphs using the computer and that much of the input was readily available.

Question 3: It is easy to answer questions when it is in the form of a graph.
The learners acknowledged that it was easy to answer questions when it was graphically presented. This is evident from the figure above (Figure 15) which indicates that that 90 percent of the learners agree while 10 percent each disagree and do not know.

Question 4: I can predict what can happen in the future by looking at information in a graph.
This question is related to the final level of the 7E model of Eisenkraft (2003:56-57) which establishes the learners' level of understanding by their ability to answer open-ended questions by observation and available evidence. In response to this question it was found that a small group of learners (15 percent) are able to make predictions by studying a graph. These findings seem to indicate that learners are still not able to make predictions by studying a graph. This is related to the deep and surface learning which is vital in understanding the learners thought processes. In addition the inability to make predictions as experienced by the learners is related to their pre-knowledge framework. It was noted that 25 percent disagreed with the statement while a large number of learners, 60 percent stated that they were not sure. It is evident from the findings that 15 percent of the learners reached the formal operational stage as advocated by Piaget. In comparison to this, none of the learners in the control group was able to achieve this level of competence.

Question 5: I must be able to draw well to be able to draw a graph.
The findings for this question seem to indicate that learners understand that it is not important to be able to draw well in order to understand the concepts related to graphs.

4.3.4 Section D: Questions on Computer Activities

SECTION D of the questionnaire was used to determine learners' responses to questions after their mathematics exercises on bar graphs and pie graphs using the computer.

Question 1: What did you learn from the computer activity?

The response to this question was varied as the learners listed all aspects of data handling that they were exposed to when using the computer. These results are consistent with the notion that students learned to use the computer effectively and found the exercise stimulating. Besides the learners' understanding of how to draw graphs and the ease of doing it by computer the learners mentioned the following pertinent points:

- Modern technology is cool
- That working with computers is easy and fun. You can spend more time on understanding
- It is very easy. You just need to know your information
- It is much more easy and fast to do drawings and work out answers
- It is faster and more accurate than working by hand

Question 2: Do you think that using the computer to learn about graphs is easier than using a worksheet? Explain.

Learners discussed how easy it was to do a task using the computer. The comments of the learners explain this fact:

- Drawing freehand is time consuming and can be difficult
- You don't have to calculate or write or draw
- Yes because it gives details
- Yes because you just need to write the names and number of things and the computer does the work
- Yes because you can ask for information

Question 3: Did you find the instructions on the computer easy to understand or was it difficult? Explain.

Learners acknowledged that they found the instructions easy to follow and they expressed this in the following way:

- Easy to understand because it explains well
- The commands for the computer were simple
- Easy to understand because it does everything for you and even people who don't understand will understand
- Easy- They give you step by step instructions
- It was easy and understandable

Question 4: How would you rate the computer exercise? (5=excellent; 4=very good; 3=satisfactory; 2=fair; 1=poor? Explain

The findings for this question seem to indicate that learners enjoyed the lesson with 85 percent giving it a rating of 5 and 15 percent rated it as a 4. The ease of using the computer and the fun aspect were the two dominant explanations. The following comments helped summarise what the majority of learners expressed:

- They give all the information you want.
- It makes things easy to understand-sometimes not even a teacher can explain as a computer can.
- Children could learn faster and make children understand better.
- it is much easier. You don't have to calculate you can just press a button and it's done.

Question 5: Complete the statement: I would like maths lessons more if …

All learners in the group expressed the wish to use computers in the mathematics lessons. It is evident from the views that are quoted from the learners' response that computers have become a catalyst for change. These are some of the responses:

- We could each use a computer for maths.
- We add a little more of computer fun.
- There are computers to work with in maths.
- We could use a Personal Computer more often to do lessons.

4.4 SYNTHESIS AND ANALYSIS OF QUESTIONNAIRE: CONTROL GROUP AND EXPERIMENTAL GROUP

The feedback of the responses to the questionnaire was assessed according to the information provided by the learners. A number of different experiences was recorded by both groups. These findings are in keeping with the skills and knowledge level of each group. It was also found that not all learners were able to attain the set level of understanding as per the 7E model. The questions in the questionnaire attempted to answer the research question of learners' attitude towards computers.

4.5 ANALYSIS OF PRE-TEST AND POST-TEST

4.5.1 Definition

Dimitrov and Rumrill (2003: 159) suggest that pre-test and post-test designs are broadly used in behavioural study, largely for the intention of comparing groups and for assessing if there are changes prevalent as a result of the study. This would therefore be accepted as a tool that identifies the qualitative aspect of the study.

A succinct definition of these terms would lead to a better understanding of the rationale for its use. Pre-test is a test given to learners to determine whether they are sufficiently prepared for a course of study. Post-test is a test administered after a lesson or instruction to see what has been assimilated.

4.5.2 Procedures

The pre-test, based on questions relating to bar graphs and pie graphs was given prior to learners receiving any classroom or computer-based instruction related to the study. Pre-test testing conditions allowed for limited time for learners to complete the test. The learners were encouraged to do their best work, but were not given any assistance with completing the test. Once the pre-test was scored, forty learners were randomly divided into two groups based on their achievement and this formed the control group and the experimental group.

AIl learners attended their regular mathematics class and received the same mathematics instruction on bar graphs and pie graphs in data handling. The experimental group attended the computer laboratory after they had completed their classroom instruction. While in the computer laboratory, the learners received instructions based on using the computer to work on bar graphs and pie graphs, while the control group received traditional instructions in the classroom based on the same lesson. Pre-mathematical framework of Davis (1994) was used as the platform for this aspect of the study.

While working in the laboratory, the Integrated Learning System automatically recorded any activity on each individual learner account. At the end of three weeks, the post-test was administered to all the learners. The same instrument that was used for the pre-test served as the post-test, and the same testing conditions were used. The post-test was scored, and data was analysed using the Statistical Package for the Social Sciences (SPSS).

4.5.2.1 Population distribution based on pre-test scores

A summary of the pre-test scores for both the control group as well as the experimental group is represented in Figure 16. The range of scores is presented leading to the distribution of the learners into the two groups. The manner of distribution is graphically presented in Figure 16.

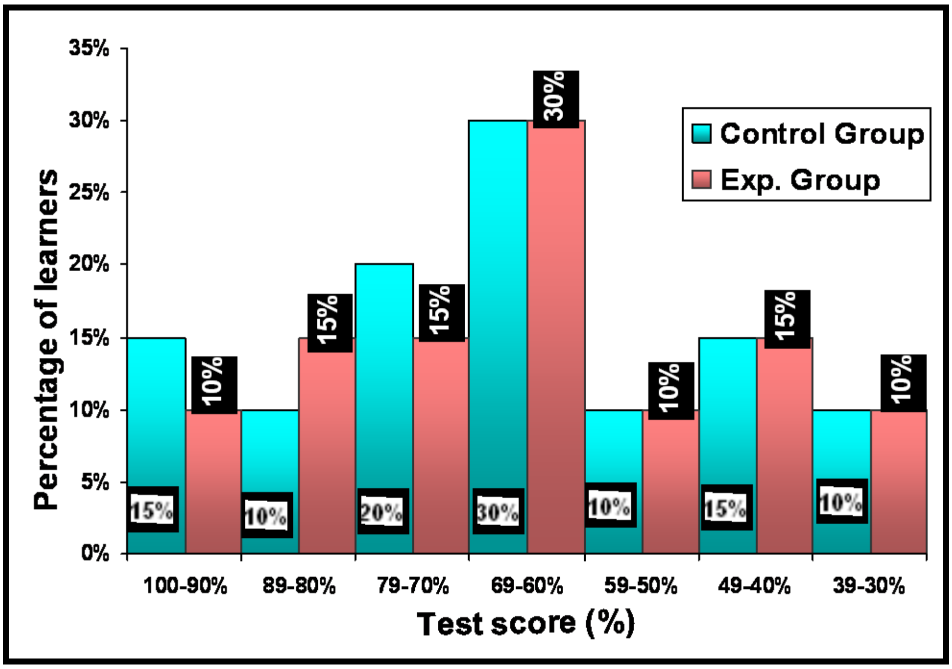
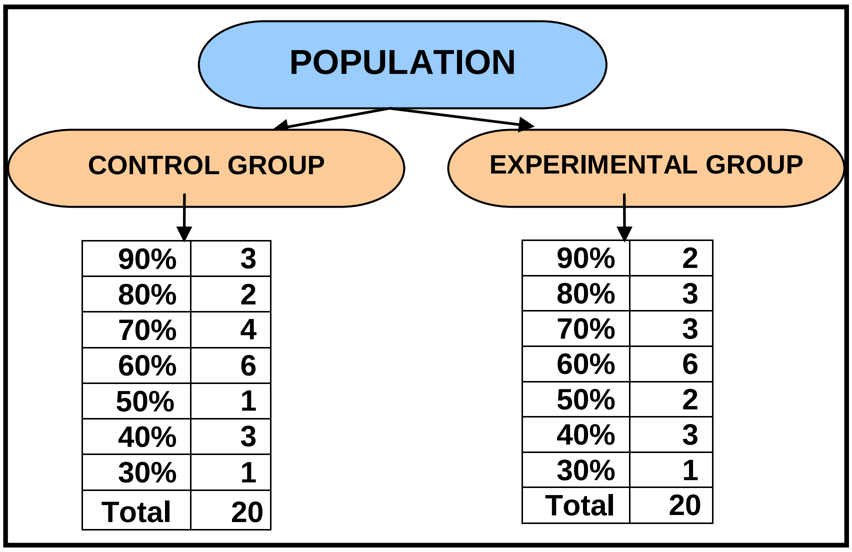


Figure 16: Pre-test Test Scores of Control Group and Experimental Group

There was an attempt to distribute the learners into the two groups (control group and experimental group) evenly, providing for purposeful sampling. Figure 17 demonstrates the distribution of the two groups based on the scores achieved in the pre-test. The learners who participated in the study numbered forty, divided into the two groups of 20 each.



90%	3
80%	2
70%	4
60%	6
50%	1
40%	3
30%	1
Total	20

90%	2
80%	3
70%	3
60%	6
50%	2
40%	3
30%	1
Total	20

Figure 17: Distribution of Learners

4.5.2.2 Pre-test and Post-test: Control Group

Figure 17 reveals the frequency of scores in both the pre-test and post-test of the control group. There was a marginal increase in the post-test score as compared to the pre-test. This result meant that learners performed better in the post-test than in the pre-test. It is evident from the study of figure 17 that all learners (100 percent) achieved higher marks in the post-test. The implication is that new knowledge was built on from previous knowledge as proposed by the theory of constructivism (Huitt & Hummel 2003:6).

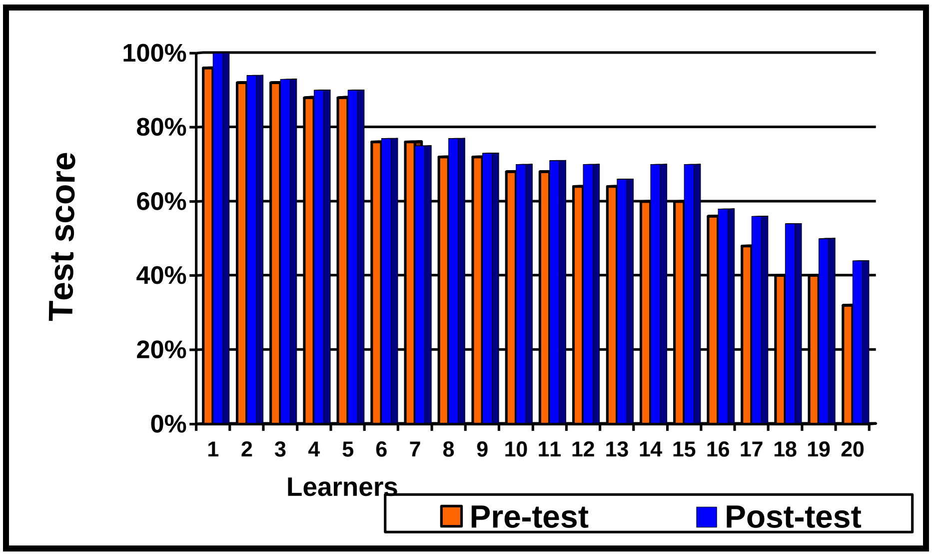


Figure 18: Control Group Pre-test and Post-test Scores

The analysis of the results of the twenty learners (graphically presented in figure 18) in the control group is as follows:

- There was an increase in the scores of all learners in the post-test schedule.
- Only 1 learner (5 percent of the control group) achieved the maximum mark of 100 percent.

