The effect of using a Computer Assisted Instruction on teaching Circle Geometry in Grade 11

by

Lovejoy Comfort Gweshe

submitted in accordance with the requirements for

the degree of

MASTER OF EDUCATION

In the subject

MATHEMATICS EDUCATION

at the

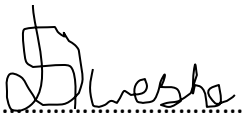
University of South Africa

Supervisor: Dr Joseph J Dhlamini

December 2014

Declaration

I declare that the project *"The effect of using a Computer Assisted Instruction on teaching Circle Geometry in Grade 11"* is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.



2014-12-05

…….. ……

SIGNATURE

MR L. C. GWESHE DATE

Dedication

I would like to dedicate this dissertation to the following people:

- My mother Ivy;
- My wife Melody; and,
- My son Nigel and daughter Nobuhle.

Acknowledgements

Thank you to Dr Joseph J Dhlamini, my supervisor, for his guidance throughout the dissertation process. I am very grateful to his support, encouragement, and patience with me as I went through this journey.

Thank you to Dr ZMM Jojo, Prof L Kaino, Prof N Planas, Dr S Ijeh, Dr R Paulsen, and all my colleagues. Your questions, comments, suggestions, wisdom, and assistance were greatly appreciated.

Thank you to my wife, son, daughter, father, late mother, and three sisters. Without you all, I would not have emotionally managed to complete this qualification. You gave me the strength to carry on when times were tough.

Thank you to the Department of Basic Education (DBE), school principals, the computer laboratory technicians, the computer laboratory assistants, teachers, participant learners, their parents, and everyone else who had a hand in assisting me to carry out this study.

Abstract

South African learners continue to perform poorly in high school Circle Geometry. Lack of learner confidence and motivation in Mathematics may be the contributing factors to the low success rate in Circle Geometry. These factors, coupled with Conventional Teaching Instructions (CTI), may have contributed to the significant reduction in the number of learners enrolled for Mathematics, and provided a rationale for the study that explored a possible alternative teaching pedagogy to motivate and eventually improve learner performance in Circle Geometry. The study aimed to investigate the comparative effects of Computer Assisted Instruction (CAI) and CTI on the performance and motivation of Grade 11 learners in the topic of Circle Geometry. The population of the study consisted of Grade 11 Mathematics learners from 65 secondary schools in the Ekurhuleni North District of Gauteng province in South Africa. Using convenience sampling techniques two schools with n=136 Grade 11 Mathematics learners and two teachers participated in the study. One school formed the experimental group (n=71) and the other school formed the control group (n=65).

The study followed a quasi-experimental design with a non-equivalent control group approach consisting of pre-and post-test measures. Intact classes participated in the study as it was not possible to randomly select participants for the study. Both groups wrote a standardised achievement pre-test to ascertain their performance status at the beginning of the study. CAI was implemented in the experimental school while CTI was implemented in the control school. A similar post-test was administered on both groups to measure the comparative effects of each teaching method on the performance of learners. A questionnaire was also administered to both groups to measure the motivation of learners. A purposive sample (n=12) was selected from both groups to participate in semi-structured interviews to account for the results of the test and the questionnaire. A socio-constructivist theory framed the study. Analysis of Covariance (ANCOVA) was used to analyse data. The results of this investigation indicated that the use of the computer software, GeoGebra, in the teaching and learning of Circle Geometry improved the performance and motivation of Grade 11 learners.

Key terms

Computer Assisted Instruction

Conventional Teaching Instructions

Geometry

Motivation

Abbreviations

ANCOVA	Analysis of Covariance
CAI	Computer Assisted Instruction
CAPS	Curriculum and Assessment Policy Statement
CITEd	Centre for Implementing Technology in Education
CTI	Conventional Teaching Instructions
GDE	Gauteng Department of Education
DBE	Department of Basic Education
DoE	Department of Education
HG	Higher Grade
H_O	Null Hypothesis
H_1	Alternate Hypothesis
HOD	Head of Department
NCS	National Curriculum Statement
NCTM	National Council of Teachers of Mathematics
NSC	National Senior Certificate
SES	Socio-Economic Status
TREs	Technology Rich Environments
UNISA	University of South Africa

TABLE OF CONTENTS

Chapter One: INTRODUCTION 1

1.1 Background 1
1.2 The problem statement 3
1.3 The aim of the study 5
1.4 Objectives of the study 5
1.5 Research questions 5
1.6 The rationale of the study 5
1.7 The significance of the study 6
1.8 Definition of key terms 7
1.8.1 Computer Assisted Instruction (CAI) 7
1.8.2 Conventional Teaching Instructions (CTI) 8
1.8.3 Geometry 8
1.8.4 Motivation 8
1.9 Limitations of the study 8
1.10 The organization of chapters 9

Chapter Two: REVIEW OF LITERATURE 10

2.1 Introduction 10
2.2 Research on the use of CAI in Mathematics classrooms 10
2.2.1 The role of CAI in Mathematics lessons 10
2.2.2 Integrating CAI in Mathematics lessons 12
2.2.3 Mixed results in the use of CAI in Mathematics classrooms 13
2.3 Motivation and Computer Assisted Instruction in Mathematics lessons 15
2.4 Other factors affecting CAI use in the classroom 17
2.4.1 The influence of the teacher on CAI 17
2.4.2 Learning space, heterogeneous groups, and digital divide 17
2.4.3 Globalization and Mathematics instruction 18
2.5 Educational goals and CAI in Mathematics lessons 19
2.6 A theoretical framework for the study 20
2.6.1 The constructivist perspective 20
2.6.2 Socio-constructivism 22
2.7 Summary and conclusion of the chapter 25

Chapter Three: RESEARCH METHODOLOGY 26

3.1 Introduction 26
3.2 Research hypothesis 26
3.3 Research design for study 27
3.4 Population and sample 29

3.4.1 Description of the population 29
3.4.2 Sampling techniques 29
3.4.3 The study sample 30
3.5 Instrumentation 31
3.5.1 A Circle Geometry test 31
3.5.2 The questionnaire 33
3.5.3 Semi-structured interviews 34
3.6 Assessment of measurement properties 35
3.6.1 Reliability of the test 35
3.6.2 Reliability of a questionnaire 36
3.6.3 Reliability of semi-structured interviews 37
3.6.4 Validity of the test 37
3.6.5 Validity of a questionnaire 37
3.6.6 Validity of semi-structured interviews 38
3.7 Ethical considerations 39
3.8 Data collection 39
3.8.1 The pilot study 39
3.8.2 The main study 41
3.9 Data analysis of the main study 41
3.9.1 Data collected from the test 41
3.9.2 Data collected from a questionnaire 42
3.9.3 Data collected from the interviews 42

Chapter Four: DATA ANALYSIS 43
4.1 Introduction 43
4.2 Data analysis for the pilot study 44
4.2.1 Testing the Mathematics performance null hypothesis and alternative hypothesis for the study 44
4.2.2 Computing the reliability of the achievement test from the pilot results 45
4.2.3 Reliability of the questionnaire 47
4.2.4 Validity of semi-structured interviews 51
4.3 Data analysis for the main study 52
4.3.1 Data analysis for test scores 52
4.3.2 Data analysis for the questionnaire 56
4.3.3 Data analysis for the interviews 58
4.4 Summary and conclusions of the chapter 61

Chapter Five: DISCUSSION AND CONCLUSION 62
5.1 Introduction 62
5.2 Summary of literature review 62
5.3 Findings 63

5.3.1 Research question 1 63
5.3.2 Research question 2 64
5.3.3 Research question 3 65
5.4 Conclusions 67
5.5 Recommendations 67
5.6 Summary and conclusion of the chapter 68

6. REFERENCES 70

7. APPENDICES SECTION 77

List of Figures

Figure	Title	Page
2.1	Socio-constructivism in a Circle Geometry lesson	24
4.1	Computation of the t-test value	45
4.2	Steps to compute the reliability of the Geometry test for the study	46
4.3	Results of participants' levels of motivation in a double bar graph	57

List of Tables

Table	Title	Page
1.1	Provincial performance in Mathematics: 2009 – 2011	4
4.1	Pilot study questionnaire responses	48
4.2	Computing the reliability of questionnaire items	50
4.3	Mean and standard deviation of pre- and post-test scores in both groups	53
4.4	Analysis of covariance to analyse test scores in the main study	54

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

In the modern era the teaching and learning of Mathematics has been considered to be largely teacher-centred (Slattery, 2006). However, the postmodern era has brought with it alternative ways of teaching and learning Mathematics that are learner-centred (Slattery, 2006). Teachers now have a variety of teaching methods that they may use when teaching Mathematics. To this end, Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) have become an integral component of Mathematics education. In the current study CAI refers to a teaching and learning approach that incorporates the use of computers. Any other teaching method used by the teacher in the control group was termed CTI.

In Gauteng[1] province most learners are being gradually exposed to CAI in line with the Gauteng Department of Education's (GDE) five year strategic plan to improve Mathematics education through projects such as e-learning (GDE, 2010). Recently, a number of South African secondary schools in the townships[2] have received computers either through government programmes such as the Gauteng Online initiative (GDE, 2010) or through private sponsors. Programs have been installed into these computers including those that relate to Mathematics instruction.

However, the researcher believes that most schools in South Africa that are using technology, particularly computers, use it more and better in other subjects than in Mathematics at the moment. In particular, there is a paucity of research to suggest that the teaching of Circle Geometry at school level has been integrated with technology in South Africa. Furthermore, there is a lack of quality software and limited research on the

[1] Gauteng is one of nine provinces in South Africa.

[2] A township is an area in South Africa normally occupied by persons of non-European descent, especially blacks (Probyn, 2009).

effectiveness of computers as a teaching and learning tool (D'Souza, 2005). Geiger, Faragher, Redmond and Lowe (2008) after their study to investigate the effect of a Computer program in enhancing Mathematical modelling concluded that the role of technology rich learning environments in Mathematics was an area worthy of further research.

Technological innovation is affecting education, and Mathematics education in particular stands to benefit if the use of CAI in teaching Mathematics proves to be significant in improving learner performance and motivation. In Grade 11, a lesson of Circle Geometry is supposed to teach learners problem-based skills as it entails various geometrical problem scenarios that require learners to explore different problem solving approaches (UNISA, 2011a). A possible avenue for developing these problem-based skills in learners might be through computer interaction.

The "*One Laptop per Child Project",* which is a tentative idea from the Department of Basic Education (DBE) to supply each learner with a laptop, and the Thutong[3] website, are some of the highlights taking place in South Africa in line with the international trends towards an increasing technological awareness in schools (Brandt, 2010). In particular, there are a number of computer-linked Mathematics programs that have been designed to assist learners to develop problem solving abilities.

However, some of the questions that may be asked are:

- Are these programs providing better instructional options than the Conventional Teaching Instructions (CTI) (see also, Section 1.8.2)?;
- Will the computer programs improve teaching and learning of Mathematics?; and,
- What effect do computer programs have on learner performance and motivation towards Circle Geometry?

[3] Thutong is a Setswana word meaning place of learning.

Shann (2006) highlights that “computers and calculators are widely used in daily activities in this informationalised society; however Mathematics is the foundation of technology” (p. 35). What Shann (2006) is emphasising is that the advancement of technology is dependent on the development of Mathematics, and in the same vein, for Mathematics to develop it may require the use of technology, and computers in particular. Therefore these two areas of human development and emancipation are closely dependent on each other. Hence, for the learners in South African township schools to improve mathematically, they may require constructivism that uses a computer program as a learning tool (UNISA, 2011b).

Also, most of the learners in South Africa seem not to be motivated enough to take Mathematics, as evidenced by the small number of learners who do the subject in Grade 12 (see, Section 1.2). Beres (2011) points out that learners experience difficulties with content resulting in demotivation to learn Mathematics. However, in order to change learners’ negative views of failure and hatred of Mathematics, it is the teacher’s responsibility to provide instruction and a learning environment that may motivate them (Mansukhani, 2010). Complementing this view point, Hlalele (2012) argues that the creation of a learning environment that helps learners to feel successful regardless of failure is likely to enhance motivation and improve academic performance. In a study conducted by D’Souza (2005) on the effect of incorporating collaborative learning methods in a core first year Mathematics subject, learners pointed out that it was exciting and enjoyable to use computers in class. Therefore, CAI might be the teaching method that may motivate learners, leading to improved Mathematics performance.

However, Diamond (2012) argues that most of the times learners are more comfortable and knowledgeable in using technology than their teachers. This might be the reason why CAI implementation in schools is slow. In addition, there is a topical issue of the digital divide (Woolfolk, 2010), which may also determine how effective CAI can be utilised in South African township schools (see also, Section 2.4.2).

1.2 THE PROBLEM STATEMENT

In my experience as a Mathematics teacher I have observed that the number of learners who are taking pure Mathematics as a subject in Grade 10 to Grade 12 has been decreasing

recently. Many learners are opting to do another form of Mathematics termed Mathematical Literacy, since it is considered to be less demanding that pure Mathematics. For instance, evidence shows that the number of learners who wrote Mathematics in the Ekurhuleni North district[4] of Gauteng province in South Africa decreased from 5818 learners in 2010 to 3123 learners in 2011, and to 3110 learners in 2012 (Ngobese, 2013). These observations are also corroborated by similar statistics at the provincial level (see, Table 1.1).