4.5.2.3 Pre-test and Post-test: Experimental Group

The graph below (Figure 19) reveals that the frequency of learners obtaining higher marks, increased in the post-test as compared to the pre-test. This result meant that learners performed better in the post-test than in the pre-test. It could be noted that the intervention of the computer-assisted learning as espoused by Papert (1980; 1996) could have led to better scores. The scores for pre-and post-tests were compared using the mean score graph (see Figure 20).

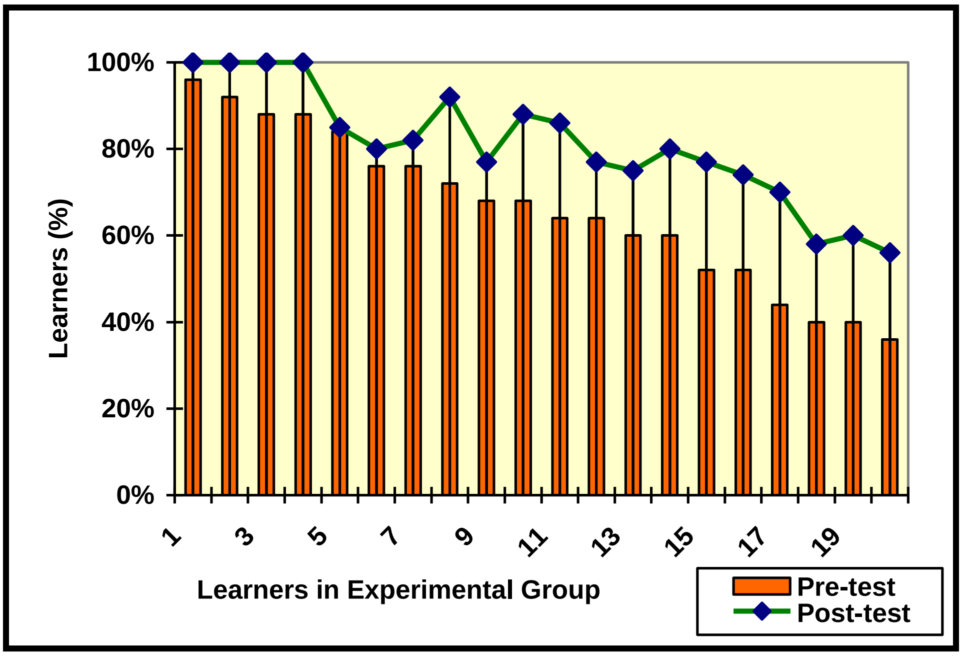


Figure 19: Experimental Group Pre-test and Post-test Scores

The analysis of the results of the twenty learners in the control group as presented in figure 19 follows:

- All the learners achieved an increase in the score after the intervention using the computer
- The number of learners achieving the maximum of 100 percent was four. This translated to 20 percent of all learners who participated in the study
- The average score of the experimental group during the pre-test was 66 percent while the average score for the post-test was 81 percent. There was therefore a marked increase in the scores

- No learner achieved less than 50 percent in the post-test; the implication of this is that every learner achieved a pass score in the post-test

4.5.2.4 Pre-test and Post-test: Control Group and Experimental Group

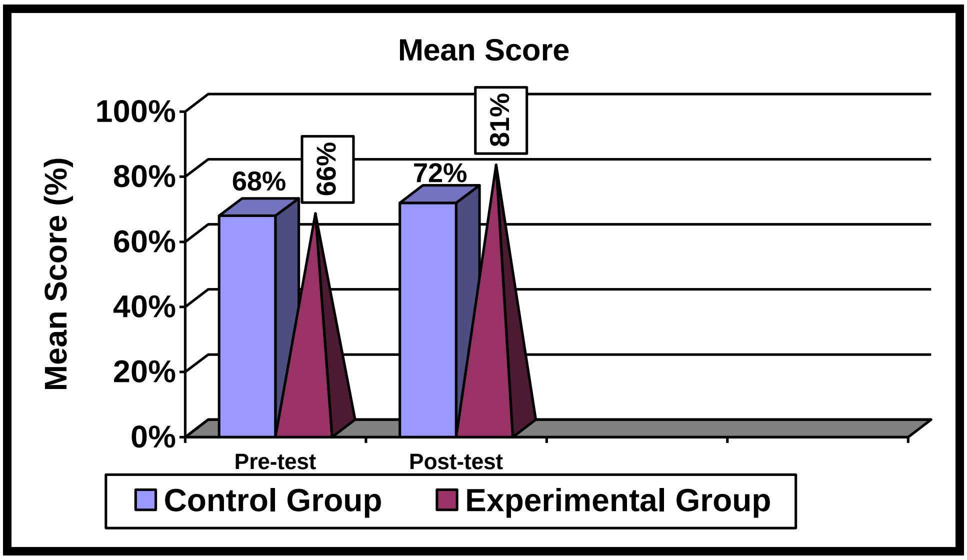


Figure 20: Post-test Control Group and Experimental Group: Mean Score

In relation to the pre-test there was no significant difference in performance between the two groups as indicated in Figure 20. The post-test however shows a significant difference between the two groups. The mean for the control group was recorded as 70 percent while the mean for the experimental group was 81 percent. This indicated better performance for the experimental group than the control group. This superior mean-score by the experimental group suggests that the intervention of computers had a significant impact on the learning process of those involved in the experimental group (Papert: 1990).

These results indicated that there was a statistically significant difference in the performance of the experimental group in the post-test. The above results provide evidence that learners' results could improve through the intervention of computer assisted learning in mathematics. It was therefore concluded that instruction using computers improved learners' performance in data handling in mathematics.

4.5.3 SYNTHESIS OF TEST ANALYSIS

From the above discussions the following points became apparent.

- Mathematics lessons that are conducted solely in the classroom do not provide learners with the tools available that makes understanding of concepts easier
- Mathematics lessons using technology allowed the learners to be introduced to a different strategy which enabled better understanding of the task

The discussions around errors by Donaldson (1964) as cited in Kogan (1966) in problem-solving have important implications for teaching and learning. To guide the development of this study, the extant literature related to errors have to be understood. The discussion in chapter two bears reference to the three types of errors being:

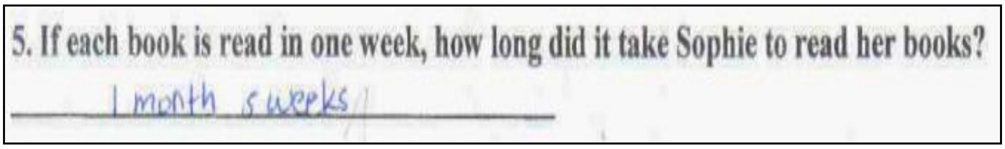
1. Arbitrary errors
2. Structural errors
3. Executive errors

Given that these are important components in the process of understanding learning, the findings as illustrated in table 15 reveals the errors made by learners and a sample of the errors is illustrated in figure 21.

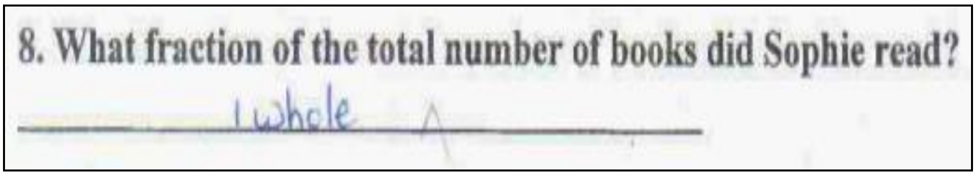
Table 15: Types of Errors

Type of errors	**PRE-TEST**		**POST-TEST**	
	Control group	**Experiment group**	**Control group**	**Experiment group**
Arbitrary	10%	5%	5%	5%
Structural	30%	25%	25%	20%
Executive	25%	20%	20%	15%

Arbitrary error:

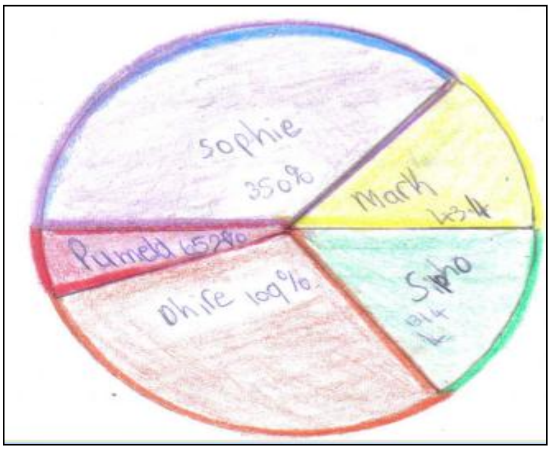

5. If each book is read in one week, how long did it take Sophie to read her books?

1 month 5 weeks

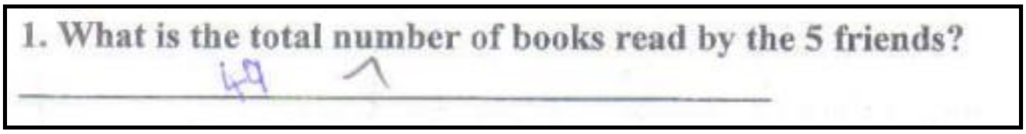

8. What fraction of the total number of books did Sophie read?

1 whole

Structural error:



Executive error:


1. What is the total number of books read by the 5 friends?

49

Figure 21: Sample of Errors

4.6 ANALYSIS OF THE INTERVIEW

4.6.1 Introduction

The interview was conducted with ten participants of the experimental group for reasons explained in Chapter Three. Hoepfl (1997:52) mentions that an interview schedule is a collection of questions or general topics that the researcher wants to investigate during each interview and although questions are prepared and asked of each learner there are no predetermined responses. The interviewing methods were designed to allow for free flowing discussion guided by the established foci and by emergent foci as they developed. Interviews were recorded and then transcribed for the purpose of analysis. The learner interviews were conducted on a one-to-one basis during the school day and were approximately fifteen minutes in length. The purpose of the interviews was to determine the learners' perceptions of mathematics in general, their attitude to the mathematics curriculum and questions on data handling. Discussion of the questions and responses follow.

The demographic data as set out in Table 16 reveals that the gender and age distribution of the participants.

Table 16: Gender and Age Distribution: Interview

Age	**11**	**12**	**13**	
Male	1	5	1	7
Female	-	2	1	3
Total	1	7	2	10

4.6.2 Detail Analysis of Interview

4.6.2.1 SECTION A: SELF PERCEPTION

This section provides details about the learners' perception of mathematics as a learning area; its relation to other learning areas and the introduction of computers to mathematics.

Question 1: What is your favourite subject? Why do you like this subject?

It is evident from the information in Figure 22 that mathematics is one of the favourite learning areas together with Natural Science with each receiving 30 percent of the responses. This is of interest as the reasons for the learners' choice is diverse. The following were responses of the learners for choosing mathematics as their favourite subject:

- I like this subject because it is challenging and helps you think better.
- I love maths and I know that maths is very important.
- I just like numbers.

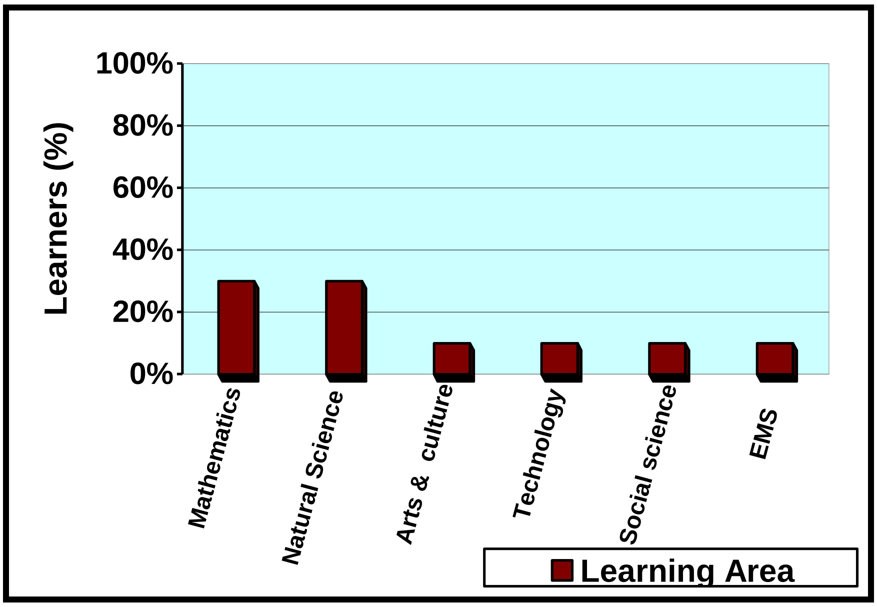


Figure 22: Learners' Favourite Subject or Learning Area

Analysis of the responses in terms of deep and surface learning reveals that the first two respondents revealed a deep understanding of the question. They were able to clarify their choice of mathematics being their favourite subject by explaining its importance. The third respondent produced a surface response and was non-committal in terms of explaining the reason for the response.

Question 2: What is your least favourite subject? Why do you not like this subject?

None of the participants chose mathematics as their least favourite subject. They listed the following subjects as being their least favourite: Zulu (50 percent), Afrikaans (30 percent), Life Orientation (10 percent) and Natural Science (10 percent).

Question 3: What is your favourite section in mathematics? Why do you like this section?

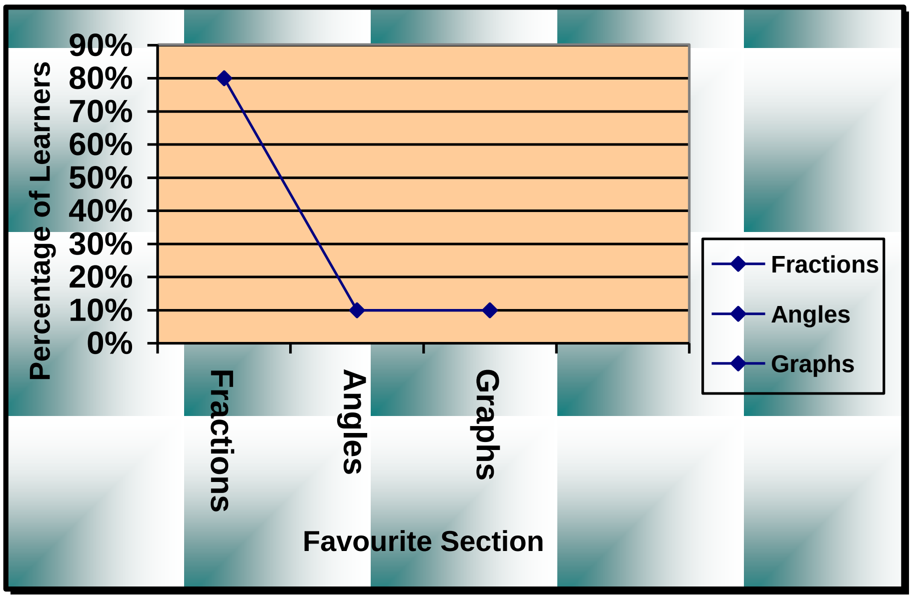


Figure 23: Learners' Response to Their Favourite Section in Mathematics

Figure 23 deals with the learners' favourite section in mathematics. The reason for including this question in the interview was to gauge the frequency of the section that is most popular so as to understand why it is popular. The information also helps to promote other sections by recognising what learners search for in a section. The section on fractions in mathematics is the favourite with 80 percent of the participants choosing this section. Only 10 percent of the participants chose angles and the remaining 10 percent chose graphs. This is of concern as it seems that only 1 in 10 learners chose graphs as their favourite section.

A sample of the responses for choosing fractions as the favourite section in mathematics is:

- Because I like to learn about percentage
- It is very challenging and you don't have to only multiply whole numbers, you also have to do the same to the fractions

- I enjoy this section because it involves drawing and makes you think hard
- It involves sharing and drawing sometimes and there are cool methods for using them
- Easy to understand
- I find it very easy
- It's fun to subtract, add and multiply and divide and draw
- You learn about different numbers and operation signs

Analysis of the responses in terms of deep and surface learning reveals that of the eight participants 75 percent of the learners' display deep learning while 25 percent display surface learning.

Question 4: What is your least favourite section in mathematics? Why?

The analysis revealed that 30 percent of the learners did not have a section in mathematics that they did not like. Figure 25 sets out the learners' least favourite sections. The following sections posed the most difficulties for the learners: shape (30 percent), problem-solving (20 percent), tessellations (10 percent) and fractions (10 percent).

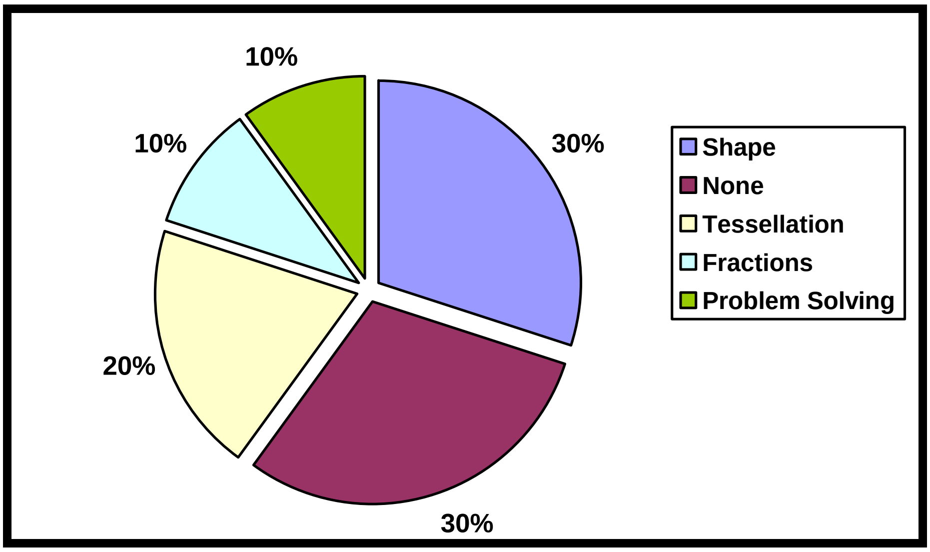


Figure 24: Learners' Response to Their Least Favourite Section in Mathematics

Learners who enjoyed mathematics and did not have a section in mathematics that they did not enjoy responded as follows:

- None. I like all
- I don't have one. I like everything about maths
- I don't have a least favourite section. Most of the sections are rated the same

Question 5: Do you think computers should be used more often to teach mathematics lessons?   Explain.

The results revealed that 70 percent of the learners accept that computers should be used more often in the mathematics class while 30 percent believed that it should not.

Learners who were in favour of more use of the computer in the mathematics responded as follows:

- It should be because in the real world computers play a major role in industries and business
- Computers make maths much easier and more fun. You don't have to always draw diagrams on the board because they will automatically come on with a computer
- Children would learn faster and lessons would be more fun
- You don't have to know your timetables or calculate anything
- The teachers could teach faster and make things simpler for pupils to understand by using the computer
- So children can not only learn maths but they can learn to use a computer

Learners who felt that computers should not be used more often to teach mathematics lessons explained their thoughts as follows:

- It's hard to understand what's going on in the lesson.
- The teachers make it look easy on the board.
- Teachers make maths look easy because they explain.

4.6.2.2 SECTION B: QUESTIONS ON MATHEMATICS CURRICULUM

At this juncture it is important to note that it is vital to ascertain the level of competence of the learners by directing their thoughts to the mathematics curriculum. This is based upon the theories of Davis (1984:6-12) proposes cognitive changes takes place according to what was learnt in early childhood. The results in this section will highlight learners' thoughts on the mathematics curriculum.

Question 1: What was the most interesting activity that you did in mathematics this year? What did you enjoy about this activity?
Fractions and problem solving were chosen as the most interesting activities that learners were involved in accounting for 80 percent of the responses (40 percent each) while 20 percent of the learners chose shapes and net.

Question 2: How can maths lessons be made more interesting?
This question was included in the study so as to glean from the learners' strategies that they felt could make mathematics more interesting. Learners brought forth two ways of improving mathematics teaching; these being using computers and the use of diagrams. Figure 25 gives an indication of the trend of thought of the learners with a strong majority of 80 percent choosing computers as a strategy that would make mathematics lessons more interesting, while 20 percent hose the use of diagrams.

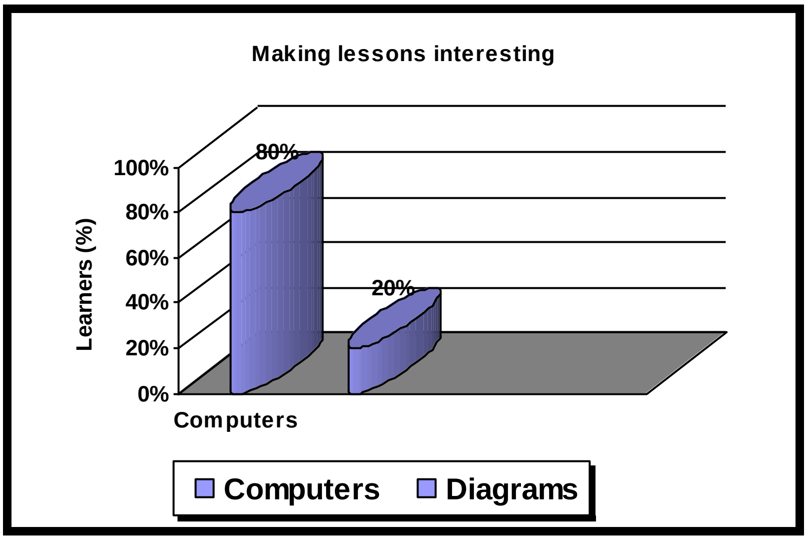


Figure 25: Learners' Choice of Making Mathematics Lessons Interesting

Learners who noted that mathematics lessons can be made more interesting by using the computer responded in the following manner when asked this question:

- The use of more computers; we can learn more at a faster pace and it will be more fun
- It would be better if we did more practical activities or if we used computers
- Using computers to draw pie graphs and bar graphs etc.
- By using computers; to draw bar graphs and pie charts

Question 3: Do you use what you have learnt in your maths class in everyday life? How?

All the respondents (100 percent) stated that the mathematics that is learnt in class is used in daily life in the following ways:

- Buying from a shop
- Baking and cooking
- Money matters example budgeting
- Selling a product
- Family budget

Question 4: What job would you like to do when you complete your studies? Why did you choose this job?

The choice of professions that the learners hoped to pursue was diverse and included engineer (40 percent), medical (30 percent), accountant (10%), biologist (10 percent) and quantity surveyor (10 percent). The reason for the choice of the profession was because the majority of the learners found the job interesting.

Question 5: Do you think you need mathematics for this job? Why?

All the participants (100 percent) agreed that mathematics was necessary for the job that they chose.

Question 6*:* Would the job require you to be able to use a computer? Why or how?

Every learner (100 percent) responded that the job they will follow requires them to be able to use a computer. The responses were:

- Computers give you information about net access.
- With new technology I will need to use a computer for certain scans.
- To draw.
- You use a computer to do x-rays.
- To calculate people's budget.
- For documents, e-mails, etc.
- You can even visualise the object, how it is going to look.

4.6.2.3 SECTION C: QUESTIONS ON DATA HANDLING

When attempting this question learners' pre-knowledge was very important. In any investigation in mathematics there are several prerequisites before learners are involved in the lesson proper. The first step is to elicit the learners' prior knowledge. In the data handling aspect it is important for learners to be able to translate everyday situations into a mathematical context and by using the survey method they will be able to do this.

Question 1: You want to help the tuck-shop make a selection of cool drinks to sell. What would be your first step? Why would you start with this first?

The response to this question is set out in table 17 where it was noted that 80 percent of the learners answered correctly that a survey would be the first step.

Table 17: Response to Question 1

Response	Percentage of learners
Survey	80%
Taste	10%
Wholesaler	10%

Question 2: How could you represent this information in the form of a diagram?

The learners responded to this question by choosing three different types of answers. This is of interest as two of the responses are graphs and the other a mind map. The information in the graph in Figure 26 shows the number of learners and their choice.