Table 1.1: Provincial performance in Mathematics from 2009 to 2011

CANDIDATES	2009	2010	2011
Total wrote	39 688	33 763	28 605
Total achieved at 40% +	10 314	12 969	12 142
% Achieved at 40% +	26.0	38.4	42.4

Source: Cassim (2012)

As a high school Mathematics teacher I have observed that many learners who choose not to pursue Mathematics in the Grades 10, 11 and 12 have cited the Geometry component as an obstacle. With the recent re-introduction of Geometry in high school curriculum many learners seem to support the move to keep away from Mathematics, while those who choose to do Mathematics end up performing poorly due to the inclusion of the Geometry component in the examination.

Given this background, this study saw a need to explore teachers' instructional methods and learner motivation when addressing issues relating to the observed exodus of learners in high school Geometry classrooms. The idea that learners are enthusiastic about computers was explored in this study as an instructional avenue to address instructional issues of teaching Circle Geometry with the anticipation that this approach would elevate learners' motivation, and eventually attract more learners to do Mathematics. Hence the current study aimed to investigate the comparative effects of Computer Assisted Instruction (CTI)

[4] Ekurhuleni North is a district in Gauteng province, which is in South Africa.

and Conventional Teaching Instructions (CTI) on learners' performance in Grade 11 Circle Geometry, and also on their motivation to do Mathematics.

1.3 THE AIM OF THE STUDY

The aim of the study was to investigate the effect of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on the performance and motivation of Grade 11 learners in Circle Geometry.

1.4 OBJECTIVES OF THE STUDY

To achieve the aim of the study the following objectives were set out:

- **1.4.1** To teach Grade 11 Circle Geometry using Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI);
- **1.4.2** to measure the statistical significance of teaching Circle Geometry using CAI and CTI on the performance of Grade 11 learners; and,
- **1.4.3** to establish if Grade 11 learners' motivation levels were affected by using CAI or CTI in the topic of Circle Geometry.

1.5 RESEARCH QUESTIONS

The following were the over-arching research questions to guide the study:

- **1.5.1** How can a Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) be used in the teaching of Grade 11 Circle Geometry?
- **1.5.2** Is there a statistically significant difference in the average pre-test and post-test performance scores of Grade 11 learners taught Circle Geometry using CAI and those taught using CTI?
- **1.5.3** How does CAI or CTI affect the motivation levels of Grade 11 learners in the topic of Circle Geometry?

1.6 THE RATIONALE OF THE STUDY

The decreasing number of learners taking Mathematics in South African secondary schools and the poor quality passes in Mathematics over the years (Cassim, 2012; GDE, 2010;

Ngobese, 2013), provided a justifiable rationale to conduct this study . In addition, according to D'Souza (2005), there are not many technology-related research studies on Mathematics. Hence the researcher was of the view that a research that explored the use of Computer Assisted Instruction (CAI) had to be conducted to determine its effect on the performance and motivation of Grade 11 learners in the area of Circle Geometry. In South African secondary school Mathematics, few studies have been conducted on the topic of Circle Geometry, comparing CAI and CTI. Therefore, this study sought to fill this gap.

It may also be argued that technology in Mathematics education is still providing the drill and practice method resulting in learners only acquiring procedural knowledge while ignoring the acquisition of conceptual knowledge, through a constructivist approach (see also, Sections 1.8 & 2.6). In addition, some of the Mathematics computer programs may be of benefit to the learners while others may not, depending on factors such as the degree of difficulty, complexity and language. In this regard, it was the researcher's view that any computer program on Circle Geometry needed to be tested first for effectiveness and user-friendliness before it was introduced to learners. Berkhout (2010) argues for the conceptualisation of context, that is to say, modifying the South African classroom environment to accommodate CAI, and adjusting the way in which CAI is presented to suit the South African township secondary school scenario.

Also, the study was aimed at addressing an issue that is currently catching the interest and attention of young people, technology, and from which most sectors of life have benefited. Most importantly, Circle Geometry was recently re-introduced into the South African secondary school Mathematics curriculum. Therefore, this research further provided a useful avenue to explore an alternative approach to the teaching and learning of Circle Geometry in Grade 11 in South Africa.

1.7 THE SIGNIFICANCE OF THE STUDY

Given that most learners experience difficulties in obtaining correct solutions for geometric problems (Cassim, 2012; Chauke, 2013), the significance of this study lied in the fact that it was likely to introduce a computer-generated program to teach Circle Geometry using a constructivist approach that was learner-friendly, and was likely to motivate learners to

explore other approaches to geometrical problem solving. According to Mansukhani (2010), the creation and provision of the right "hands on" tools motivates learners to want to learn, in addition to building stronger connections to the taught concept.

From this perspective, this study was significant because it contributed to the body of knowledge in Mathematics education by adding another dimension to the existing empirical evidence on the influence of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on Mathematics performance and motivation of learners, as there seems to be mixed views on the subject (see, Section 2.2.3). Shoemaker (2013) also argues that there is little empirical research on the effect of technology on learner motivation.

Poor teaching methods, lack of learner motivation and material resources are some of the factors associated with secondary school learners' poor performance in Mathematics (Makgato & Mji, 2006; Mamba, 2012; Tachie & Chireshe, 2013). Therefore, the study contributed by investigating the effect of CAI and CTI on the performance and motivation of Grade 11 learners when the learning area of Circle Geometry was taught through a constructivist approach (see, Section 2.6.1) that used a computer program as a cultural tool (UNISA, 2011b); thus introducing learners to an alternative and possibly motivating teaching method in technological problem solving.

1.8 DEFINITION OF KEY TERMS

The following are operational definitions of key terms that were used in the study:

1.8.1 Computer Assisted Instruction (CAI)

A Computer Assisted Instruction (CAI) is the use of computers to interact instructionally with learners in the educational process (Ramani & Patadia, 2012). While interacting with computers, learners were expected to recognise and construct relationships between both new and old pieces of information, thus developing conceptual knowledge (Hiebert & Lefevre, 1986). The term Instruction in CAI meant that little or no interaction between the learner and the teacher was expected, thus allowing learners to create their own internal representational systems of Circle Geometry concepts. In this study a computer program

called GeoGebra was used as a tool to facilitate the teaching and learning of Circle Geometry in Grade 11.

1.8.2 Conventional Teaching Instructions (CTI)

For the purposes of this study, Conventional Teaching Instructions (CTI) are described as any teaching and learning techniques that are traditional and familiar to the teacher in the control school. This method should not have been influenced by the method of teaching or pedagogy that was implemented in the experimental group; therefore, the teacher in the control school was expected to continue to use his/ her everyday methods of teaching. Most teachers in South African secondary schools still provide learners with symbols, algorithms, and step-by-step instructions without explaining the reasons behind the steps, thus developing in learners, procedural knowledge (Hiebert & Lefevre, 1986). The terms teaching and instruction in CTI meant that the learners interacted with the teacher, and the teacher could give instructions during the learning process.

1.8.3 Geometry

Geometry is concerned with obtaining insights into shapes, the nature of space and visual phenomena (Malkevitch, 2013). Goldman (2007) describes Geometry as being concerned with quantitative relationships between collections of points.

1.8.4 Motivation

Woolfolk (2010) describes motivation to learn as the tendency to find academic activities meaningful, worthwhile, and try to benefit from them by putting quality effort. In other words, motivation may be viewed as a "productive disposition" described by Kilpatrick, Swafford and Findell (2001) as one of the five strands of Mathematical proficiency that builds learner diligence and self-efficacy. D'Souza (2005) defines motivation as perceptions about task worth, enjoyment, difficulty, and willingness to stay on task. Motivation can either be intrinsic (from within an individual) or extrinsic (from an outside source) (Beres, 2011). The type of motivation that is advocated for is one that lasts and helps learners to persevere when faced with the most challenging and difficult Mathematical problems, which is intrinsic motivation (Woolfolk, 2010).

1.9 LIMITATIONS OF THE STUDY

The current study was not without limitations. It is acknowledged that the research design followed in this study might have posed some challenges to the external validity of the study. A quasi-experimental design that was used in the study lacked random assignment of participants to experimental and control groups because intact classes were used. While the sample in the study might approximate the target population, caution should therefore be excersised when generalising beyond participants. Therefore, conclusions should not be extended beyond the Ekurhuleni North District, in which the experiment was conducted.

1.10 THE ORGANISATION OF CHAPTERS

Chapter 1 provides an introduction to the study. Mainly, this chapter is aimed at presenting the problem to be investigated. Also, the chapter provides the aim, objectives of the current study, research questions to be answered, and limitations of the study.

Chapter 2 provides a review of related literature for the study. The folllowing issues are discussed in Chapter 2: the influence of Computer Assisted Instruction (CAI) in Mathematics classrooms, the influence of CAI on learners' motivation in Mathematics classrooms; the theoretical framework for the study; factors affecting the implementation of CAI in the Mathematics classrooms; and, the exploration of educational goals in relation to CAI.

Chapter 3 provides a research methodology that was employed in conducting the current study. The chapter provides discussions on the population and sample of the study, the instrumentation process in the current study and sampling techniques that were followed to select the population and sample of the study, issues of reliability and validity, and finally ethical considerations.

Data collection is covered in Chapter 4, which provides a comprehensive discussion and techniques used to analyse data.

Chapter 5 constitutes the discussion of study results and conclusions made for the study. The discussion of results is presented in terms of the research questions and the theoretical framework of the study. Suggestions for future related research are also made in Chapter 5.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 INTRODUCTION

The literature was reviewed to determine the extent of the existing knowledge in relation to Computer Assisted Instruction (CAI), as well as the related research on the influence of CAI on the teaching of Mathematics, learners' performance, and motivation of learners. Furthermore, literature review helped the researcher to establish a theoretical framework for the study which guided the implementation of both CAI and CTI, and was used to interpret and explain the results. The identification of gaps in related literature, such as the lack of research on the effect of CAI in teaching Circle Geometry in South Africa and contradictions in existing studies on the effect of CAI in teaching Mathematics, are also some of the reasons why literature review was conducted in this chapter.

2.2 RESEARCH ON THE USE OF COMPUTER ASSISTED INSTRUCTION (CAI) IN MATHEMATICS CLASSROOMS

2.2.1 The role of Computer Assisted Instruction (CAI) in Mathematics lessons

According to Olive (2000), dynamic geometry technology is any technological medium that provides the user with tools for creating the basic elements of Geometry through direct motion via a pointing device such as a mouse. GeoGebra is a dynamic Mathematics software for teaching and learning Circle Geometry that was used in the current study. It allows learners to create Mathematical constructions and models by dragging objects and changing parameters.

In a study to investigate the effect of Computer Algebra Systems in enhancing Mathematical modelling on Grade 11 and Grade 12 learners, Geiger *et al.* (2008) concluded that technology had an interactive role to play in Mathematics rather than to simply be used as a computational tool. Also, the study by D'Souza (2005) on the effects of incorporating

collaborative learning methods in a core first year Mathematics subject to college learners suggested that most learners viewed a computer as a useful and enjoyable tool with which to learn Mathematics concepts. Ramani and Patadia (2012) proposed that CAI may be used as a supplement to the traditional teaching approach. It is the researcher's belief that CAI may be of necessity in the South Afican township schools which are overcrowed, and teachers have little time for individualised learner attention. Barrow, Debraggio and Rouse (2008) in a research based policy analysis article, provided evidence to the fact that Computer Assisted Instruction (CAI) programs had the potential to significantly enhance Mathematical achievement by increasing the amount of individualised instruction available. In this regard, the current study was used to support or contradict this potential.

The National Council of Teachers of Mathematics (NCTM) (2000) argues that technology has an important role to play in the teaching and learning of Geometry. This view is also echoed by Department of Education (DoE) (2003) and Department of Basic Education (DBE) (2011) when they suggest that learners should be able to use science and technology effectively, critically, and in the development of models. In line with this DBE's goal on technology, one of the objectives of the current study was to teach Grade 11 Circle Geometry using Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI).

Manuel and Jose (2002) claim that computers have graphic animation and computing capabilities that allow for simulations and visualisation.These important capabilities were tested by determining whether there was a significant difference in the average pre-test and post-test performance scores of Grade 11 learners taught Circle Geometry using CAI and those taught using CTI. It is further argued that technology provides learners with greater access to a vast array of information and resources, thus empowering them to become free agent learners, able to create meaningful personalised learning experiences outside the traditional classroom (Keengwe, 2013). In another way, "Technological Rich learning Environments (TREs) can situate learning in authentic contexts and support the social construction of knowledge by providing models, coaching, and support for collaboration" (Woolfolk, 2010: 337).

In addition, a major reason for the utilisation of the computer may be to reduce cognitive load (Sweller, 1994, 1988). Cognitive load is the measure of difficulty that learners experience each time they solve a problem solving task in Mathematics (Dhlamini, 2012; Sweller, 1988). Therefore, with appropriate use of technology and a substantial reduction in cognitive load , it was anticipated that learners could develop deeper understanding of Mathematics, and Circle Geometry in particular, resulting in improved performance (NCTM, 2000).

According to Skemp (1962), an integrated system of Mathematical knowledge is a result of sensory, motor, and conceptual experiences. It was the researcher's view that solving Circle Geometry problems while interacting with computers would provide learners with such kind of experiences, necessary for the development of an integrated system of Mathematical knowledge. Furthermore, as learners worked with the computer software GeoGebra and with each other in connecting already existing Geometric knowledge to new and to old knowledge, their conceptual understanding and adaptive reasoning strands of Mathematical proficiency were expected to develop, in addition to the procedural fluency strand that was expected to developed in both CAI and CTI, (Kilpatrick *et al*., 2001).

2.2.2 Integrating CAI in Mathematics lessons

The lack of technological integration in the classroom is a major concern in education (D'Souza, 2005; Keengwe, 2013). Olive (2000) concurs by suggesting that while there have been many personal accounts of the powerful learning that can take place when learners work with dynamic geometry technology, there have been very few well designed research projects to study the effects of dynamic geometry technology on learning Mathematics. By allowing learners to solve Circle Geometry problems while interacting with computers, the current study strived to provide an alternative to CTI while at the same time contributing to the already existing empirical evidence on CAI and Mathematics education.

Lindsey (2005) investigated the effect of computers on the Mathematical achievement of American 8th Grade learners and recommended that there was a need to do more research on computer usage in relation to Mathematics or Mathematics lesson plans, where computers could and could not be utilised as a teaching and learning tool. Therefore, it is

only through continuously inquiring and exploring the nature and characteristics of these technologies through studies such as this one, that we can develop a clearer understanding of how computers can be used to enhance learning (Groom, 2012).

The use of CAI tends to limit the teacher's involvement in the learning process, this may force learners to create their own solution paths, thus developing a stronger relational understanding of Circle Geometry concepts, as compared to learners who are exposed to CTI where the teacher is tempted to tell learners what to do, but not why, thus developing instrumental knowledge, (Skemp, 1976).

2.2.3 Mixed results in the use of CAI in Mathematics lessons

A study of literature related to the current study showed that there existed mixed results on the use of Computer Assisted Instruction (CAI) in Mathematics lessons. Subrahmany, Greenfield, Kraut and Gross (2001) conducted a survey on the impact of computer use on children and adolescent development and concluded that there was evidence that using computers supported the development of visual mental rotation, spatial visualisation, the ability to deal with two dimension and three dimension space, the ability to keep track of too much of different information at the same time, and the ability to read pictures and diagrams, all of which are skills essential in Circle Geometry. However, they hinted that more research is still needed to show a link, if any, between these skills and academic achievement.

On the other hand Lin (2008), while studying beliefs about using technology in the Mathematics classroom, interviewed pre-service elementary teachers and concluded that using technology effectively as a learning tool improved learners' Mathematical achievement by providing visual representations of shapes in addition to it being very colourful, thus making Mathematics exciting for learners. In a random assignment pretest-posttest experimental study that investigated the impact of CAI and CTI on the Mathematics achievement of elementary school children from Grade 3 to Grade 6, experimental group (n=92) and control group (n=92) in at risk environments (learners below Grade level and those who are economically disadvantaged), Jackson (2005) concluded that CAI had a significant effect on Mathematics acheivement as compared to CTI.

While investigating the effect of CAI on the Mathematics performance of Grade 3, Grade 4, and Grade 5 disabled learners with a convenience sample of experimental group (n=25) and control group (n=165), Trexler (2007) concluded that learners who were taught using CAI improved their performance in Mathematics as compared to those who were taught using CTI. This was attributed to the computer program that provided varying problem formats, immediate and correct feedback to the learners. A study by Lindsey (2005) investigated the effect of computer use on academic achievement of 8th Graders as compared to Socio-Economic Status (SES) variables such as family income, and school variables such as class size that affect achievement. The study concluded that a statistical significant difference existed between learners who had relatively easy access to computers as compared to those who had little or no access to computers.

However, the Center for Implementing Technology in Education (CITEd) (2005) argues that research on the use of virtual manipulatives or models that can be transformed and manipulated on a computer screen is still limited. In other words, there is limited research in the area of technology use and its effect on Circle Geometry, especially in South Africa. In addition, according to Lindsey (2005), "there is a need to do research on the software used on the computers because the computer is only as good as its software" (p. 125). Barrow *et al.* (2008) are of the opinion that the effectiveness of technology on learner achievement has been mixed, but they believe that determining the benefits of CAI could have significant implications in improving the low levels of Mathematics achievement. Furthermore, they argue that there is no supporting empirical evidence on the several hypotheses explaining the benefits of CAI programs, such as learner motivation.

The results by Tucker (2009) revealed that the effect of CAI on academic achievement was not statistically significant and was negatively correlated with Mathematics passing percentage. Brent (2008) used a constructivist approach to investigate the effect of learning using the Computer-Assisted Program, Algebra 1 Cognitive Tutor, and Conventional Instructions on Grade 9 learners. He found out that there was no difference in the performance of the experimental and control groups. However, sighting that it might have been due to a lack of technological exposure at home. Also, Roschelle, Pea, Hoadley, Gordon

and Means (2000, cited in Woolfolk, 2010) argued that there are no strong conclusions on whether computer use supports academic learning or not.

Likewise, Rha and Richardson (1986) conducted an experiment to determine the effect of CAI on Mathematics achievement of 4th Graders. However, Rha and Richardson's (1986) study could not provide evidence to support the effectiveness of CAI in improving Mathematics achievement. Reasons for this conclusion included the effectiveness of the software, the type of students who can benefit from CAI, and the type of environment in which CAI is delivered. Also, the results of the study by Spradlin (2009) on the effectiveness of Computer Assisted Instruction in developmental Mathematics showed no statistically significant difference in the performance levels of learners who used CAI and those who used CTI. Similarly, Teal (2008) studied college learners in a comparative analysis of modes of instruction using learner test scores in developmental Mathematics and concluded that there was no difference in academic achievement between the CAI (n=59) exposed learners and CTI (n=48) exposed learners, rather CAI facilitated the development of computational skills and flexibility in teaching and learning processes.

In light of the contradicting findings by other researchers the current study aimed to contribute to this debate by determining whether a statistically significant difference in the average pre-test and post-test performance scores of Grade 11 learners taught Circle Geometry using CAI and those taught using CTI existed.

2.3 MOTIVATION AND CAI IN MATHEMATICS LESSONS

Woolfolk (2010) describes motivation to learn as the tendency to find academic activities meaningful, worthwhile, and try to benefit from them by putting quality effort, (see also, Section 1.8.4). It may therefore be argued that if learners are to be motivated to learn, then the results of learning should be of value and helpful to their survival (Skemp, 1962).

In a survey to identify what Grade 7 and Grade 8 learners (n=147) say is the source of their motivation to learn Mathematics, Diamond (2012) argued that an examination of learners' motivation was a stepping stone to improving learner Mathematical proficiency and success. Mansukhani (2010) while studying the effects of conceptual understanding,

motivation, and communication in the creation of a strong Mathematical identity in Grade 9 Geometry learners concluded that increasing the motivation levels could be increased by creating an environment in which learners were inventors of their own knowledge through hands on projects and discovery activities. Keaney (2012) studied the 7th Grade learners' perceptions of motivating factors in the Mathematics classroom and observed that learners view a Mathematics class environment as motivating when teachers present concepts in various ways such as models and diagrams. CAI might be one of the various motivational ways in which Circle Geometry concepts may be presented, that may eventually lead to improved performance in the topic. If learners are motivated to learn Circle Geometry, they may put more time in trying to understand the topic resulting in improved performance, rather than giving up quickly.

However, the results by Shoemaker (2013) while investigating the effect of CAI on the attitude and achievement of 5th Grade Mathematics learners showed that CAI had no impact on the motivation levels of low-achievers, and there was no significant difference in the achievement levels of the control and experimental groups. This was attributed to the software that did not give immediate feedback, the time spend using the software, the software just not being enjoyable to use or not being user-friendly for the learners. Teal (2008) concluded that even though learners had voiced positive attitudes towards CAI, this did not translate into a difference in academic achievement between CAI exposed learners and CTI exposed learners; rather, learners learned equally well regardless of the mode of instruction.

The results obtained by Bayturan(2012) while studying 9th Grade learners' (n=60) success and attitude towards CAI and CTI showed that CAI was effective in improving learner Mathematics performance as compared to CTI, but it was not effective in changing the attitude of learners towards Mathematics, "because the more the learners are exposed to Mathematics the more they develop negative attitudes towards Mathematics lessons" (p. 56).

In order to make a contribution to the existing body of knowledge on the effect of CAI and CTI in motivating learners to do Mathematics, one of the research questions of the current

study asked how CAI or CTI affected the motivation levels of Grade 11 learners in Circle Geometry.

2.4 OTHER FACTORS AFFECTING CAI USE IN THE CLASSROOM

2.4.1 The influence of the teacher on CAI

According to NCTM (2000), teachers' attitudes play an important role in using technology in teaching and learning. Likewise, Barrow *et al*. (2008) argue that factors such as individual teacher effect might be correlated with the use of computers in the classroom and to learner performance. However, the need to move with the times and to adapt up to date technologies seems to be easier said than done as it involves a significant identity shift for the teachers (Marsden & Piggot-Irvine, 2012). Similarly, Laborde (1998, cited in Olive, 2000) believes that it will take a long time for teachers to adapt their teaching to take advantage of technology.

Doering, Huffman and Hughes (2003, cited in Lin, 2008) believe that many teachers lack the knowledge of how to properly incorporate technology in the classroom. Furthermore, Honan (2012) claims that even though teachers are aware about the diversity of technologies that learners are exposed to at home, they do not use this same diversity in the classroom and they seem to be unable to perceive that the learning that takes place at home can be integrated into the classroom. Also, the study conducted by Lindsey (2005) provided evidence that the number of years a teacher has taught Mathematics and the teacher's qualifications have a statistically significant effect on learners' Mathematics achievement. On the contrary, Jackson (2005) provided evidence that the teacher's years of experience had no impact on Mathematics scores of learners taught using CAI and those taught using CTI.

It is the researcher's view that if CAI is to be effectively used in the classroom then the teacher must be the first to learn how and when to use it. Therefore, CAI should be one of the teaching methods that trianee teachers should be exposed to at teachers' colleges and universities.

2.4.2 Learning space , heterogenous groups and digital divide

The teacher-learner ratio and heterogenous groups of learners in a normal South African township secondary school classroom make it difficult for the teacher to reach out to all the learners, thus allowing for CAI to provide a possible solution to this problem (Ramani & Patadia, 2012), that may be one of the reasons of poor performance by learners in Mathematics. The large class sizes make it difficult for teachers to maintain discipline in the class, effectively and immediately mark and correct each learner's work, late alone provide individual attention to learners. CAI might be the solution to some if not all of these problems, since learners are computer enthusiasts, and the computer has the ability to show each and every individual learner where he/she will be making errors.

The digital divide (Woolfolk, 2010) may also be a factor to consider when determining the effectiveness of computers in the teaching and learning of Circle Geometry. The digital divide is the gap between those who have and those who have not in an economically complex society, which is a day-to-day reality of teaching within classrooms with social constraints (Groom, 2012) such as South African township secondary schools. Van Niekerk (2010) also cautions on the different technological backgrounds between teachers and learners, with learners being from the post-technological era that is rapidly changing while teachers are from the pre-digital age. Thus, resulting in conflicting value preferences.

2.4.3 Globalisation and Mathematics instruction

Globalisation may be described as a process of interaction and integration of people and economies of different nations, with the aid of technology (Udofa & Udo, 2012). It involves practices linking Mathematics education to technology, and international curriculum harmonisation (Namukasa, 2004). Middleton (2004) argues that globalisation should involve countries borrowing good Mathematical ideas from each other, integrating and modifying them so that they fit into the already existing good ideas, rather than copying raw Mathematical ideas from one country and rejecting even one's own good ideas. It would therefore be advisable for the Department of Basic Education [DBE], teachers, researchers, and all those involved in Mathematics education to find out from countries that are successfully using CAI in their classrooms on how they use it, and then borrow and modify

these good ideas through research such as the current study so that the ideas can fit into the South African situation.

In a case study and interviews on workers, Marr and Hagston (2008) concluded that globalisation and technology are increasing workplace Mathematics related tasks such as reading and interpreting diagrams, measurement skills, and problem solving. These are tasks that are linked to Circle Geometry. Delivering their paper at an annual conference of Mathematics education research, Clarkson and Atweh (2003) proposed that globalisation develops Mathematics Education and also bridges the economic gap between countries. Shann (2006) argues that computers are widely used in daily activities in this informationalised society, noting that Mathematics is the foundation upon which technology is built. In this regard, for technology to develop it is dependent on Mathematics, and conversely for Mathematics to develop it may require the use of technology. Therefore, a symbiotic relationship exists between technology and Mathematics.

According to Department of Basic Education (DBE) (2011b), learners should be prepared for the world of work and to participate as responsible citizens in the life of global communities, including the use of technology in Mathematics education and more specifically in the topic of Circle Geometry, which is useful in real life situations such as in construction. The results obtained by Udofa and Udo (2012) in a survey of 50 secondary school learners in Nigeria to determine the influence of globalisation on Mathematics education revealed that globalisation had no significant influence on Mathematics content as well as Mathematics teaching methods since Nigerian learners were yet to feel the impact of globalisation in Mathematics content. Interestingly, they also argued that American learners were mediocre in Mathematics as compared to their peers in other countries even though America is a developed country with access to some of the best technologies in the world.