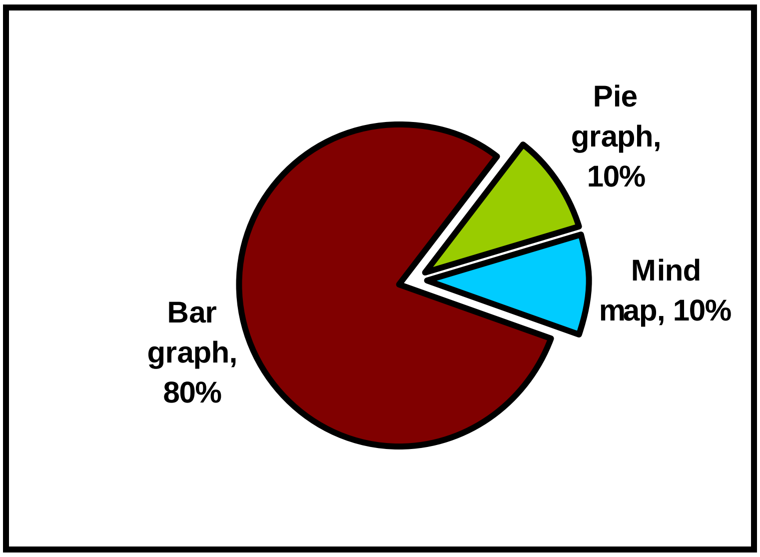


Figure 26: Learners Response to Question 2

Question 3: Which type of graph is easy to draw and understand? Why?

In response to this question 90 percent of the learners chose the bar graph as being easy to draw and understand while 10 percent chose the pie graph. The response of the learners for choosing the bar graph is:

- Bar graph; you can get the answer just by looking at the tallest bar
- The bar graph; it is simple to draw and displays the answers more specifically
- A bar graph; it is simple and you could see your data easily without using different methods
- Bar graph; easier to do and understand
- Bar graph; it is very easy because you just have to look at the bars and you probably get the answer
- Bar graph; because you do not need a protractor and need to measure in degrees

Question 4: Which type of graph is difficult to draw and understand? Why?

It was found that 80 percent of the learners found that the pie graph was difficult to draw and understand while 20 percent felt that the histogram was a difficult graph to draw and understand.

- Pie graph. Because you have to first find degrees and then form an angle with a protractor and calculate the percentages on the graph
- The pie chart. To draw the pie chart you need to know angles of each total and the pie chart is not very specific
- Pie chart. There are too many measurements involved
- Pie chart. Because of the measurement of the angles
- Pie chart. You need to know the degree
- Pie chart. Easy to understand but hard to draw. A lot of stationary and measuring will be needed
- A pie chart. It involves a lot of methods to work out degrees and percentages

- Pie graph. You have to measure angles, which is not hard but can be confusing when numbers are close

Those learners who chose the histogram as being difficult to draw and understand gave the following explanations:

- Histogram. Because it shows you two bars
- Histogram. You usually confuse it with a bar graph

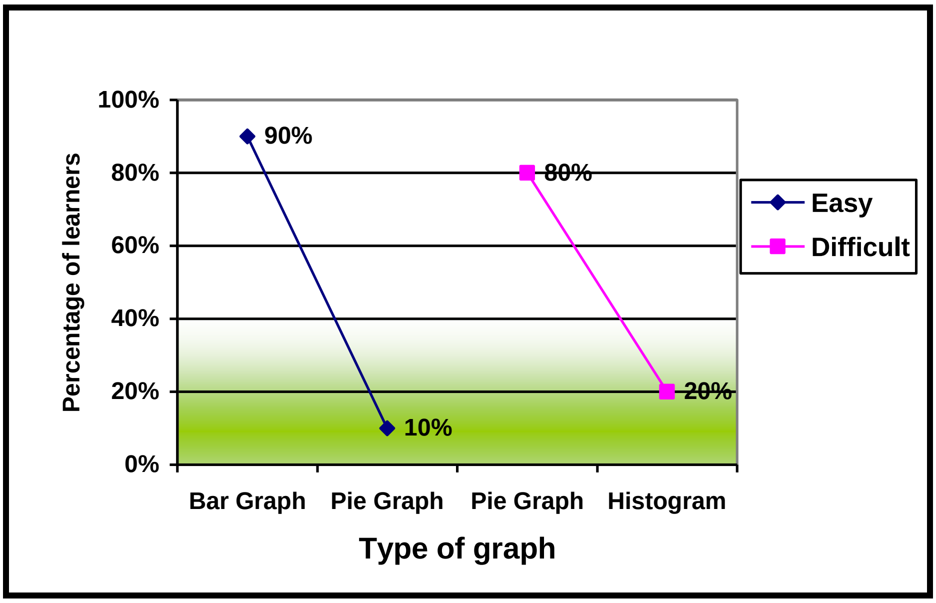


Figure 27: Types of Graphs that are Easy and Difficult to Draw

Question 5: Do you think graphs are an important aspect of mathematics? Why?

The response to this question was that 90 percent of the respondents stated that graphs are an important aspect of mathematics while ten percent was not in total disagreement but showed uncertainty and stated that they were unsure. The reasons for the choice of graphs being an important aspect of mathematics forwarded by three of the respondents are:

- It helps with controlling your data and simplifies your surveys.
- You can use it to record information and read it easily.
- Graphs show percentages and amounts in an easier and more understanding way especially in maths.

- You can use it to record information and read it easily.

Question 6: If you had a choice of drawing a pie graph by hand or using the computer which method would you use? Why?

The response to this question was that 90 percent of the learners chose to use a computer to draw a graph while 10 percent opted to draw the graph by hand.

Analysis of the question suggests that learners prefer to use the computer to draw graphs for the following reasons:

- Because it has software called paint which you can use to draw circles more easily and also draw straight lines.
- The computer will draw an accurate graph as long as you key in the correct information. It can also give other information that you don't have to calculate.
- Because you can make so many mistakes drawing a pie chart with hand and by computer it's easy. You can also make mistakes when you have to calculate.
- You don't have to colour or draw, just type the information in excel.
- It will help you to do it faster and accurate.
- You can get all the important information example average, mean etc.

The following is the justification put forward by the learner who chose to draw graphs by hand:

> Drawing it by hand. When we draw it, it will be better to understand and we can learn more. Everywhere we go is not going to have computers. So it is better to learn how to do it ourselves even though it is much easier on a computer.

The learner who responded that he would prefer to draw a graph by hand rather than use a computer showed a concern for the availability and accessibility of computers. Mention of this regarding the use of computers at schools was discussed in chapter 2. For the purpose of this study it was found that in the province of KwaZulu-Natal 16,6 percent of the schools had computers while 10,4 percent of schools used computers for teaching and learning (DoE, 2002:14). Of the 9 provinces KwaZulu-Natal was placed seventh nationally for both availability and learner use of computers.

4.6.3 SYNTHESIS OF INTERVIEW

Several issues were raised during the interview session with the learners that brought forth many view about the use of computers and its application in mathematics and data handling. The following issues are relevant and have surfaced in the interviews:

- Mathematics is one of the favourite subjects of the learners
- Learners are enthusiastic about using computers in the mathematics class. This confirms an established trend that is prevalent throughout this study
- It is evident from the response to the questions on data handling that some of the challenges experienced by the learners deal with their understanding of pie graphs
- Learners are aware of the importance of graphs in everyday situations

4.7 CLASSROOM OBSERVATION AND DISCUSSION ON ERRORS

Deep analysis of learners' errors involved the examination of learners' written work and discussion of the work, in which the learners explained their answers and clarified their errors. A study of the literature revealed classifications of common mistakes and this was used to analyse the errors made by the learners. The description of common errors involved three broad categories being arbitrary errors, executive errors, and structural errors as mentioned by Donaldson (1963:185-202) and Orton (1983:1-8).

It was possible to distinguish errors as those reflecting common errors by using the categories of errors that are commonly identified in the literature as a template. A sample of questions chosen from the test was used to illustrate the types of errors students made. The analysis of selected questions as seen in Table 18 revealed that executive errors and structural errors were the most common kinds of errors that learners made while dealing with data handling in mathematics.

Table 18: Classification of Errors

Classification of items	**Arbitrary Errors**		**Executive Errors**		**Structural errors**	
	Experimental	**Control**	**Experimental**	**Control**	**Experimental**	**Control**
ITEM 1: Tally Chart and Frequency	10%	20%				
ITEM 2: Conversion to Angles and Fractions				10%	10%	40%
ITEM 3: Drawing of Pie Graph			10%	20%	10%	30%
ITEM 4: Questions relating to Item 1	10%	20%	10%	20%	40%	70%

It can be noted that although both groups were identified as having made errors, there were more errors made by the learners in the control group. The reasons for this is explained in Table 19 which explains in some detail the errors made by the learners.

Table 19: Analysis of Results

Type of Error	**Items**	**Error or Misconception**
Arbitrary error	• What is the fraction of red pens represented in the pie graph?	Learner confused fractions with degrees or angles.
Executive error	• What is the sum of the two lowest frequencies? • What is the difference between the highest and lowest frequency? • Drawing of a pie graph.	Learner understands only part of the question by identifying the numbers but unable to work out the sum and the difference. Lack of understanding in drawing a pie graph.

Structural error	• Convert the frequency to the angles of a pie graph. • Convert the frequency to a fraction. • Drawing of a pie graph. • If we draw a circle twice the size of the one above will the percentage double? Explain. • Explain what would happen if you double the lowest number and halve the highest number.	The learner is unable to use the frequency to convert to angles. Failure of learners to understand and use the given formula in determining the angle of a pie graph. Lack of understanding in drawing a pie graph and difficulty in using a protractor in drawing the angles. Failure to explain that a circle is 360 degrees therefore the size will not change the angle. Lack of understanding of numbers that are doubled and halved may not add up to the total.

Scrutiny of a sample response shown in Figure 28 revealed the occurrence of arbitrary errors. The first instance (marked Sample A) is a clear case of a failure to abide by the constraints with respect to the fraction. The learner understood that the question required a fraction as the answer, but chose the incorrect fraction. The second sample (Sample B) shows that the learner was able to identify the correct fraction but when asked to simplify the fraction could not understand the concept of whole numbers in relation to fractions. Piaget's (1970) idea of assimilation and accommodation is inherent here.

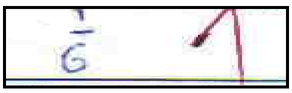
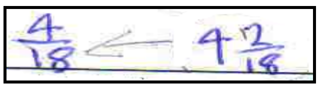
QUESTION: What fraction of red pens is represented in the pie graph?	
Sample A  	**Sample B** 

Figure 28: Samples Illustrating Arbitrary Error

In responding to the question on drawing of a pie graph Sample A and Sample B as shown in Figure 28 reveals that the errors were executive in nature. Although learners understood the nature of pie graphs they were unable to apply this in drawing an accurate diagram. Sample A revealed that the learner measured the angles incorrectly and when questioned about the error the learner proceeded to change the measurement of the red pens by encroaching into the other angles. Sample B revealed that the learner did not understand that the whole circle needed to be measured in order to complete the graph. In Sample C the learner identified the two lowest frequencies but did not answer the question by finding the sum of the two numbers. All these Samples revealed executive errors.

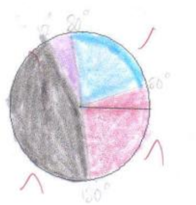
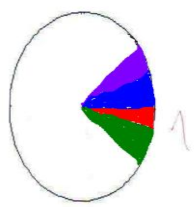
QUESTION: Using the information in table draw a pie graph.	
Sample A 	**Sample B** 
QUESTION: What is the sum of the two lowest frequencies? **Sample C** 	

Figure 29: Samples Illustrating Executive Error

Figure 29 illustrates a sample of structural errors made by the learners. Further analysis of the structural errors shown in Figure 22 reveals the learners lack of understanding of the problem. Samples A and B are examples of the inability of the learners to convert the numbers to angles. Learners show a lack of understanding of using the formula for conversion. Sample C and D expose the failure of the learners to understand that if numbers are changed through the process of halving or doubling then the total may change. Their lack of understanding in this regard reveals a surface approach to understanding.

QUESTION: Convert the frequency to the angles as shown in a Pie Graph.

Sample A

7	126°
5	90°
2	36°
4	72°

Sample B

6	6%
3	3%
5	5%
4	4%

QUESTION: Explain what would happen if you double the lowest number and halve the highest number.

Sample C

Black will be the lowest and the other colours will be the highest

Sample D

the lowest number will become the higher than the highest number that was halved.

Figure 30: Samples Illustrating Structural Error

In order to further understand the learners' approach to learning, understanding of the deep and surface approach to learning must be considered. The deep and surface approaches to learning describe what learners do when they go about learning and why they do it. The fundamental difference between the two approaches is that a deep approach to learning leads to learners aiming towards understanding, and a surface approach to learning is when learners are aiming to reproduce material in a test or examination rather than actually understand it. The study explored learners' approaches to the tasks as set out in Table 20 regarding the understanding of data handling. This offered a glimpse of their understanding of the task in terms of their approach to learning. The learners adopted two differing approaches to answering these questions. The first group adopted an approach where they tried to understand the whole picture and tried to comprehend and understand the questions. These learners were identified with adopting a deep approach to learning. The second group tried to remember facts contained within the question, identifying and focusing on only the given information. They demonstrated an approach that would be recognised as rote learning, or a superficial, surface approach. It is evident that the experimental group showed a qualitative understanding of the question whereas the control group could not explain beyond the routine knowledge of the topic.

Table 20: Classification of Errors

QUESTION	**DEEP LEARNING**		**SURFACE LEARNING**	
	Experiment Group	**Control Group**	**Experiment Group**	**Control Group**
5. If we draw a circle twice the size of the one above will the percentage double? Explain.	100%	70%	0%	30%
6. Explain what would happen if you double the lowest number and halve the highest number.	50%	20%	50%	80%

In examining the evidence in Figure 31, it is apparent that some learners are still operating at the surface level of competence. A sample of the responses showed that the learners failed to understand the reasoning behind the answer because the question was not based on the ability to memorise information. The answer to the questions required the learner to make use of evidence, inquiry and evaluation. In order to answer the question adequately learners had to delve into the deeper thought processes as defined by Piaget (1970).

QUESTION 5: If we draw a circle twice the size of the one above will the percentage double? Explain.

Sample A

Yes, It Changed the circle so the
number also have to change.

Sample B

Yes
If You have two circles You circles will be bigger

QUESTION 6: Explain what would happen if you double the lowest number and halve the highest number.

Sample C

we are swiping the biggest and smallest around

Sample D

The percentage will change if
you halve the biggest number and multiple
the lowest number

Figure 31: Sample of Deep and Surface Errors.

Question 5 dealt with understanding that a circle remains 360 degrees no matter how large or small it is. Here it was evident that thirty percent of the learners could not comprehend this as it was abstract in nature. The experimental group was able to answer this question effectively as they were able to interpret the information successfully. A possible explanation is that the learners in the experimental group were able to comprehend the information as they were introduced to the construction of the pie graph using the computer. They were asked to make the circle smaller and larger. This ensured that they understood the material and were able to relate to the question.

Question 6 required the learners to explain the scenario of doubling and halving in relation to given numbers as well as how this process affects the pie graph. It involved learning as an interpretive process aimed at understanding the application of learning in practical scenarios. The explanation by the learner who responded in Sample A is based on a narrow view of the detail. The learner provided a basic answer that by swapping the numbers the question would be adequately answered. The answer should have been that the smallest number is 3 and if this is doubled it would be 6. The largest number is 7 and half of 7 is 3,5. If the numbers were added the answer would not be 18 but would be 17,5 leading to an incomplete pie chart.

There was an emphasis among most learners that the question required a cursory explanation of the situation and as such the interpretation was very basic. A narrow view was evident with a lack of detail. The analysis of the findings revealed that in the case of the experimental group the use of the computer assisted learners in interacting with the questions by making sense of abstract concepts and comprehending information by visualisation. They were able to adequately answer the questions.

4.8 STATISTICAL ANALYSIS OF TESTS

The confidence level of both the control group and the experimental group was recorded as 95 percent.

Table 21: Statistical Analysis of Control Group

Control Group	Pre-test	Post-test	Pre-test-Post-test
Mean	67.60	72.20	-4.60
SD	18.44	15.80	4.23
N	20	20	20
Correlation	0.985877		
P value	0.4022		
t	0.8472		
df	38		

As evident in table 21 the two-tailed P value equals 0.4022. By conventional criteria, this difference is considered to be not statistically significant. It is therefore evident that the difference in the pre-test and post-test scores is not considerable. Furthermore, there is also a strong correlation of 0.98 between the pre-test and post-test score.

Confidence interval: The mean of Pre-test minus Post-test equals -4.60. There was a 95 percent confidence interval of this difference.

Table 22: Statistical Analysis of Experimental Group

Experimental Group	Pre-test	Post-test	Pre-test-Post-test
Mean	65.80	80.80	-15.0
SD	18.00	13.63	7.41
N	20	20	20
Correlation	0.927005		
P value	Less than 0.0001		
t	9.0497		
df	19		

P value and statistical significance: The analysis of the statistical data as revealed in table 16 discloses that the two-tailed P value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant. This shows that there was a marked difference in the scores that the learners obtained in the pre-test and post-test. There is a strong correlation of 0.92 between the pre-test and post-test.

Confidence interval: The mean of the Pre-test minus the Post-test equals -15.00. There was a 95 percent confidence interval of this difference: From -18.47 to -11.53.

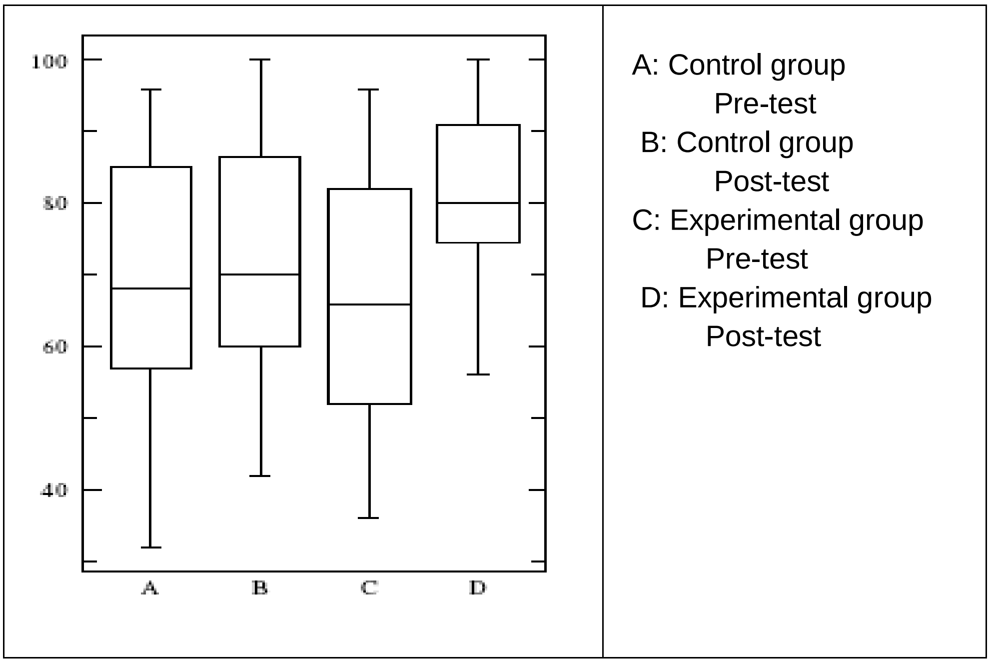


Figure 32: Box Plot of Test Scores

According to the above mentioned results, the performance of learners in mathematics can be influenced by the use of the computer. It is also reported that the computer intervention programmes led to a significant improvement in mathematics scores and a greater advance in the quality of academic performance.

Analysis of the pre-test and post-test scores of the experimental group shows significant correlation of 0.927. The strong correlation between the pre-test and post-test scores reflects the relationship between the concepts taught and the computer intervention aspect of the study. The intervention programme using the computer reflects upon the pre-knowledge framework of Davis (1984) which supports the use of representations in abstract situations. The analysis using the Spearman Rho test as set out in table 23 shows that there is a strong correlation between the pre-test and post-test scores of the experimental group. This is in keeping with the research literature of constructivism as proposed by Piaget (1970:23-80) and the Zone of Proximal Development of Vygotsky (1978: 124-156). The Mann-Whitney test was used to further analyse the distribution of the pre-test and post-test scores. The Mann-Whitney test is used to determine if there is a difference between two sets of data. Using the Mann- Whitney test in this study was a means of ascertaining if there was a significant difference between the pre-test and post-test scores.

Score A refers to the pre-test marks where pre-knowledge framework of Davis (1984:12-35) and the view of Piaget (1970) and constructivism applied. Score B is the post-test marks which was carried out after the intervention programme of the computer as espoused by Papert (1980; 1996). The differences in scores of the tests validate the argument that the computer intrinsically re-teaches the lesson and therefore there is an improvement in the scores. The theories of Vygotsky (1978), Piaget (1970), Papert (1996) and Davis (1984) support these findings. It can therefore be reported that the data is consistent with the theories.

Spearmans Rho (r_s)

Table 23: Results and Rank Differences –Experiment Group Tests

No.	Scores (A)	Scores (B)	Rank (RA)	Rank (RB)	Difference (D=RA-RB)	D^2
1	96	100	20	18.5	1.5	2.25
2	92	100	19	18.5	0.5	0.25
3	88	100	18	18.5	-0.5	0.25
4	84	100	16.5	18.5	-2	4
5	84	86	16.5	13.5	3	9
6	76	80	14.5	10.5	4	16
7	76	82	14.5	12	2.5	6.25
8	72	92	13	16	-3	9
9	68	76	11.5	7.5	4	16
10	68	88	11.5	15	-3.5	12.25
11	64	86	9.5	13.5	-4	16
12	64	76	9.5	7.5	2	4
13	60	76	7.5	7.5	0	0
14	60	80	7.5	10.5	-3	9
15	52	76	5.5	7.5	-2	4
16	52	74	5.5	5	0.5	0.25
17	44	70	4	4	0	0
18	40	58	2.5	2	0.5	0.25
19	40	60	2.5	3	-0.5	0.25
20	36	55	1	1	0	0
					$6\Sigma D^2$	**654**

Calculation

$$\boxed{r_s = 1 - \frac{6 \sum D^2}{N^3 - N}}$$

$r_s = 1 - (6\Sigma D^2 \div (8000-20))$

r_s = 0.918

Critical Values

- Critical Value 1: **0.45** (significant: r_s=0.918, N=20, p=0.05)
- Critical Value 2: **0.534** (significant: r_s=0.918, N=20, p=0.02)
- Critical Value 3: **0.591** (significant: r_s=0.918, N=20, p=0.01)

Although there is the assumption of normality, the Mann-Whitney tests as well as the t-tests confirm the difference between the two tests. Hence we find that the control scores are necessary to substantiate the argument of the results.

With reference to the post-test scores of the control group and experimental group it was found that since the control and experimental group did not exhibit normal distribution, once again the Mann-Whitney test was administered. There was a significant difference noted in the pre-test scores of the experimental group in relation to that of the control group.

Analysis of the attitude scores and the post-test scores of the experimental group was carried out so as to show the correlation between the two sets of variables. It was noted that there was a strong correlation between the variables which accounted for the positive correlation co-efficient of 0.84. It was therefore evident that the learners' positive attitude towards the use of the computer in the mathematics class is a motivating factor in improving the scores of the tests.

It can therefore be noted that the learners' attitude towards the use of the computer in learning data handling and the increase in the post-test scores reflects the value of computer-assisted learning in mathematics. Traditional teaching in mathematics is not less emphasised as there was also an increase in the post-test scores of the control group which leads to the teaching of Davis (1984) who also agrees that if the pre-knowledge frame is elaborate the new concepts to be taught will be better understood.

4.9 SUMMARY OF THE CHAPTER

Data analysis from this study of the use of computer aided learning with reference to bar graphs and pie graphs in mathematics in grade seven resulted in an in depth understanding of the impact of technology integration in the mathematics class.

Data collected from all sources: questionnaire, interviews, and activities on bar graphs and pie graphs indicated:

- renewed excitement for learning

- increased student engagement in mathematics
- collaborative learning
- frequent technology use and integration improves the quality of learning

These consistent findings are strong indicators of the successful use of computers in education in general and in mathematics education in particular. This study contributes to the understanding of learners with reference to:

- level of thinking
- attitude to mathematics
- technology development

Research results revealed that many grade seven learners were successful in using the Microsoft Excel programme in dealing with the graphical representation of bar graphs and pie graphs. There was also a marked level of reasoning which contributed to deep learning. Given the effectiveness of this programme and the need to better develop teachers abilities to integrate technology, replication of this programme is warranted.