2.5 EDUCATIONAL GOALS AND CAI IN MATHEMATICS LESSONS

The Curriculum and Assessment Policy Statement (CAPS) document is a revised version of the South African National Curriculum Statement (NCS) document (Department of Basic Education [DBE], 2011b). In the CAPS document, the topic of Circle Geometry was re-

introduced in Grade 11 in 2013 and in Grade 12 in 2014, after having been removed from Grade 11 in 2007 and from Grade 12 in 2008.

On technology, Department of Education (DoE) (2003) and Department of Basic Education (DBE) (2011a) suggest that learners should be able to use science and technology effectively, critically, and in the development of models. For instance, in the Grade 11 Circle Geometry topic learners should be able to identify and describe the parts of a circle such as the circumference, arc, chord and segment; be familiar with properties of quadrilaterals, such as the sum of angles in a quadrilateral is 360°, and properties of triangles like the sum of angles in a triangle is 180°, and that the exterior angle of a triangle is equal to the sum of the two interior opposite angles,including the properties of congruency. In addition, Grade 11 learners should be able to state and prove the theorems of Circle Geometry, solve Circle Geometry problems with reasons, and to prove riders (DBE, 2011a).

In order to accomplish these learning goals, learners must develop visual and spatial understanding of objects which might be enhanced through the use of CAI, in addition to developing the ability to make and investigate conjectures, (re)invent theorems of Circle Geometry, and to give justifications. Currently, there have been no material that has been presented to learners using technology by DBE.

2.6 A THEORETICAL FRAMEWORK FOR THE STUDY

2.6.1 The constructivist perspective

The constructivist perspective was used as a theoretical framework underpinning this study. The constructivist philosophy is based on the presupposition that learners should be actively involved in the processes of thinking and learning (Ornstein & Hunkins, 2009). Cobb, Yackel and Wood (1992) describe constructivist learning as an active construction and the representational view of the mind, whereby learners modify their internal mental representations to construct Mathematical relationships that mirror external representations to them. Similarly, Woolfolk (2010) describes constructivism as a philosophy that emphasises the active role of learners in constructing their own knowledge by building understanding and making sense of information.

Complementing these views, Cheek (1992, cited in Paulsen, 2009) maintains that in constructivism learners actively take in knowledge, connect it with previously assimilated knowledge and make it their own knowledge by constructing their own interpretations. In other words, within a constructivist approach learners are actively involved in generating meaning or understanding of their own through the processes of (re)inventing, modifying, structuring, applying, and internalising information (Ornstein & Hunkins, 2009). Learners connect new knowledge with old knowledge as they construct understanding, and critique their ideas and those of others while interacting with the real world. In a constructivist classroom, the teacher provides learners with resources and activities that ensure they are actively involved and participate in, while constructing their own knowledge and understanding.

In the current study, the constructivist approach of teaching and learning was adopted. Participants were expected to become more actively involved in building their own dynamic Mathematical understanding of Circle Geometry as they interacted with the computers, each other, and with any other learning tool. The experimental group of learners used a computer program, GeoGebra, to (re)invent strategies for solving Circle Geometry problems while the control group was expected to use any other tool besides a computer program to (re)invent strategies for solving Circle Geometry problems. The computer was expected to be a teaching and learning tool that minimised the dominance of the teacher in the learning setting while increasing individual learner participation in accordance with the principles of constructivism, as compared to Conventional Teaching Instructions (CTI). Also, because of the one-on-one situation provided by the computer, learners were expected to retrieve and modify their prior Geometry knowledge while interacting with each other and with their learning tool, and internalise the (re)constructed new knowledge as they solved Circle Geometry problems.

The use of Computer Assisted Instruction (CAI) was expected to generate a more learner-centred environment. Therefore, the current study aimed to determine if CAI was superior or not in applying constructivism as compared to CTI. Pre-test and post-test scores were used to determine the mode of instruction between CAI and CTI that was more significant in

implementing the constructivist approach, by using Analysis of Covariance (ANCOVA), (see, Section 3.9.1).

Shoemaker (2013) while investigating the effect of CAI on attitude and achievement of 5th Grade Mathematics learners adopted a constructivist teaching framework because " it helps to foster learner motivation and achievement , and it is easily married to the use of technology" (p. 31). Similarly, Teal (2008) adopted the constructivist approach in a study that compared modes of instruction, arguing that it supports learning in both the CAI and teaching approaches without the use of computer-assisted programs. In addition, D'Souza (2005) argued that constructivism gives learners an opportunity to think, make their own interpretations, construct and internalise knowledge for themselves while interacting with their surroundings. Similar reasons justify the choice of constructivism to frame the current study.

2.6.2 Socio-constructivism

Socio-constructivism is a type of constructivism in which Mathematics is taught through problem solving, with learners interacting with each other and with the teacher (Cobb *et al*., 1992). A situation in which a learner has no readily available procedures for finding a solution, but has to design and carry out a planned procedure to get to the solution may be described as a problem solving perspective (UNISA, 2011b). This component of constuctivism was also explored in the current study. Socio-constructivism allows learners to interact with each other and with their learning tools giving them the opportunity to move beyond instrumental understanding (knowing rules, but not why) to relational understanding (knowing what to do, and why) of Circle Geometry (Skemp, 1976). In other words, socio-constructivism was chosen because it provides learners with an environment in which they can behave like real mathematicians who invented Mathematics.

In this regard, learners were expected to develop their own heuristic strategies and steps of solving Circle Geometry problems like real mathematicians, in both CAI and CTI environments. For example, when learners were required to prove Circle Geometry theorems, to prove that a line is a tangent to a circle, or to prove that two lines are parallel (see, Appendix A), a socio-constructivist thinking process was supposed to be applied.

In other words, learners in the CAI group had to solve Circle Geometry problems by manipulating lines, angles and shapes on the computer, measure the angles and lines to check if their solutions were correct, and critically discuss their solutions and solution paths with their peers. Similarly, learners in the CTI group were expected to follow the step-by-step instructions provided by their teacher on how to get to solutions "only known to the teacher".

Learners in the experimental group used the computer program, Geogebra, while those in the control group used any other strategy besides a computer program to design and carry out their own problem solving plans, check and reflect if their solutions were the most viable, and also check if the used strategies were the most efficient as they solved Circle Geometry problems (UNISA, 2011a). In other words, both groups employed socio-constructivism, however, the experimental group used the computer as its cultural tool (Woolfolk, 2010), while the control group used anything but computers. Artzt and Armour-Thomas's (1998) study concluded that the problem solving perspective was useful in improving learner performance. In the current study, the computer program (Geogebra) and conventional teaching approaches were used as tools to assist learners in problem solving, and their effectiveness in improving learner problem solving skills and motivating learners in Circle Geometry were compared. Goldin (2002, 1998) suggests a problem solving model that consists of external reprentational systems[5] and internal representational systems[6]. The developed Circle Geometry test was used to compare whether CAI, or CTI improved learners' ability to develop powerful internal representational systems by comparing learner performances in the tests before and after the interventions (CAI and CTI).

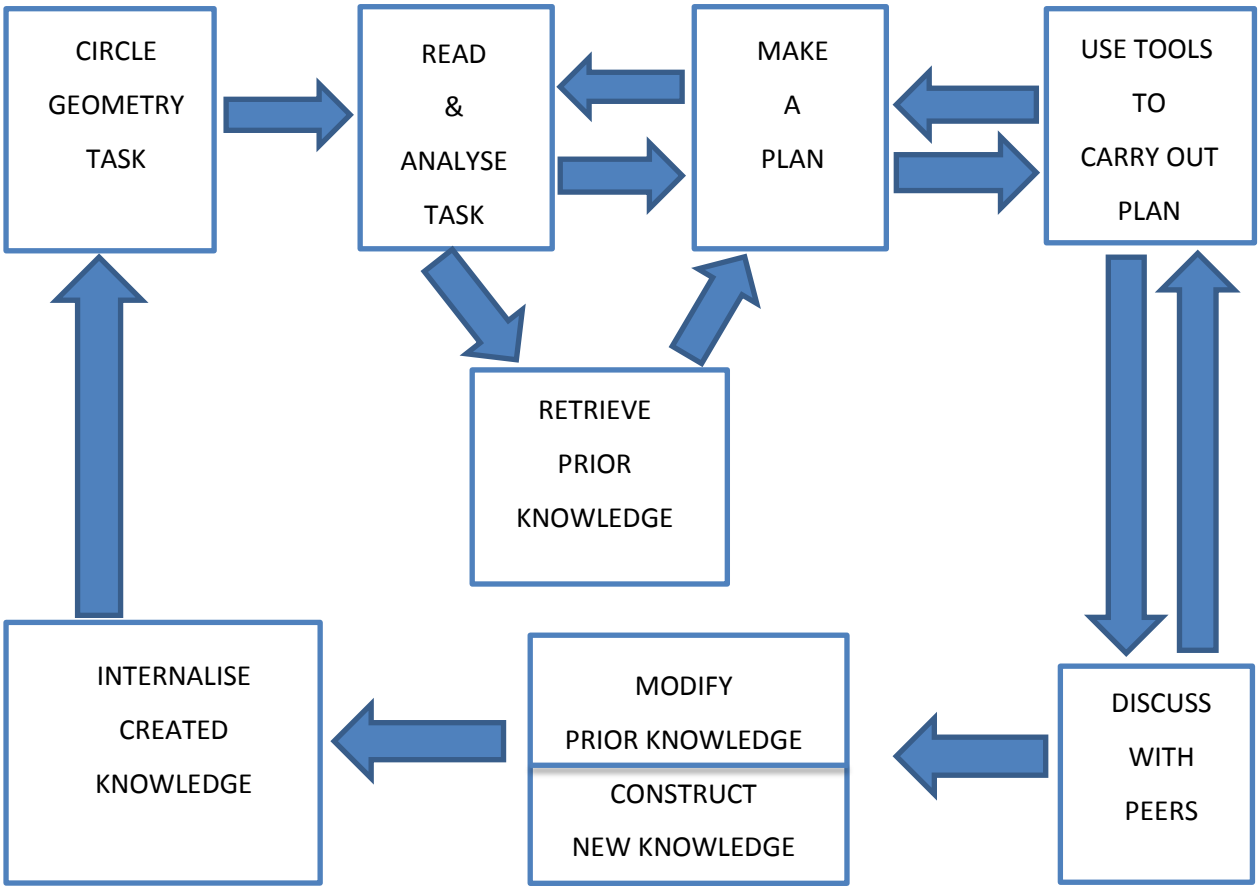
In another way, the study determined whether socio-constuctivism that uses a computer program (GeoGebra) was able to provide an alternative environment to the socio-constructivist teaching approaches that did not use a computer program. An alternative

[5] External representational systems include: syntax variables, structure variables, content and context variables, and heuristic behaviour variables (Goldin, 2002, 1998).

[6] Internal representational systems include: verbal/syntactic systems; imagistic systems; formal notational systems; systems of planning, monitoring and executive control; and affective systems of representation (Goldin, 2002, 1998).

environment in which learners could develop their own simple, appropriate, and efficient heuristics for solving problems involving Circle Geometry was sort. This was done by comparing learners' performance scores on the pre-test and the post-test, comparing learners' motivational scores from a questionnaire and analysing the interview responses from both the experimental and control groups. In Figure 2.1, steps of using socio-constructivism to learn Circle Geometry are shown.

Figure 2.1: Socio-constructivism in a Circle Geometry lesson



It is the researcher's belief that advocating for a socio-constructivist approach implies an effort to develop the habits of mind that include critical and creative thinking, pattern sniffing, inventing, experimenting, reflecting, conjecturering, guessing, tinkerering, as suggested by Cuoco, Goldenberg and Mark (1995) and social negotiation (Woolfolk, 2010). Cuoco *et al*. (1995) believe that if we are to create mathematicians out of our learners, then

these are the kind of habits that we must instil in them. Therefore, the pre-test and post-test scores, motivation scores, and interview responses of learners in the current study were used as a measure of determining which of the two teaching methods (CAI or CTI), was most appropriate in developing Cuoco *et al*.'s (1995) habits of the mind, capable of improving learner performance in Circle Geometry through a socio-constructivist perspective.

2.7 SUMMARY AND CONCLUSION OF THE CHAPTER

Computer Assisted Instruction (CAI) may be an alternative method of instruction that Mathematics teachers can use to motivate and improve the performance of learners in Circle Geometry. However, the effectiveness of a computer depends on the effectiveness of its software. Most of the Mathematics computer software that have been installed onto school computers still provide drill and practice rather than a constructivist approach.

Learners are enthusiastic about computers (Diamond, 2012; D'Souza, 2005), but evidence on the link between CAI, Mathematics performance, and motivation is limited (D'Souza, 2005; Groom, 2012; Lindsey, 2005; Olive, 2000; Shoemaker, 2013). Furthermore, there seems to be mixed results on the effect of CAI in teaching Mathematics. In particular, evidence on the effect of CAI in teaching Grade 11 Circle Geometry in South Africa is scarce. It is through research studies such as this one that the effect of CAI in teaching Circle Geometry may be determined. Therefore, this study will contribute by adding to the already existing body of knowledge on the effect of CAI and CTI in teaching Circle Geometry.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this section, the research design, population, study sample, and sampling techniques are described. In addition, issues relating to instrumentation, validity, and reliability are also given attention.

3.2 RESEARCH HYPOTHESES

The null hypotheses and the alternative hypotheses for the study are presented in this section.