Chapter Five will deal with the summary of the study. The findings of the research will be presented and recommendations suggested for further research. A brief synopsis of the research will be expressed.

CHAPTER FIVE

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents an overview of the study as well as a summary of the findings. Findings, recommendations and conclusions in relation to the research question are explained. Conclusions are drawn from both the literature study and empirical research. Recommendations emanating from the study are then made into a formal proposal that can be useful in laying a foundation for the teaching and learning of bar graphs and pie graphs in grade seven by using a computer-assisted model. For the improvement of the quality of mathematics education in grade seven various suggestions are proposed. Some limitations and constraints of the study are provided. Recommendations for future research in improving the quality of mathematics education are also suggested.

5.2 OVERVIEW OF THE STUDY

The purpose of this study was to seek definitions of and evidence for the use of computer aided learning in mathematics. Further to this was the quest to identify means of improving the quality of learning mathematics. This was achieved through the use of the techniques of conceptual analysis and data collation. The analysis showed how each of the constructs had been defined and used in the literature to this point.

The literature review sought to highlight the theoretical framework for this study. Related theories relevant to the study were identified and discussed. This study was based on both qualitative and quantitative design elements so as to form a more comprehensive collation of information.

5.3 SUMMARY OF FINDINGS

5.3.1 Main Findings

The main finding of the study is based on the two research questions. The following sections list each of the research objectives for this study and describe how each of the objectives was fulfilled.

5.3.1.1 Research question 1: What are the learners' attitude towards conventional methods of data handling and computer-supported activities?

Pursuit of the first research question resulted in both expansive and simplified definitions for each construct. Research result of this question showed that integrating technology into mathematics instruction can promote learners' attitude towards mathematics in a positive direction. From this study it was found that learners in the experimental group showed a marked difference in their attitude towards mathematics. It was evident in the experimental group questionnaire (Section B, question 1) that 100 percent of the learners stated that computers make work easier. Based on this it may be necessary for future efforts to focus on designing mathematics activities which will encourage learners' to engage in mathematics.

From the study it is proved that learners have a positive outlook towards mathematics after computer-assisted mathematics education was used. The results of this study illustrated that learners in the experiment group were aware of the usefulness of mathematics as well as technology in daily life. There was the general consensus amongst learners that teachers cannot be replaced by computers. However the data from the survey also indicated that learners do not want to receive mathematics lessons in the traditional method; there were a large number of learners who proposed that more lessons be carried out using the computer.

5.3.1.2 Research Question 2: Do computer aided lessons in data handling in mathematics improve the scores of learners?

Firstly, mention must be made of the statistically significant gain in content knowledge that was shown by the learners in general from the beginning of the unit of study to the end. The specific cause of the gain could be attributed to any number of factors, including, but not limited to, the use of computers. The findings in chapter two qualify this statement and Figure 20 bears testament to the increase in mean scores as indicated in the post-test. It could be argued that this finding does not necessarily mean that the use of computers alone caused the improvement. However the finding is consistent with prior studies suggesting the effectiveness of technology use in general in mathematics classes as mentioned in the literature review in chapter four. It also confirms that the effective use of computers by teachers of statistics in a grade 7 class is a contributing factor towards a quality education.

Secondly, it was noted that the role of the teacher in the decision-making process relating to methodology is vital. This means that the teacher's knowledge and willingness to enter into the new realm of teaching using technology will either augment or hamper learners' progress towards quality education. The TPCK models as discussed in chapter two (Figures 3; 4 and 5) is at the heart of this aspect of the study. There is general consensus by all of the researchers of the TPCK model that technology is seen as a tool to creating a positive learning experience but the inclusion of all three components of the model (technology; content and pedagogy) must integrate so as to provide meaningful quality education.

Thirdly, indicators of prior achievement were imperative in determining the level of cognition of the learners. This is based on the theory of constructivism which supports the notion that new learning is founded on what has formerly been learnt. It was found that the learners were operating at the formal operational thought stage of constructivism (Piaget: 1970) suggesting that the learners were now no longer dependent upon concrete experiences for their thinking and learning. It was found that 90 percent of the learners in the experimental group were operating at the acceptable level of experience whereas in the control group 70 percent of the learners were at the same level.

The data also suggest that all learners who had lower pre-test scores in the experimental group significantly improved their post-test score. The implication is that the approach used was effective for all learners. The scores exhibited non-normal distribution. However to overcome discrepancies normal and non-normal distributions were used. The t-tests and Mann-Whitney tests were used to show the improvement in scores between the pre-test and post-test of the experimental group. It was found that there was a strong correlation between the pre-test and post-test scores in the experimental group. The histogram reveals that the experimental group scored higher than the control group in both post-tests. Although there was assumed normality for both groups there was significant differences in the scores between the control group and experiment group. An interesting and positive result of this study was that learners from both groups made gains in the post-test; but there was significant difference in gain between the two groups in the post-test. From the study it was evident that the intervention of the computer resulted in significant difference in the post-test scores between the experimental group and the control group. The results have indicated that the intervention of the computer has had a significant impact upon the scores of the learners in the experimental group.

There has been evidence of deep learning of the experimental group. In relation to this it was found that 75 percent of the learners in the experimental group were operating at the deep level of understanding as compared to 45 percent of the control group. This also reinforces the part played by the computer intervention in terms of improving the thinking process of the learners. Against this background the issue of errors helps to contextualise the level at which learners in the experimental group were thinking. In order to frame any discussion on the errors made by learners' distinction must be made concerning the types of errors. The first type of error is arbitrary errors. Here it was found that a small percentage of learners made these errors (10 percent of the experimental group and 20 percent of the control group). The second type of error is executive errors whereby the learner fails to perform the required manipulations. The analysis revealed that 10 percent of the experimental group and 25 percent of the control group made these errors. The third type of error is structural errors which occur when learners fail to understand the basic principle of a problem. The assessment of this type revealed that 30 percent of the learners in the experimental group made structural errors as compared to 70 percent of the control group. The frequency was that in both experimental and control groups a limited number of learners were involved in the first type although the second and third type involved more learners.

The study revealed that there was also a strong correlation between the attitude of the learners towards the use of computers in the mathematics class as well as the post-test scores of the experimental group. Therefore it is noted that the positive correlation can be attributed to the learners' attitude towards the use of the computer. This is consistent with the fact that the maximum use of computers improved the learning process.

The synthesis of these results concerning errors is important in ensuring that there is an awareness of the strengths and limitations of learners. This would help to establish an inclusive educational setting so as to provide for meaningful quality education.

5.3.2 Conclusions Garnered from the Findings

The following conclusions were reached following this study:

- Learners engaged in technology activities in mathematics have shown a greater conceptual understanding of mathematics
- Technology intensive instruction through the use of the Excel tool was well received by the learners

- Research result of this study showed that integrating technology into mathematics instruction can promote learners' attitude towards mathematics in a positive direction. From this study, learners in the technology-based group changed their attitude on the impact of computers in education
- Implications of this study are that an approach that included the use of Excel software can be a valuable cognitive tool for grade seven learners in general as they study statistics and data analysis

5.3.3 The Impact of Computer Assisted Instruction

At the conclusion of this study it was established that the computer assisted teaching introduced to the experimental group in the teaching of data handling is more effective than the traditional teaching which was applied to the control group. It was found that the theory of constructivism as proposed by Piaget has a bearing on this study. Learners who were involved in computer assisted learning showed a marked increase in scores. The statistical analysis of the test scores as indicated in Appendix J has verified this increase in scores.

5.4 LIMITATIONS OF THE STUDY

This section discusses the various limitations of the study. The basic question addressed here is to what extent one can trust the findings. Various research strategies used in the study are outlined and possible improvements are suggested.

The following are some of the limitations of this research:

- The case study was limited to one primary school. The computer skills of the students were not equal
- This study was administered to a small sample of learners
- The study did not use a multicultural framework

5.5 SUGGESTIONS FOR FURTHER RESEARCH

The first observation that needs to be clarified prior to suggestions being made is that data handling is an important aspect of mathematics that has not received its rightful place in the curriculum. Secondly, the inclusion of computer-aided lessons in mathematics will provide quality education. While this study has helped to clarify the use of computer-aided teaching in learning bar graphs and pie graphs in grade seven, there remain areas that need to be further explored and understood. These areas should prove fruitful for future research. More in-depth research needs to be carried out so as to determine the validity of the study. It has been found that if the same observations are recorded using a different group of participants under different circumstances then the study is deemed to be reliable. There was no basis for this as the sampling was random. However a 95 percent confidence level was used in the statistical analysis which is an acceptable level of validity.

Further studies in the following areas are recommended:

- The incorporation of computer-aided education in mathematics at other primary schools
- Establishing the learners' attitude towards conventional methods of data handling and computer-supported activities in other primary schools
- Assessing the effective use of computer-assisted learning in other primary schools
- Evaluating effective software to be used by educators to enhance the teaching and learning of mathematics

5.6 SUMMARY OF THE STUDY

This study presented the groundwork towards the effective use of computer-aided learning as related to the learning of bar graphs and pie graphs. The study has focused on the learners' attitude towards conventional methods of data handling and computer-supported activities as well as how learners' data handling mathematical skills can be improved through the use of computer-supported programmes.

The focal point of the study was the perceived experiences that grade seven learners have in learning bar graphs and pie graphs. It is hoped that this study will help teachers to realise learner's experiences and concerns about the topic under discussion. The research has endeavoured to portray the experiences of the learners as well as their ability to use computer-assisted learning. The research has also identified some teaching methods that can be applied in classrooms to ensure active and motivated learning of data handling.

5.7 CONCLUDING REMARKS

The study has focused on the effectiveness of computer-aided teaching on the quality of learning data handling in mathematics in grade seven. It is hoped that this study will help teachers to realise learners' experiences and concerns about the topic in discussion. The research has attempted to describe the experiences of the learners, their strengths and weaknesses as well as their anxiety.

The research has identified an important teaching method that can be applied in classrooms to ensure active and motivated learning of data handling in mathematics. The research has also ascertained learners' problems with certain aspects of data handling.

This study serves as a catalyst for future research. In depth investigations involving classroom teachers and a larger sample group of learners would further define the effects of computer-aided teaching and learning in mathematics. Incorporating and studying these effects would also provide deeper insight into its influence on education in general.

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APPENDICES

APPENDIX A: DoE: PERMISSION TO CONDUCT RESEARCH

P. O. Box 504
Verulam
4340

12 November 2009

The Superintendent General
Department of Education
KwaZulu Natal

For Attention: Mr S. Alwar
Fax: 033 0418612

Sir

Permission to conduct research

I am presently pursuing my Master of Technology Degree at the Durban University of Technology. The focus of my study is the use of computers in enhancing mathematics teaching and learning. The topic for research is "The effectiveness of computer aided teaching on the quality of learning mathematics at a selected primary school". My supervisor is Professor R. Naidoo (Tel. no.0313732371).

I wish to seek the kind permission of the Department of Education to conduct research at Lotusville Pimary School in Verulam, where I am presently an educator. The invaluable assistance of the school principal and grade 7 learners is required.

The learners who participate in this study will do so voluntarily. In conducting this study I will ensure that normal learning and teaching will not be disrupted. Confidentiality and privacy will be maintained at all times.

You kind assistance in this matter will be appreciated.

Yours faithfully

Tel.(Home)	0325331456
Tel. (Cell)	0835079919
Fax.	0315059495
	0325332607

APPENDIX B: DoE: APPROVAL: PERMISSION TO CONDUCT RESEARCH

kzn education
Department:
Education
KWAZULU-NATAL

Enquiries:	Sibusiso Alwar
Date:	08/02/2010
Reference:	0016/2010

MS S ACHARY
29 GLENHAVEN DRIVE
VERULAM
4339

RESEARCH PROPOSAL: THE EFFECTIVENESS OF COMPUTER AIDED TEACHING ON THE QUALITY OF LEARNING BAR GRAPH AND PIE GRAPH IN A GRADE SEVEN MATHEMATICS CLASS AT PRIMARY SCHOOL.