Null hypothesis on Mathematics performance (H_O): There is no statistically significant difference between the average Mathematics performance scores of Grade 11 learners who participate in the Computer Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.

Alternative hypothesis on Mathematics performance (H_1): There is a statistically significant difference between the average Mathematics performance scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI) in the topic of Circle Geometry.

Null hypothesis on motivation (H_O): There is no significant difference between the average motivation scores of Grade 11 learners who participate in the Computer Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.

Alternative hypothesis on motivation (H_1): There is a significant difference between the average motivation scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI) in the topic of Circle Geometry.

3.3 RESEARCH DESIGN FOR THE STUDY

A quantitative research design is one that is based on positivism and measurability, it aims to establish cause and effect relationships, on the other hand, a qualitative research design is based on multiple socially constructed realities and aims to understand a social phenomenon from participants' perspective, (Creswell, 2012; McMillan & Schumacher, 2010). However, in quantitative research, hypothesis testing is more important than an occurring phenomenon (hypothesis generation) while in qualitative research the researcher's personal biases may easily influence the results of a research study (Johnson & Onwuegbuzie, 2004). In this regard, the use of both research designs provides more depth and detail into a research study as the results from one design would be used to enhance credibility and compensate for the limitations from the other design (McMillan & Schumacher, 2010).

The current study employed a non-equivalent control group design consisting of a pre-test , post-test, and a questionnaire to measure the comparative effects of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on the performance and motivation of Grade 11 learners in Circle Geometry (McMillan & Schumacher, 2010). This is one of the designs used in quasi-experimental studies that lack random assignment of participants to experimental group and control group. A non-equivalent control group design is a type of a quasi-experimental design that lacks random assignment of participants to the control and experimental groups (Cohen, Manion, & Morrison, 2011; Gay, Mills, & Airasian, 2011).

This design was opted in order to preserve the normal running of the participating schools and to reduce threats to the external validity of the study since natural environments were maintained. The design ensured that participating learners continued learning other subjects according to their schools time-tables, and the learners could take part in any other

school related activities. In other words, a non-equivalent control group design ensured that the study would not disturb any of the schooling activities, by fitting into the schools' term plans.

Similarly, Tucker (2009), while investigating the relationship between CAI and alternative programs to enhance 5th Grade Mathematics success, employed the quasi-experimental design with an experimental group (n=135) and a control group (n=144). In Tucker's (2009) study, a non-equivalent control group design was used because the district institutions offered intact classes. In the same vein, Pilli (2008) used a quasi-experimental research design while investigating the effect of CAI on the achievement, attitude, and retention of 4th Grade Mathematics course learners because random assignment of study participants was not possible, hence intact classes were used. Spradlin (2009) used the non-randomised control group pre-test-post-test design to investigate the effect of Computer Assisted Instruction in developmental Mathematics. Spradlin (2009) used this design because "students registered themselves for the courses and could not be randomly assigned to the experimental or control groups without disrupting their schedules" (p. 76).

Shoemaker (2013) also used a quasi-experimental non-equivalent control group design while investigating the effect of computer-aided instruction on attitude and achievement of 5th Grade Mathematics learners. The research design in Shoemaker's (2013) study was opted to prevent disruption to the educational setting. Dhlamini (2012) employed the non-equivalent control group design in a study to investigate the effect of context-based problem solving instruction on the performance of learners because it was not possible to randomly assign participants to the experimental and control groups, hence intact classes were used.

The current study used four intact classes and two teachers, all selected by convenience sampling. The two classes at the school where the researcher teaches formed the experimental group because the researcher is the one who administered CAI while the two classes at another selected school formed the control group and the teacher at that school administered CTI. The researcher administered CAI in the experimental classes to preserve uniform conditions in the implementation of a CAI. The teacher at the control school

implemented CTI in the control classes to preserve conventional conditions. CAI and CTI had to be implemented so that the effect of CAI could be compared against a teaching method that is normally used in teaching Circle Geometry (CTI). The qualitative part of the design consisted of semi-structured interviews, whose results were used to complement the results of the quantitative design.

All activities such as writing the pre-test and post-test, and teaching, that characterised the implementations of CAI and CTI were incorporated within the normal school time-table that was running in each of the participating schools during the third term of schooling in Gauteng province of South Africa, when that topic was taught in accordance to the Gauteng Department of Basic Education's year plan. This arrangement was opted because it preserved the normal running of schools while the study was conducted. It was believed that when using this design the independent variables (CAI and CTI) could be implemented at two different schools while the comparative effect of this manipulation on the dependent variables (performance and motivation) could be measured.

3.4 POPULATION AND SAMPLE

In this section, the population and the sample of the study are described.

3.4.1 Description of the population

The population for the study consisted of all Grade 11 Mathematics learners from 65 secondary schools that are located in the Ekurhuleni North district of the Gauteng province, in South Africa. Most of the township secondary schools in this district share the same characteristics of having persistently performed poorly in Geometry after 2008, and specifically in Circle Geometry before 2008, which resulted in the decrease in the number of learners who take Mathematics as a subject in Grades 10, 11 and 12 (Cassim, 2012). Before 2008 the South African Mathematics curriculum included Circle Geometry, but from 2008 to 2013 the topic was removed, to be re-introduced again in Grade 12 in 2014.

3.4.2 Sampling techniques

A convenience sampling method was used to select township secondary schools and two teachers that participated in this study. The township secondary schools and the teachers

that volunteered to participate in the study were selected (Johnson & Christensen, 2000). This sampling method was opted because it is usually difficult to secure the participation of schools in such studies as some schools fear that the study may interfere with the normal teaching and learning activities. The researcher selected township schools with whom the researcher already had existing relations and schools that were willing to participate in the study. Township schools enrol learners that share a similar socio-economic status and school resources.

According to Gay *et al*. (2011), a convenience sampling method is a non-random sampling approach that is used to find "whoever happens to be available at the time" (p. 140). The strengths of a convenience sampling method are: (1) it is less costly; (2) it is less time-consuming; (3) it is easy to administer; (4) it may secure higher participation; and, (5) it has a less attrition factor, which is the withdrawal of participants as the study progresses due to factors such as difficulty in the content being taught, or learners disliking the teaching method being used. However, the weaknesses of a convenience sampling method are also well documented. A convenience sampling method makes it difficult to generalise the study findings because a sample that is obtained from this non-random sampling approach is usually less representative of the actual study population (McMillan & Schumacher, 2010).

3.4.3 The study sample

The sample of the study consisted of Grade 11 Mathematics learners (n=136) from two township secondary schools, which were drawn by convenience sampling methods from the population of the study. Two schools were selected so that the researcher would teach at the experimental school while another conveniently sampled teacher taught at the control school. Each school had two classes that participated in the study. Participants (n=71) from the school in which Computer Assisted Instruction (CAI) was implemented formed the experimental group, while participants (n=65) from the school in which Conventional Teaching Instructions (CTI) were implemented formed the control group.

Grade 11 learners were chosen because the greater part of Circle Geometry that is assessed in the Grade 12 final examination paper is taught at this Grade level, and also, it is in Grade 11 that the theorems of Circle Geometry are taught in accordance to the South African

Mathematics curriculum. The experimental school and control school were separated by almost 20km to minimise possibilities of contact and contamination between participants in both groups (Dhlamini, 2012). The distance between the participating schools ensured that threats to external validity such as treatment diffusion and participant effect were minimised (Gay *et al*., 2011; McMillan & Schumacher, 2010). However, non-randomisation of participants meant that the sample might not be a representative of the populations in other districts to which the study findings could be generalised (Cohen *et al*., 2011).

To minimise threats to internal validity of the study the following measures were taken: (1) selected learners were drawn from schools that shared similar socio-economic and educational characteristics and therefore were affected by similar conditions (see, Section 3.4.1; Section 3.4.2); (2) the researcher taught in both Grade 11 Mathematics classrooms in the experimental school to ensure uniformity in the implementation of the intervention instruction (CAI), and the control school was taught by another teacher to preserve conventional teaching conditions ; (3) the researcher personally collected assessment data from both schools (Teal, 2008); and, (4) the researcher used Analysis of Covariance (ANCOVA) to eliminate confounding variables in the test scores (Field, 2012). The latter could include possible intelligence differences between learners in the experimental and control groups, which could have been the product of non-random assignment.

3.5 INSTRUMENTATION

The instruments for data collection were a Circle Geometry test (Appendix A), a motivation questionnaire (Appendix C) and an interview schedule (Appendix D).

3.5.1 A Circle Geometry test

The test consisted of four questions that totalled 50 marks. Question 1 of the test asked learners to prove one of the seven theorems in the section that deals with Circle Geometry in Grade 11 (DBE, 2011c). The item in question 1 was open-ended and was structured in such a way that it assisted the researcher to determine which of the interventions, CAI and CTI, was/ were more effective in developing flexible Mathematics knowledge and problem solving skills of learners. Question 1 required the learners to prove a Circle Geometry theorem which states that opposite angles of a cyclic quadrilateral are supplementary. In

this question, learners could use any strategy of their own to prove the theorem as long as the strategy was mathematically correct. This is in line with the socio-constructivist perspective which aims to develop individuals who create their own strategies to solving problems and have flexible knowledge (see, Section 2.6).

Question 2, question 3 and question 4 were drawn from the Curriculum Assessment Policy Statement's (CAPS) Orientation Grade 11 booklet (DBE, 2012). The CAPS Orientation booklet was considered because it was used to train teachers on how to teach the topics that had been re-introduced into the South African secondary schools Mathematics curriculum, such as Circle Geometry. In addition, the booklet contains typical Grade 11 examination questions covering the re-introduced topics in CAPS. In Questions 2, 3 and 4 participants were expected to demonstrate their constructivist skills to obtain solutions to the problems.

According to DBE (2011c), tests should cover the following four cognitive levels; (1) knowledge (20%); (2) routine procedures (35%); (3) complex procedures (30%); and, (4) problem solving (15%). In this regard, questions were selected in such a way that they covered three of the four cognitive levels with the exception of the knowledge level; this is because typical examination questions on Circle Geometry do not cover this level adequately. Therefore in the test, routine procedures were Questions 1; 2; 3.2; and Question 4.2.2 making up 42% of the test; complex procedures were asked in Question 3.1, which made up 30% of the test; problem solving items appeared in Questions 4.1 and 4.2.1, making up 28% of the test (see, Appendix A).

Participants in the experimental group wrote the pre-test using pen and paper, and the post-test using the computer to assist them in finding solutions just as they use a calculator in tests. This was done because the teaching method in the experimental group largely embraced the use of computers. Participants in the control group wrote both tests (the pre-test and the post-test) using a pen and paper. This is because the control group had been taught using CTI, which did not incorporate the use of computers. The test was assessed using a marking memorandum (see, Appendix B), which had been developed in accordance with the Department of Basic Education's assessment guidelines (DBE, 2011c). The memorandum was developed by the researcher and was validated by a team of experts that

also validated the test (see, Section 3.6.4). The experts had experience in setting and moderating District and Provincial Mathematics question papers. These included a Mathematics facilitator who is the head of Mathematics in a district, and three Heads of Mathematics Department (HODs) at three schools. The team of experts checked if the test was well balanced according to the Bloom's taxonomy and the four cognitive levels as per the requirements of the Department of Basic Education's assessment guidelines (DBE, 2011c), in addition to checking the mark allocation, among other things.

The experts made the following recommendations: (1) that alternative solutions should also be written in the memorandum; and, (2) not to repeat similar questions, such as asking learners to prove more than one Circle Geometry theorem in a test of 50 marks but rather try to cover all concepts in Grade 11 Circle Geometry. The recommendations suggested by the experts were effected, meaning, six theorems were covered (see, Appendix A) and alternative solutions to problems were written in the memorandum (see, Appendix B).

The test was used to measure and compare the performance levels of the CAI and CTI groups. The performance was measured in terms of test scores of participants before and after the interventions (CAI and CTI). The same test was used for pre-testing and post-testing so as to determine if there was any improvement in terms of learners' understanding of the concepts in the test, and also to ensure that all conditions were similar except for the interventions. In particular, pre-testing was used to determine the performance status of both groups before interventions, and after three weeks of administering the interventions, the post-test was administered, which served to measure the effect of each teaching method on the performance of learners.

3.5.2 The questionnaire

Another dependent variable that was measured in this study was motivation. The effect of both teaching methods (CAI and CTI) on the motivation of learners towards Circle Geometry was determined. To this end a questionnaire was administered to the participants (n=131) in both groups after the interventions. The decreasing number of learners who do Mathematics from Grade 10 to Grade 12 (see, Section 1.2) was considered to provide evidence that learners are not motivated to do Mathematics. The administration of a

questionnaire after the interventions aimed to determine whether the motivation levels of learners in the experimental group had been raised by using computers to learn Circle Geometry, as compared to learners in the control group.

Motivation to learn may be described as the way one thinks and feels about academic activities, (Woolfolk, 2010). Therefore, the constructed items for the questionnaire probed learners on issues that relate to their motivation levels towards learning Circle Geometry after using CAI and CTI. For instance, some of the items probed them if they liked Circle Geometry, how much they invested in doing Circle Geometry problems or tasks, and how they preferred to learn Circle Geometry.