Your application to conduct the above-mentioned research in schools in the attached list has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educator programmes are not to be interrupted.
5. The investigation is to be conducted from 08 February 2010 to 08 February 2011.
6. Should you wish to extend the period of your survey at the school(s) please contact Mr Sibusiso Alwar at the contact numbers above.
7. A photocopy of this letter is submitted to the principal of the school where the intended research is to be conducted.
8. Your research will be limited to the schools submitted.
9. A brief summary of the content, findings and recommendations is provided to the Director: Resource Planning.

...dedicated to service and performance beyond the call of duty.

KWAZULU-NATAL DEPARTMENT OF EDUCATION
POSTAL: Private Bag X9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa
PHYSICAL: [illegible] PIETERMARITZBURG, 3201
TEL: [illegible]

kzn education
Department:
Education
KWAZULU-NATAL

10. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Resource Planning
Private Bag X9137
Pietermaritzburg
3200

We wish you success in your research.

Kind regards

R. Cassius Lubisi (PhD)
Superintendent-General

Dedicated to service and performance
beyond the call of duty.

kzn education

Department: Education KWAZULU-NATAL

MS S ACHARY
29 GLENHAVEN DRIVE
VERULAM
4339

Enquiries: [illegible]

Date: [illegible]

Reference: [illegible]

PERMISSION TO INTERVIEW LEARNERS AND EDUCATORS

The above matter refers.

Permission is hereby granted to interview Departmental Officials, learners and educators in selected schools of the Province of KwaZulu-Natal subject to the following conditions:

1. **You make all the arrangements concerning your interviews.**
2. **Educators' programmes are not interrupted.**
3. **Interviews are not conducted during the time of writing examinations in schools.**
4. **Learners, educators and schools are not identifiable in any way from the results of the interviews.**
5. **Your interviews are limited only to targeted schools.**
6. **A brief summary of the interview content, findings and recommendations is provided to my office.**
7. **A copy of this letter is submitted to District Managers and principals of schools where the intended interviews are to be conducted.**

The KZN Department of education fully supports your commitment to research: **The effectiveness of computer aided teaching on the quality of learning bar graph and pie graph in a grade seven mathematics class at primary school.**

It is hoped that you will find the above in order.

Best Wishes

R Cassius Lubisi, (PhD)
Superintendent-General

APPENDIX C: LETTER TO PARENTS

Lotusville Primary School
58 Trevennen Road
Lotusville
Verulam
Tel: 0325332607

Dear Parent

Re: Informed Consent

I am currently pursuing a Master of Technology degree at the Durban University of Technology. My research is on *Using computer –assisted learning to improve the quality of mathematics.* The primary aim of this study is to improve the quality of your child's learning experience through the use of the resources available in the school's computer centre. Permission has been sought from the KwaZulu-Natal Education Department to conduct this study as part of the normal school program.

All lessons will be conducted in school during normal school hours. Furthermore the content of the lessons form part of the Grade 7 syllabus. In addition to being involved in the lessons your child will be required to answer a short questionnaire and participate in a brief interview based on his/her perceptions of the learning model.

Please note that participation in this study is voluntary. If you decide to grant permission for your child to participate you are free to withdraw your consent and discontinue participation at any time.

Thanking you

____

Ms. S. Achary

DECLARATION BY PARENT

I, ……………………………………………………………(full names of parent), hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to my child, ……………………………………………, participating in the research project.

I understand that I am at liberty to withdraw my child from the project at any time, should I so desire.

…………………………………………… ………………

SIGNATURE OF PARENT DATE

APPENDIX D: WRITTEN QUESTIONNAIRE

MATHS RESEARCH QUESTIONNAIRE

LEARNER'S QUESTIONNAIRE: GRADE 7

INSTRUCTIONS

FORM NUMBER		

- Please complete this questionnaire in blue ink.
- Read the questions carefully and answer as honestly as possible.
- Where a range of options is given, please tick through the relevant box or boxes. If you tick a box by mistake, please completely fill it then tick the correct answer.

Thank you for your careful attention to this questionnaire. We appreciate the time you are taking to help us better understand mathematics teaching and learning.

SECTION A: PROFILE

Tick the correct box

AGE:	11	12	13	14
MALE		FEMALE		

SECTION B: ATTITUDE TO COMPUTERS

STATEMENT	*YES*	*NOT SURE*	*NO*
1. Computers make work easier.			
2. Learning about computers is worthwhile and necessary.			
3. Working with computers makes me nervous.			
4. It is important to know how to use computers in order to get a good job.			
5. I wish I could use computers more frequently.			
6. Computers can replace teachers.			
7. A job using computers would be very interesting.			
8. Most jobs need people to be computer literate.			
9. Lessons done using a computer would be interesting.			
10. I think more maths lessons should be carried out using computers.			

1. Explain your choice of answer for question 6.

2. Explain your choice for question 9.

3. Explain your choice for question 10.

SECTION C: DATA HANDLING

1. UNDERSTANDING MATHS TERMS ON DATA HANDLING:

Before the lesson on Data Handling what was your understanding of the following terms?

1= you could explain to someone else easily.

2 = you think you understand, but might have trouble explaining to someone.

3 = you still don't understand the term well.

tally chart		estimate		handling data	
bar graph		fractions		gathering data	
percentage		calculate		surveys	
pie graph		solve problems		analysing results	
questionnaire		angles		presenting results	

2. I CAN DO THE FOLLOWING:

FUNCTION	*Yes*	*No*	*Don't Know*
1. Collect data			
2. Design a simple questionnaire in order to collect data			
3. Record data on a Tally chart			
4. Draw a Bar graph and double bar graph			
5. Draw a Histogram			
6. Draw a Pie chart			
7. Answer questions based on a bar graph			
8. Answer questions based on a pie chart			
9. Draw conclusions from findings			
10.Make recommendations from findings			

3. THOUGHTS ABOUT DATA HANDLING

	Agree	*Disagree*	*Don't know*
1. Drawing graphs are difficult.			
2. Graphs are easy to read.			
3. It is easy to answer questions when it is in the form of a graph.			
4. I can predict what can happen in the future by looking at information in a graph.			
5. I must be able to draw well to be able to draw a graph.			

4. POST- COMPUTER ACTIVITY

1. What did you learn from the computer activity?

___

___

2. Do you think that using the computer to learn about graphs is easier than using a worksheet? Explain.

___

3. Did you find the instructions on the computer easy to understand or was it difficult? Explain.

___

___

4. How would you rate the computer exercise? (5-excellent, 4-very good, 3-satisfactory, 2-fair, 1-poor? Explain

___

___

5. Complete the statement: I would like maths lessons more if ……. .

___

___

Thank you for taking your time to fill in the questionnaire

APPENDIX E: INTERVIEW QUESTIONNAIRE

GRADE 7: INTERVIEW QUESTIONNAIRE

PROFILE:

State your name.	
What is your age?	
Gender?	

SECTION A: SELF PERCEPTION

Question 1:

What is your favourite subject? Why do you like this subject?

Question 2:

What is your least favourite subject? Why do you not like this subject?

Question 3:

What is your favourite section in maths? Why do you like this section?

Question 4:

What is your least favourite section in maths? Why?

Question 5:

Do you think computers should be used more often to teach maths lessons? Explain.

SECTION B: QUESTIONS ON MATHS CURRICULUM

Question 1:

What was the most interesting activity that you did in maths this year?

What did you enjoy about this activity?

Question 2:

How can maths lessons be made more interesting?

Question 3:

Do you use what you have learnt in your maths class in everyday life? How?

Question 4:

What job would you like to do when you complete your studies? Why did you choose this job?

Question 5:

Do you think you need maths for this job? Why?

Question 6:

Would the job require you to be able to use a computer? Why/ How?

SECTION C: QUESTIONS ON DATA HANDLING

Question 1:

You want to help the tuck-shop make a selection of cool drinks to sell. What would be your first step? Why would you start with this first?

Question 2:

How could you represent this information in the form of a diagram?

Question 3:

Which type of graph is easy to draw and understand? Why?

Question 4:

Which type of graph is difficult to draw and understand? Why?

Question 5:

Do you think graphs are an important aspect of maths? Why?

Question 6:

If you had a choice of drawing a pie graph by hand or using the computer which method would you use? Why?

Thank you for your participation in this interview.

APPENDIX F: PRE-TEST

<u>GRADE 7: PRE-TEST: DATA HANDLING</u>

<u>STUDY THE TALLY TABLE AND ANSWER THE QUESTIONS</u>

A group of friends record the number of books that they read.

<u>1. Complete the TALLY TABLE:(5)</u>

Name	Frequency	Total	Degree
Sophie	~~1111~~ ~~1111~~ 11		
Pamela	~~1111~~ 1111		
Dhiren	~~1111~~ ~~1111~~ ~~1111~~		
Sipho	~~1111~~ ~~1111~~ ~~1111~~ 111		
Mark	~~1111~~ 1		

<u>2. Answer the following QUESTIONS:(10)</u>

1. What is the total number of books read by the 5 friends?

____

2. Who read the most number of books?

____

3. What is the difference in the number of books read by Dhiren and Mark?

____

4. Who read the least number of books?

____

5. If each book is read in one week, how long did it take Sophie to read her books?

____

6. If Pamela wants to read the same number of books as Sophie, how long will it take her?

____

7. Which 2 friends have read the same number of books as Dhiren?

____

8. What fraction of the total number of books did Sophie read?

____

9. What percentage of the total did Dhiren read?

____

10. The teacher has given the friends one week to reach a target of 65 books. How many more must each person read?

____

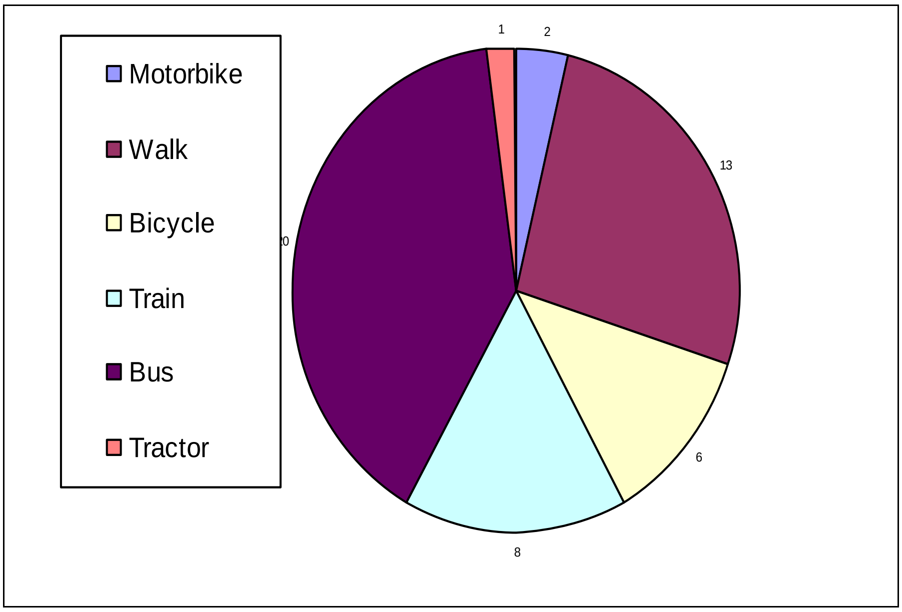
3. Using the information in the tally chart draw a BAR GRAPH:(5)

4. Using the information in the tally chary draw a PIE GRAPH:(5)

APPENDIX G: Post-test

Interpreting a Pie Chart

How Children in Year 6 travel to School



1. What percentage of children go by train to school?

___

2. What fraction of children do not walk to school?

___

3. How many children are in Year 6?

___

4. How many more children take the bus than the train, tractor or bicycle?

___

5. What is the difference between the number of children walking and taking the bus?

___

6. What fraction of children take the bus?

___

7. In term 2 a fifth of the children in Year 6 will take the bus. How many children will take the bus?

___

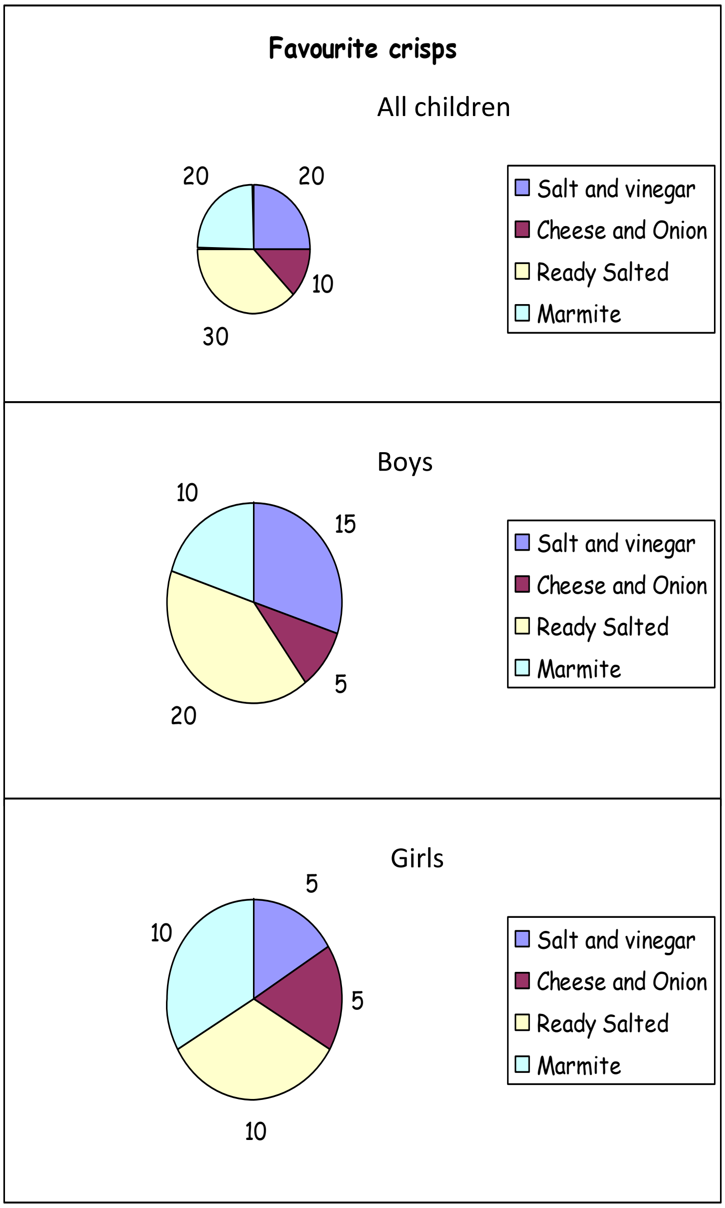
(7)

- Present this information this using a line graph. (3)
- Present this information using a bar graph. (3)

SURVEY : CHIPS

The children in grade 7 took part in a survey to find out their favourite crisps.

These pie charts show the results:



A) How many children took part in the survey all together?

B) What fraction of children preferred salt and vinegar?

C) How many children did not like Marmite? What fraction was this?

D) How many girls took part in the survey?

How many boys took part in the survey?

E) What fraction of boys liked Ready Salted crisps?

F) What fraction of girls liked Cheese and

onion crisps?

G) How many more boys liked ready salted crisps than girls?

H) What fraction of boys liked ready salted crisps more than girls?

I) What difference is there between the number of girls and boys who liked marmite crisps?

J) There are 100 children in grade 7 altogether.

How many children did not take part in the survey?

K) What fraction of grade 7 did not take part in the survey?

(12)

APPENDIX H: Interview: Errors

INTERVIEW: DATA HANDLING

QUESTION 1: Take 4 different coloured pens. Put them into a bag. Now select a pen and record the colour, then replace it in the bag. Repeat this 18 times recording the results in the tally chart below.

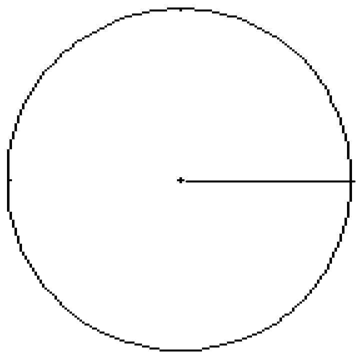
Tally Chart		
Pen Colour	Tally (2 EACH)	Frequency (1 EACH)
Blue		
Black		
Red		
Purple		
Total		

QUESTION 2

2.1 Using the information from the Tally chart complete the Table below.

PEN COLOUR	FREQUENCY (1 EACH)	CONVERSION	
		ANGLE (2 EACH)	FRACTION (2 EACH)
Blue			
Black			
Red			
Purple			

2.2 Now record your results in the pie chart below. Label, colour and write the details.



(8)

QUESTION 3

8. What frequency of blue pens did you select? (1)

____

9. What fraction of red pens is represented in the pie graph? (1)

____

10. What is the sum of the two lowest frequencies? (2)

____

11. What is the difference between the highest and lowest selection? (2)

____

12. If we draw a circle twice the size of the one above will the percentage double? Explain. (2)

____

____

____

13. Explain what would happen if you double the lowest number and halve the highest number. (2)

____

____

____

(10)

APPENDIX H: COMPUTER-BASED ACTIVITY

Basic Excel
Data input, chart creation and simple calculations

http://www.icteachers.co.uk/resources/resources_numeracy.htm

1. Open Microsoft Excel (it's in Handling Information)
2. When you have a new book sheet select B2 and type Jan 99
3. We are going to fill the columns to the right so that they go up in monthly steps. This can be done in two ways.

The easy way – left click and hold the black square in the bottom right-hand corner of B2 and drag it to F2 and drop. As you drag across you will see what Excel is going to put in the cells. It has assumed you are going up in months.

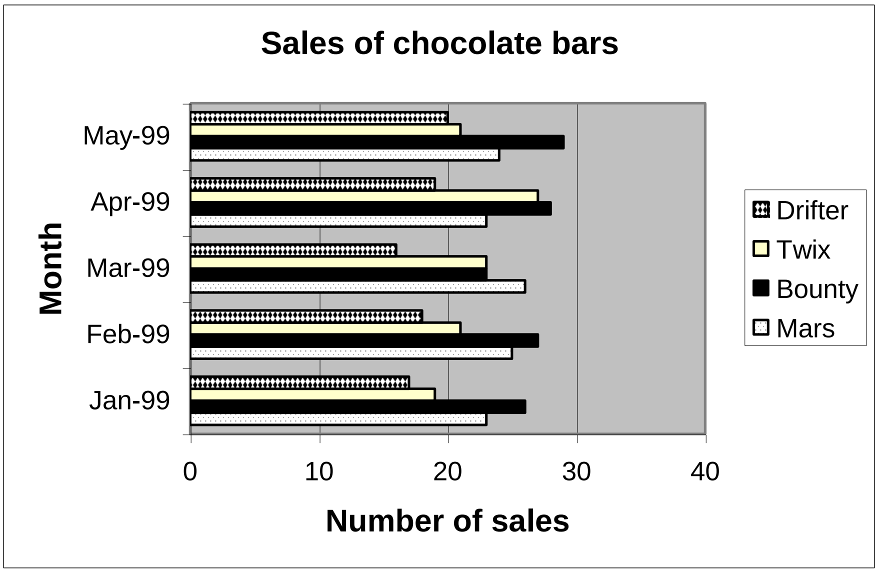
The harder way is to fill the cells using **Edit**. Highlight the cells B2 to F2 by dragging with your mouse OR using your **Shift** and cursor keys.

Then **Edit → Fill → Series →** select **Date -- Month → OK**

4. Select A3 and type Mars. When you press **Enter** it will automatically go down to the next cell. Fill in the chocolate information below into your sheet.

	Jan-99	Feb-99	Mar-99	Apr-99	May-99
Mars	23	25	26	23	24
Bounty	26	27	23	28	29
Twix	19	21	23	27	21
Drifter	17	18	16	19	20

5. We are going to create a selection of charts with this information. Highlight all the information. Click the **Chart wizard** button. Choose a column OR bar chart. Go through the series of questions and complete your title, x and y axis.



This is just one chart that can be created using the information.

6. You will have noticed that I have changed the patterns on the chart so that I can print it in black and white.
7. Now you have a go. Click one of the columns then click again. You should see a box come up. From here you can change the colour and fill pattern of the column. I have also changed the size of the font used by double clicking the writing and making it smaller.
8. The last thing to do is print your chart. You have two choices;

   ~ you can have a large chart on its own

   ~ you can have the table of information and the chart together

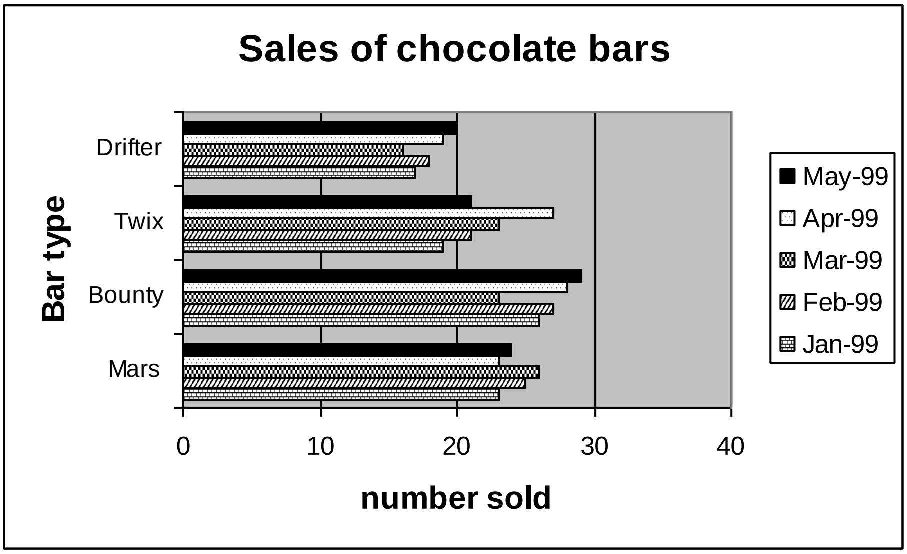
   If your chart has been selected it will have black squares around it. If you print now you will get a big chart.

   If you want the table and chart together you click the page to get rid of the black squares. If you print now you will get table and chart.

   You may notice that the table does not have any lines. You have to put these on yourself ~ if you want them! There's a handy little button that does that.

9. Now have a go at creating different styles of charts using the information in the table. The more times you do it the easier it becomes.
10. There is one last thing – You can change your chart to display the information in a different way. This is important as different questions can be asked of different charts.

Go back to your table. Highlight, as you did before, and begin to create a chart. When you click OK there is a page in the wizard (Data range) that asks you if you want the information in rows OR columns. We are going to select columns this time. Now finish the wizard as before and look at the difference in the two charts you have created.



See what I mean!!!

Now for some simply calculations

Sometimes the information you have collected is too detailed and you only need totals or averages. We are going to find the total number of chocolate bars sold each month.

If you look at your table you can work out what you have to do. You need to add the contents of each column. This can, of course, be done in a number of ways.

1. Select the cell B7. We are going to add B3, B4, B5 and B6 together. We need to tell the computer that we are going to calculate something so we type = in the cell. You will notice that the equals sign also appears in the formula bar. Now type the sum with NO GAPS.
2.
   =b3+b4+b5+b6 then press the **Enter** key. You get the answer 85
3. Second way ~ Select the cell B7. Type = then click each of the cells you want added in turn with + in between. As you do this they appear in the formula bar. Then press **Enter.**
4.

5. Third way ~ Highlight the information you want to add then click the **Autosum** button Σ. The sum is done for you.
6. Fourth way ~ type in a shorten version of the sum. =sum(B3:B6)

I know there are a lot of different ways BUT you choose which ones you can use personally AND in class with the pupils.

7. Once you have completed one column you can do all the others by selecting B7 and dragging the formula across the bottom of the other columns. As you drag you will see Excel changes the information for the different columns.
8. Now the last calculation ~ we are going to average the rows. This will tell us the average monthly sales for each chocolate bar. Select G3 and type =average(B3:F3) and press **Enter.** This works out the average of all the cells between B3 and F3. Once you have entered the formula you can drag and drop it for the other rows.

	Jan-99	Feb-99	Mar-99	Apr-99	May-99	**Average**
Mars	23	25	26	23	24	**24.2**
Bounty	26	27	23	28	29	**26.6**
Twix	19	21	23	27	21	**22.2**
Drifter	17	18	16	19	20	**18**
Total	**85**	**91**	**88**	**97**	**94**	