The questionnaire adopted by Bryan (2009) in a study to investigate high school learners' motivation to learn Science was modified in this study to measure learners' motivation towards Circle Geometry. Bryan (2009) proved that the questionnaire was reliable and valid in Science. In the questionnaire used in the current study, learners responded to each of the 30 Circle Geometry motivation questionnaire items on a 5-point scale where *1=never*, *2=rarely*, *3=sometimes*, *4=often*, and *5=always*. The Circle Geometry motivation questionnaire maximum total score was 150 and the minimum was 30. A learner's total Circle Geometry motivation questionnaire score was interpreted in the following way:

120-150 motivated "often to always" (high motivation)
90-119 motivated "sometimes to often" (moderate motivation)
60-89 motivated "rarely to sometimes" (low motivation)
30-59 motivated "never to rarely" (very low motivation)

3.5.3 Semi-structured interviews

At the end of the interventions (CAI and CTI), a purposive sample (n=12) of learners was selected to participate in the semi-structured interviews, (n=6) learners were selected from the experimental group while (n=6) learners were selected from the control group. The interviewees consisted of two learners who performed fairly well in the post-test; two learners who performed averagely, and two learners who performed poorly in the post-test. Interview respondents were selected from both groups. Interviews were semi-structured to

allow the researcher to probe learners' responses where it was necessary, for example, asking a learner how he/ she would like to be taught Circle Geometry and then asking the learner to explain why, after giving an answer. All interview respondents were asked the same interview questions. The researcher used the same interview schedule to conduct all interviews. Interviews were conducted on both groups to document the effect of CAI and CTI on learners' performance, and motivation levels towards CAI and CTI. All interviews were voice-recorded for analysis purposes. This involved comparing the interview responses to the questionnaire responses and test results, and determining how they correlate.

The semi-structured interviews were a modification of the interview questions used by D'Souza (2005) while studying the effect of incorporating collaborative learning methods in Mathematics. Items in the interview schedule were meant to address key variables in the study, namely, learners' performance and motivation that could have been affected through learning Circle Geometry using Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI). Items were also developed in terms of the aim, objectives and the research questions of the study, for example, asking how a learner would advise his/ her teacher to use CAI/ CTI in a way that would make learners perform better in Circle Geometry. This question is linked to the objective of using CAI and CTI to teach Circle Geometry and the research question of how to use CAI and CTI to teach Circle Geometry. The question which asked the learner if CAI/ CTI had motivated him/ her to work harder in Circle Geometry was aimed at answering the research question on the effect of CAI and CTI on the motivation levels of learners in Circle Geometry.

3.6 ASSESSMENT OF MEASUREMENT PROPERTIES

This section provides a description of how the researcher addressed the reliability and validity issues relating to the data collection instruments.

3.6.1 Reliability of the test

The consistency of items within the test (McMillan & Schumacher, 2010) was determined by the researcher at a convenience sampled pilot school before the main study was conducted (see, Section 3.8.1) to collect data to compute the reliability of the test, (see, Section 4.2.2). The pre-test that was administered during the pilot study was used to compute the

Spearman-Brown reliability of the test. The Spearman-Brown formula determines how much error in a test score is due to poor test construction. According to Johnson and Christensen (2012), the Spearman-Brown formula determines how consistently the items in a test measure a single construct or concept such as performance in Circle Geometry. The Spearman-Brown reliability was used because after the pre-test learners were taught using CAI before writing the post-test. Therefore, it was most likely that the pre-test scores were not going to be similar to the post-test scores.

3.6.2 Reliability of a questionnaire

The pilot study conducted by the researcher at the pilot school before the main study was done to also collect data to compute the internal consistency reliability of the questionnaire. This was administered a day after learners had written the post-test of the pilot study. The Cronbach's reliability coefficient was calculated (see, Section 4.2.3). This was because each item in the questionnaire had several response options (Gliem & Gliem, 2003). The Cronbach's Alpha value shows the degree to which items are interrelated (Johnson & Christensen, 2012). George and Mallery (2003, cited in Gliem and Gliem, 2003) in a paper on calculating, interpreting, and reporting Cronbach's Alpha reliability coefficient for Likert-type scales provided the following Alpha value interpretations:

$$\propto > 0.9 - excellent;$$
$$\propto > 0.8 - good;$$
$$\propto > 0.7 - acceptable;$$
$$\propto > 0.6 - questionable;$$
$$\propto > 0.5 - poor;\ and,$$
$$\propto < 0.5 - unacceptable.$$

The "Alpha if item deleted" was compared to the Alpha value at the bottom of the item-total statistics table (Table 4.2) to determine if the item could be deleted so as to increase the Cronbach's Alpha. Increasing the number of items in the Circle Geometry motivation questionnaire increases the Alpha value (Cooper & Schindler, 2001, cited in Cohen *et al*.,

2011; Johnson & Christensen, 2012). In this regard, items where increased from 11 to 30 (see, Appendix C).

3.6.3 Reliability of semi-structured interviews

A purposive sample of three learners was selected from the participants at the pilot school to respond to interview questions. The three respondents consisted of a low performer (0-4), an average performer (25-29), and a high performer (40-50) in the post-test of the pilot study. The researcher conducted the three interviews to preserve the similarity of conditions in all of them. The interviewer used the same interview schedule, following the same order of questions for all interviews. In addition, all interviews were conducted under the same conditions, that is, at the school in a classroom. Interviews were conducted between 14h00 and 15h00.

3.6.4 Validity of the test

To address the content validity of the test seven theorems in the Grade 11 Circle Geometry curriculum were drawn from state-approved curriculum documents (DBE, 2011c). In addition, the test was also given to an expert panel (see also, Section 3.5.1) consisting of the district Mathematics facilitator, and three Mathematics Heads of Department (HODs), from conveniently sampled schools in the district in which the study was conducted to validate the alignment of the test items to the Department of Basic Education's (DBE) curriculum content. Possible adjustments that were suggested by the panel were considered to strengthen the validity of the test. These include proving only one of seven theorems because it was a test out of 50 marks, and covering almost all the theorems (see, Appendix A).

3.6.5 Validity of a questionnaire

The constructed questionnaire was given to a panel of experts consisting of a university Professor (in Mathematics education), the district Mathematics facilitator who holds a Master's degree in Mathematics education, and two Heads of Departments of Mathematics who hold degrees in Mathematics education and further have experience in secondary school Mathematics teaching and learning. This panel assisted productively in the validation process. These people were selected because they are knowledgeable about learner

motivation. They have studied about the development of learner motivation, factors affecting learner motivation, and they deal with learners in their line of work on a daily basis. The experts were provided with copies of the questionnaire and they suggested changes which were considered so as to strengthen the validity of the questionnaire. The recommended changes that were implemented include linking all the questions to the aim, objectives and research questions, finding a way of using the questionnaire scores to measure motivation levels, and sequencing the questions such that there was a relationship between the previous and the next question (see, Appendix C).

3.6.6 Validity of semi-structured interviews

Validity of the interviews was determined with the help of data that had been collected through the questionnaire. Since both the questionnaire and the semi-structured interviews were used to measure the motivation levels of learners in both the experimental and control groups, data from both instruments was compared to establish its validity. To achieve this, convergent validity was examined.

Convergent validity may be determined when data collected on the same variable from more than one instrument is compared (Johnson & Christensen, 2012). In other words, convergent validity is demonstrated when factors of a construct (motivation) are shown by indicators (interviews) and measures (questionnaire scores) to be related or similar to each other (Cohen *et al*., 2011). In this study the researcher used the same techniques to determine the validity of data collected through the semi-structured interviews (see, Section 4.2.3 & Section 4.2.4).

According to the questionnaire responses, 22% of the learners said they were motivated to learn Circle Geometry through computers, 45% were not motivated, 33% were not sure and therefore not motivated. In other words, 22% of the questionnaire responses were motivated, while 78% were not motivated. Also, 31% thought that CAI was a better teaching method while 76% did not think that CAI was a better teaching method to use in teaching Circle Geometry. Similarly, 33% of the interview responses preferred CAI while 67% did not prefer CAI. Therefore, the results of the questionnaire agreed (converged) with those of the interviews.

3.7 ETHICAL CONSIDERATIONS

According to McMillan and Schumacher (2010), educational research focuses primarily on human beings and as such the researcher is ethically responsible to protect the rights and welfare of participants in the study. In this regard, the researcher applied for ethical clearance from the University of South Africa's (UNISA) Ethics Clearance Committee, in accordance with the UNISA policy on ethics (see, Appendix N). After approval from the ethics committee, all parents signed informed consent forms to agree that their children would participate in the study, school principals of participating schools and the participating teacher also signed informed consent forms (see, Appendices E to L). In the letters, the researcher assured the parents, principals, teacher, and participating learners of confidentiality, anonymity, protection, voluntary participation and exit, before taking part in the study. Participant learners signed appropriate letters of assent. Also, the researcher applied to the Department of Basic Education (DBE) through the District Director to get permission to access participating schools, and to have access to departmental records and information on learner performance (see, Appendix M).

3.8 DATA COLLECTION

Data for the study was collected at two stages, namely: (1) during the pilot study stage; and, (2) during the implementation of a main study programme.

3.8.1 The pilot study

The pilot study was carried out using participants (n=71) from another township secondary school in Ekurhuleni North District of Gauteng province in South Africa. This is the same district in which sampled schools for the main study were drawn (see, Section 3.4). Therefore, even though the school at which the pilot study was conducted did not take part in the main study, it did project similar characteristics as the schools in the main study. These include being a township secondary school with Grade 11 learners, poor performance in Geometry, and a decrease in the number of learners who are doing Mathematics from 2008 to 2012. As schools in the main study, the school that participated in the pilot study was selected using a convenience sampling method (see, Section 3.4.2).

The researcher administered the pilot study at the beginning of the study, after school

hours. An arrangement was made between the teacher at the pilot school and the researcher, for the researcher to teach the selected classes using CAI. On day 1, learners wrote a 1 hour pre-test. On the second day the researcher assisted the learners to familiarise themselves with the GeoGebra computer software. As from day 3 to day 24 learners were taught 45 minute lessons using Computer Assisted Instruction (CAI). Learners worked individually on their computers and then discussed their solutions with their peers. They were provided with worksheets. The teacher moved around providing scaffolding, that is giving clues on which icon to use in order to draw lines like a chord, a tangent, parallel lines, solving examples similar to questions on the worksheet (Woolfolk, 2010), and where necessary demonstrating on the white board. However, learners were expected to act as real mathematicians by (re)inventing Circle Geometry while using the GeoGebra computer program. The first lesson was used to allow learners to familiarise themselves with the GeoGebra software. The software tells the user what to do in terms of drawing lines and shapes or measuring lines and angles.

On day 25 learners wrote a 1 hour post-test. However, the post-test was identical to the pre-test, that is, the same test was written twice. On day 26, a 30 minute questionnaire (Appendix C) was administered to learners (n=64). On day 27, the researcher interviewed a purposive sample of learners (n=3) using an interview schedule to determine the effect of Computer Assisted Instruction (CAI) on the motivation levels of learners. Interview sessions were also voice-recorded for analysis. The results of the questionnaire and semi-structured interviews in the pilot study were used to review the items in both instruments. For example the question, “would you say Computer Assisted Instruction has motivated you to learn Circle Geometry?” was re-structured into the three questions “I find learning Circle Geometry interesting, I enjoy learning the topic of Circle Geometry” and, “the Circle Geometry I learn is more important than the mark I receive” (see, Section 4.2.3; Appendix C).

In addition, the results from the pre-test and post-test of the pilot study were used to compute the t-test. The t-test was computed to determine whether there was a statistically significant difference between the average pre-test score and the average post-test score of learners in the pilot study. This procedure was chosen since two means obtained from one

group of learners in the pre-test and post-test could be calculated (McMillan & Schumacher, 2010).

3.8.2 The main study

The same procedures as those followed in the pilot study were followed when implementing the intervention programme in the main study. The only difference was that the main study included the control group in order to determine the comparative effect of the intervention instructions in teaching Circle Geometry. The control group did not feature in the pilot study since in the pilot study the aim was to develop reliable and valid instruments. Also, the teacher at the control school implemented CTI, (see, Section 3.3).

3.9 DATA ANALYSIS OF THE MAIN STUDY

3.9.1 Data collected from the test

In the current study, random assignment of learners into the experimental and control groups was not possible since normal lessons and other school activities had to continue. Therefore, the Analysis of Covariance (ANCOVA) was used to either reject or not reject the null hypothesis and the alternative hypothesis on Mathematics performance (see, Section 3.2). Johnson and Christensen (2012) define ANCOVA as "a control method that is used to statistically equate groups that differ on a pre-test or some other variable" (p. 293). In other words, the ANCOVA was selected because it serves the purposes of reducing within-group error variance and of eliminating confounds such as differences in intelligence between learners in the two groups before the pre-test (Field, 2012), in a quasi-experimental study where intact classes are used. May (2012) argues that ANCOVA estimates the expected differences in post-test scores between participants who started with the same pre-test.

Rejecting the null hypothesis on Mathematics performance and accepting the alternative hypothesis would mean that CAI that uses a socio-constructivist approach and CTI that uses a socio-constructivist approach have different effects on learner performance and on ability to instil in learners Cuoco *et al*.'s (1995) habits of the mind. Conversely, not rejecting the null hypothesis would mean that a socio-constructivist approach that uses CAI and one that uses CTI have no effect on learner performance.

3.9.2 Data collected from a questionnaire

The mean scores and the standard deviations for learners' Circle Geometry motivation questionnaire scores in both groups were calculated and analysed. The percentage of learners at each motivational level was also calculated and analysed in both groups. A double bar graph showing the percentage of learners on the vertical axis and motivation levels on horizontal axis was drawn and analysed for both groups (see, Section 4.3.2).

Rejecting the null hypothesis on learner motivation and accepting the alternative hypothesis would mean that CAI that uses a socio-constructivist approach and CTI that uses a socio-constructivist approach have different effects on learner motivation. Conversely, not rejecting the null hypothesis would mean that a socio-constructivist approach that uses CAI and one that uses CTI have no effect on learner motivation.

3.9.3 Data collected from the interviews

The data collected from the interviews was used to give a more detailed explanation of the results from the tests and the questionnaire (Creswell, 2012). This was done by comparing the results and making interpretations on whether they supported or contradicted each other. In another way, the interview responses were expected to strengthen the weaknesses of the results of the Circle Geometry achievement test and those of the Circle Geometry motivation questionnaire.

CHAPTER FOUR

DATA ANALYSIS

4.1 INTRODUCTION

The purpose of this study was to measure the comparable effects of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on the performance and motivation of learners, when doing a selected topic of Circle Geometry in Grade 11. The descriptions of both CAI and CTI are provided in Section 1.8.1 and Section 1.8.2, respectively. The two measurable dependent variables were learners' performance in a Grade 11 achievement test, and their motivation to do certain activities in Circle Geometry. The study investigated whether or not there was a statistically significant difference between the average Circle Geometry test scores of Grade 11 learners who participated in the CAI program and those who were subjected to CTI. In addition, the current study investigated whether or not there would be a notable difference in the motivation levels of Grade 11 learners who used CAI and those who used CTI in the topic of Circle Geometry. A non-equivalent control group design consisting of a pre-test, post-test, questionnaire, and interview to measure the comparative effects of CAI and CTI on the performance and motivation of Grade 11 learners was used in this study. The following null hypotheses and alternative hypotheses were cast for the study:

> **Null hypothesis on Mathematics performance (H_O):** There is no statistically significant difference between the average Mathematics performance scores of Grade 11 learners who participate in the Computer Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.
>
> **Alternative hypothesis on Mathematics performance (H_1):** There is a statistically significant difference between the average Mathematics performance scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI), in the topic of Circle

Geometry.

Null hypothesis on motivation (H_O): There is no significant difference between the average motivation scores of Grade 11 learners who participate in the Computer Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.

Alternative hypothesis on motivation (H_1): There is a significant difference between the average motivation scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI), in the topic of Circle Geometry.

4.2 DATA ANALYSIS FOR THE PILOT STUDY

In order to ensure that the data collection instruments used in the main study were reliable and valid, a pilot study was conducted. The data collection instruments that were used in the pilot study were a Circle Geometry test, a motivation questionnaire, and an interview schedule. The purpose of administering a pilot test was to use the pilot study observations to anticipate the possible outcome of the main study, to make adjustments to the test and the memorandum such as time allocation, wording of the test questions, and to determine alternative solutions to the questions in the test. The pilot test was also done to ensure that the test was reliable before it was used in the main study. The pilot questionnaire was used to compute the reliability of the questionnaire before it was administered in the main study. In the pilot study, the interview schedule was used to determine and improve the validity of the interview schedule.

4.2.1 Testing the Mathematics performance null hypothesis and alternative hypothesis for the study

The null and alternative hypotheses on Mathematics performance are presented in Section 4.1. The results of the pre-test and post-test were used to either preserve one of the hypotheses or reject one the hypotheses. The number of learners who wrote the pre-test and the post-test was 71 from a conveniently sampled pilot school. The researcher administered CAI, the pre-test, post-test, questionnaire and interviews (see, Section 3.8.1).

Marks from the pre-test and post-test were used to compute a t-test value. The t-test was used because two means could be obtained from one group of learners when administering the pre-tests and post-tests (McMillan & Schumacher, 2010). A t-value was computed at 2.186, which was greater than the critical value that was set at the 5% level (see, Figure 4.1).

Figure 4.1: Computation of the t-test value

$$t = \frac{\overline{D}}{\sqrt{\frac{\sum D^2 - \frac{(\sum D)^2}{N}}{N(N-1)}}}$$

$$t = \frac{1{,}265}{\sqrt{\frac{1881 - \frac{15376}{71}}{71(71-1)}}}$$

$$t = 2{,}186$$

Where,

$\overline{D}$ = mean difference for all pairs of scores;

$\sum D^2$ = sum of the squares of the differences;

$(\sum D)^2$ = square of the sum of the differences;

N = number of pairs of scores; and

$N-1$ = degree of freedom.

Given the results in Figure 4.1 the null hypothesis, which stated that there would be no statistically significant difference between the average pre-test score and average post-test score of Grade 11 learners before and after CAI on the topic of Circle Geometry was rejected with 95% confidence. The results obtained in the pilot study seemed to suggest that CAI was more superior as compared to CTI. In particular, the pilot study result further suggested that the methodology employed in this study would be workable in the main study.

4.2.2 Computing the reliability of the achievement test from the pilot results

The pre-test that was administered during the pilot study was used to compute the Spearman-Brown reliability value (r_{SB}) of the test. Since the pre-test scores were expected

to differ from the post-test scores due to the intervention (CAI) that was administered during the pilot study, the Spearman Brown formula was used "because it can estimate reliability from giving one form of a test once" (McMillan & Schumacher, 2010: 181), (see also, Section 3.6.1). Spearman Brown coefficient (r_{SB})ranges from 0 to 1.00 with values close to 1.00 indicating high consistency (Wells & Wollack, 2003). According to Cohen, *et al*. (2011), the Spearman Brown split-half coefficient follows the guidelines given below:

> 0.90 very reliable;
0.80 – 0.90 high reliable;
0.70 – 0.79 reliable;
0.60 – 0.69 minimally reliable; and
< 0.06 unacceptably low reliable.

A value of $r_{SB} = 0{,}82$ and therefore a good reliability of the test was obtained (see, Figure 4.2).

Figure 4.2: Steps to compute the reliability of the Geometry test for the study

$$r_{XY} = \frac{\sum(X - \bar{X})(Y - \bar{Y})}{\sqrt{(X - \bar{X})^2(Y - \bar{Y})^2}}$$

$$r_{XY} = \frac{691{,}26}{\sqrt{(794{,}36)(1267{,}29)}}$$

$$r_{XY} = 0{,}69$$

$$r_{SB} = \frac{2r_{XY}}{1 + r_{XY}}$$

$$r_{SB} = \frac{2(0{,}69)}{1 + 0{,}69}$$

$$r_{SB} = 0{,}82$$

Where,

r_{XY} *is Pearson Product Moment Correlation between the* 2 *halves of the test*;

X *is the learner'sscore on the first half of the test*;

$\bar{X}$ *is the mean score on the first half of the test*;

Y *is the learner'sscore on the second half of the test*;

$\overline{Y}$ *is the mean score on the second half of the test; and*

r_{SB} *is the Spearman – Brown value.*

4.2.3 Reliability of the questionnaire

The reliability of the questionnaire was computed from the questionnaire responses of the pilot study. The purpose of the questionnaire was to establish if Grade 11 learners' motivation levels were affected by using CAI or CTI in the topic of Circle Geometry. For the pilot study the questionnaire was administered to 64 participants. The participants' responses are presented in Table 4.1. The questionnaire items are also reflected in Table 4.1.

Table 4.1: Pilot study questionnaire responses

ITEM	QUESTIONNAIRE ITEM	PERCENTAGE RESPONSE DISTRIBUTION PER ITEM		
1	What is your feeling towards mathematics?	**1**	**2**	**3**
		I like maths 62%	Not sure 26%	I do not like maths 12%
2	Do you like the section of geometry of circles?	**1**	**2**	**3**
		Yes 38%	Not sure 24%	No 38%
3	How often do you practice geometry?	**1**	**2**	**3**
		More often 25%	Less often 70%	Not at all 5%
4	How would you prefer to learn geometry?	**1**	**2**	**3**
		With teacher 49%	With friend 34%	With computer 17%
5	What has been your average performance in geometry?	**1**	**2**	**3**
		Good 5%	Average 24%	Not good 71%
6	Which is your main source of accessing a computer?	**1**	**2**	**3**
		School 63%	Home 20%	Friend or other 17%
7	Did you like the idea of learning geometry through a Computer Assisted Instruction?	**1**	**2**	**3**
		Yes 37%	Not sure 40%	No 23%
8	Describe your level of participation during Computer Assisted Instruction.	**1**	**2**	**3**
		Minimal 29%	Average 36%	Maximum 35%
9	Do you think Computer Assisted Instruction is a better method to teach geometry	**1**	**2**	**3**
		Yes 31%	Not sure 26%	No 43%
10	Would you say Computer Assisted Instruction has motivated you to learn geo?	**1**	**2**	**3**
		Yes 22%	Not sure 33%	No 45%
11	Do you think learning with computer can improve your marks in geometry?	**1**	**2**	**3**
		Yes 35%	Not sure 22%	No 43%

The results in Table 4.1 were used to review the items in the questionnaire. This process involved reviewing the wording of the questions (see, Section 3.8.1), and increasing the number of items in the instrument so as to gather more information (see, Appendices C and D). To compute the reliability of the questionnaire responses in Table 4.1, the Cronbach's Alpha was used. This statistical technique was used because each questionnaire item had

more than one response (Johnson & Christensen, 2012; McMillan & Schumacher, 2010).

A day after writing the post-test, learners (n=64) from the pilot school responded to a questionnaire. The Cronbach's Alpha value (α) was calculated using the results of the questionnaire. A value of $\alpha = 0,759 > 0.7$, and therefore acceptable due to its closeness to 1.00 more than to 0 was obtained (see, Table 4.2; Section 3.6.2). The "Alpha if item deleted", which is the Alpha value that the questionnaire would have if that item is removed, was compared to the Alpha value at the bottom of the item-total statistics table to determine if the item could be deleted so as to increase the calculated Cronbach's Alpha value (see, Table 4.2). The number of items in the questionnaire was increased from 11 to 30 so as to increase the Alpha value and thus improve the reliability of the questionnaire (Cooper & Schindler, 2001, cited in Cohen *et al*., 2011; Johnson & Christensen, 2012).

Table 4.2: Computing the reliability of questionnaire items

Cronbach's Alpha	N of Items
0.759	11

Item Statistics			
	Mean	**Std. Deviation**	**N**
Item1	1.48	.690	64
Item2	2.23	.750	64
Item3	1.80	.510	64
Item4	1.94	.732	64
Item5	2.66	.570	64
Item6	1.55	.775	64
Item7	1.84	.761	64
Item8	1.83	.680	64
Item9	1.89	.715	64
Item10	2.11	.737	64
item11	1.80	.760	64

Item-Total Statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
Item1	19.64	9.345	.489	.752
Item2	18.89	8.226	.367	.853
Item3	19.33	9.589	.283	.762
Item4	19.39	9.791	.493	.772
Item5	18.47	8.666	.334	.806
Item6	19.08	8.172	.492	.770
Item7	19.28	8.142	.420	.749
Item8	19.30	10.434	.479	.782
Item9	18.23	8.928	.445	.821
Item10	19.02	8.238	.488	.752
item11	19.33	8.002	.457	.737

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
21.13	20.111	3.180	11

4.2.4 Validity of semi-structured interviews

A day after administering the questionnaire, the researcher interviewed a purposive sample of learners (n=3) using the interview schedule to determine the effect of Computer Assisted Instruction (CAI) on the motivation levels of learners. Participant learners were named A13, A19, and A20 for anonymity and confidentiality purposes. Validity of the interviews was determined by comparing the interview responses with the data that had been collected through the questionnaire. Since both the questionnaire and the semi-structured interviews were used to measure the motivation levels of learners in the pilot study, data from both instruments were compared to establish the validity of the interview schedule. To achieve this, convergent validity was examined (see, Section 3.6.6).

Some of the learner participants who were interviewed said they found Circle Geometry to be *"interesting, fun and helpful".* In the questionnaire, 38% of learners said they liked Circle Geometry, while 38% said they did not like it (see, Table 4.1). In addition, 62% of questionnaire responses suggested that respondents liked Mathematics, while 12% did not like Mathematics (see, Section 4.2.3). Three learners who were interviewed said *"Mathematics is fun, nice, beneficial, and is in everything we do every day".* Furthermore, 43% of the learners who responded to the questionnaire did not think that CAI was a better method to teach Circle Geometry at Grade 11, while 31% thought it was a better method. Similarly, two interviewees did not prefer CAI preferring the use of real objects instead, one interviewee preferred CAI.

> **A13:** *"Computers are not the same as teachers, if you don't understand you can ask a teacher but you can't ask a computer".*

A20: *"I do not prefer computers but we need objects for demonstrating and making circle geometry more practical".*

A19: *"I prefer to be taught the pilot way, the computer way".*

According to the questionnaire responses, 22% of the learners said they were motivated to learn Circle Geometry through computers, 45% were not motivated, 33% were not sure and therefore not motivated. In other words, 22% of the questionnaire responses were motivated, while 78% were not motivated. Also, 31% thought that CAI was a better teaching method while 76% did not think that CAI was a better teaching method to use in teaching Circle Geometry. Similarly, 33% of the interview responses preferred CAI while 67% did not prefer CAI. Therefore the results of the questionnaire agreed (converged) with those of the interviews.

4.3 DATA ANALYSIS FOR THE MAIN STUDY

The participants in the main study were n=136 learners and n=2 teachers. The experimental group consisted of n=71 learners, while the control group had n=65 learners. The researcher administered CAI to the experimental group and the other teacher administered CTI to the control group. This was done to ensure that similar conditions within the two groups were maintained. A pre-test and a post-test, which were both scored out of 50 marks, were administered before and after the interventions (CAI and CTI). In fact, the same test (out of 50 marks) was administered at pre- and post-stages of the experiment. Analysis of Covariance (ANCOVA) was used to either accept or reject the null hypothesis and the alternative hypothesis on Mathematics performance (see, Section 3.2), and to answer research question 1 and research question 2 (see, Section 1.5). The questionnaire scores and interview responses were used to answer research question 1, research question 3 (see, Section 1.5), and to either accept or reject the null hypothesis and the alternative hypothesis on motivation (see, Section 3.2).

4.3.1 Data analysis for test scores

Participants who wrote the pre-test were n=71 learners for the experimental group and n=65 learners for the control group. The researcher administered the pre-test and the post-

test in both groups to ensure similar conditions were maintained. Both the pre-test and the post-test were marked out of 50 marks each and were written within one hour. After administering the pre-test, it took three weeks to administer the interventions after which the post-test was administered.

Table 4.3: Mean and standard deviation of pre- and post-test scores in both groups

PRE-TEST	n	$\overline{x}$	SD	POST-TEST	N	$\overline{x}$	SD
EXPERIMENTAL GROUP	71	6.56	6.08	**EXPERIMENTAL GROUP**	71	32.35	7.64
CONTROL GROUP	65	5.45	5.52	**CONTROL GROUP**	65	27.12	9.66

Table 4.3 shows that the mean score of the experimental group increased by 25.79 (from 6.56 to 32.35), while the standard deviation of the experimental group increased by 1.56 (from 6.08 to 7.64). The mean score of the control group increased by 21.67 (from 5.45 to 27.12) while the standard deviation increased by 4.14 (from 5.52 to 9.66).

The mean score of the experimental group increased more than that of the control group indicating that learners' performance in the experimental group improved more than in the control group. The standard deviation of the experimental group had a smaller increase as compared to that of the control group indicating that the gap between learners who understood Circle Geometry and those who did not was bigger in the control group than in the experimental group.

Table 4.4 Analysis of covariance to analyse test scores in the main study

Dependent	Post-test
Sample size	136

Levene's test for equality of error variances

F	DF 1	DF 2	P
1.3802	1	134	0.242

Homogeneity of regression slopes

Source	Sum of Squares	DF	Mean Square	F	P
Heterogeneity of slopes	231.920	1	231.920	3.147	0.078
Individual residual	9728.704	132	73.702		

Tests of Between-Subjects Effects

Source	Sum of Squares	DF	Mean Square	F	P
Corrected model	1172.434	2	586.217	7.828	0.001
Intercept	52903.150	1	52903.150	706.393	<0.001
pre-test	244.588	1	244.588	3.266	0.073
group	831.082	1	831.082	11.097	0.001
Residual	9960.625	133	74.892		
Total	132336.000	136			
Corrected Total	11133.059	135			
Coefficient of determination R^2	0.1053				
R^2-adjusted	0.09186				

Estimated Marginal Means

Group	n	Mean	Std. Error	95% Confidence interval
control	65	27.2575	1.0760	25.1293 to 29.3857
experimental	71	32.2291	1.0293	30.1931 to 34.2650

Pairwise comparisons

Factors	Mean difference	Std. Error	P [a]	95% CI [a]
control - experimental	-4.9716	1.4924	0.0011	-7.9235 to -2.0196
experimental - control	4.9716	1.4924	0.0011	2.0196 to 7.9235

[a]Bonferroni corrected

Summary statistics for dependent variable and covariate(s)

Variable	Mean	Standard deviation
Post-test	29.8529	9.0811
Pre-test	6.0294	5.8676

Analysis of Covariance (ANCOVA) is a statistical method that removes confounding variables such as differences in intelligence between the experimental and control groups from the possible explanations of variances in the dependent variable (post-test). It is used in quasi-experiments such as the study that is reported in this dissertation where participants could not be randomly selected for participation in the study and further be assigned to experimental and control groups.

Table 4.4 shows that the Leneve's test for equality error variances was $= 0.242 > 0.05$. A value that is greater than 0.05 indicates that the homogeneity of variances assumption for ANCOVA has been met. Therefore, the homogeneity of variances assumption for ANCOVA was met in this study. In other words, the groups were homogeneous. The homogeneity of slopes was $P = 0.078 > 0.05$ (see, Table 4.4), showing that there was no interaction between the covariate (pre-test) and the independent variable (post-test). Therefore, it is reasonable to conclude that the ANCOVA results for this study were reliable. In addition, the results of the $F\ test$ support the effect of CAI in teaching the topic of Circle Geometry to Grade 11 learners $F\ (1\ ,133\ ) = 11.097, P < 0.05$ (see, Table 4.4). This shows that CAI is more superior as compared to CTI in teaching the topic of Circle Geometry in Grade 11. Hence the null hypothesis on Mathematics performance, in Section 3.2 was rejected and the alternative hypothesis was accepted.

The Bonferroni test is a post hoc test used to determine which means are significantly different when comparing more than two means. Since in this study only two means were compared, the post hoc test was not necessary because it gave a similar result to the $F\ test\ P = 0{,}001 < 0{,}05$. A statistical significant difference was therefore confirmed to exit between the average CAI score and the average CTI score; so the null hypothesis was rejected.

Therefore, learners taught using CAI performed better than those taught using CTI. It may also be argued that CAI was more appropriate in developing Couco *et al*.'s (1995) habits of the mind, Kilpatrick *et al*.'s (2001) and Hiebert and Lefvre's (1986) conceptual knowledge, and Skemp's (1976) relational understanding in Circle Geometry.

4.3.2 Data analysis for the questionnaire

The purpose of the questionnaire was to determine the effect of CAI and CTI on the motivation levels of Grade 11 learners towards Circle Geometry. Sixty six (n=66) learners from the experimental group and n=65 learners from the control group responded to the Circle Geometry motivation questionnaire. Learners responded to each of the 30 Circle Geometry motivation questionnaire items on a 5-point Likert scale, where *1=never*, *2=rarely*, *3=sometimes*, *4=often*, and *5=always*. The Circle Geometry motivation questionnaire maximum total score was 150 and the minimum score was 30. A learner's total Circle Geometry motivation questionnaire score was interpreted in the following way:

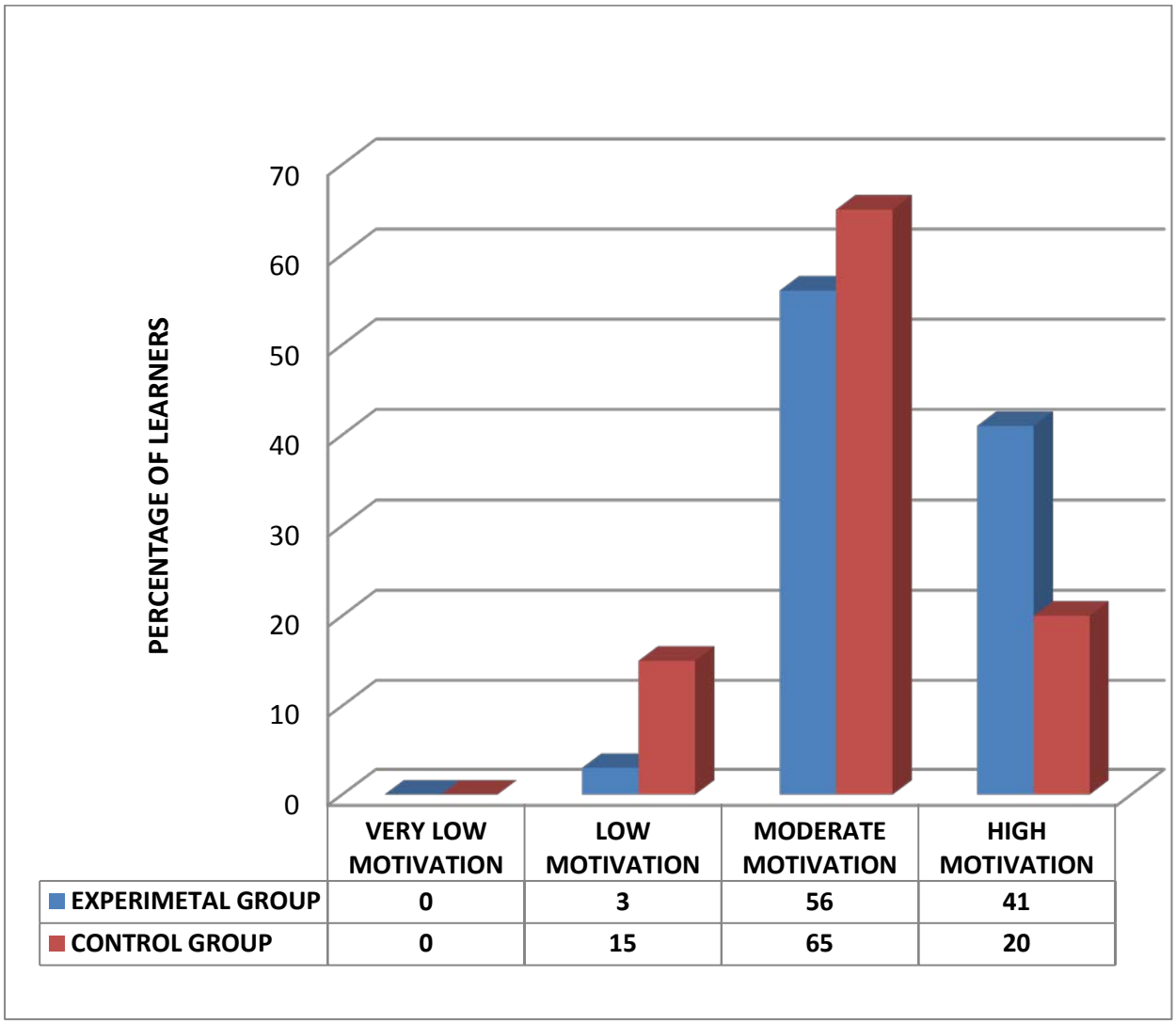
120-150 motivated "often to always" (high motivation)

90-119 motivated "sometimes to often" (moderate motivation)

60-89 motivated "rarely to sometimes" (low motivation)

30-59 motivated "never to rarely" (very low motivation)

Figure 4.3: Results of participants' levels of motivation in a double bar graph



	VERY LOW MOTIVATION	LOW MOTIVATION	MODERATE MOTIVATION	HIGH MOTIVATION
EXPERIMETAL GROUP	0	3	56	41
CONTROL GROUP	0	15	65	20

The results in Figure 4.3 show that none (0%) of the respondents from the experimental group experienced very low motivation. Furthermore, Figure 4.3 shows that n=2 (3%) respondents had low motivation, n=37 (56%) had moderate motivation, while n=27 (41%) had high motivation. The mean motivation score for the experimental group was 115 out of 150 (77%), representing moderate motivation experienced by participants in this group. The standard deviation of the same group was computed at 12.96.

In the control group the questionnaire was administered to n=65 respondents. In Figure 4.3, none (0%) of the control group respondents experienced very low motivation. In addition, n=10 (15%) had low motivation, n=42 (65%) had moderate motivation, and n=13 (20%) had

high motivation in the control group. The mean motivation score for the control group was 106 out of 150 (71%), representing moderate motivation. The standard deviation was 15.17 for this group.

Even though both the mean motivation scores and the standard deviations suggest that the difference in the motivation levels of the two groups is not that much, the double bar graph shows that double the number of learners in the experimental group (41%) than in the control group (20%) had high motivation. In addition, five times the number of learners in the control group (15%) than in the experimental group (3%) had low motivation.

Hence, the null hypothesis on motivation (see, Section 3.2) was rejected and the alternative hypothesis was accepted. In other words, socio-constructivism that used the computer software, GeoGebra, as the teaching and learning tool motivated learners more than socio-constructivism that did not use the computer software.

4.3.3 Data analysis for the interviews

To ensure anonymity and confidentiality for the interview respondents, the following identification codes were used for the respondents in the experimental group: E1, E2, E3, E4, E5 and E6, where the notation E1 stood for the first interviewee in the experimental group (E). Also, in the control group the following codes were designated to the interviewees: C1, C2, C3, C4, C5 and C6. The letter "C" in the preceding codes represented the control group, and the attached numerical to each letter C represented the order in which the interviews were conducted (first interviewee C1, second interviewee C2, and so on). The choice of interview participants was purposive in nature (see, Section 3.5.3 for the criterion used for selection). The interviewee respondents were selected as follows: (1) Respondents E1, E2, C1, and C2 had obtained the lowest post-test scores (0-14); (2) respondents E3, E4, C3 and C4 had obtained average post-test scores (25-29); and, (3) respondents E5, E6, C5 and C6 had obtained the highest post-test scores (40-50).

When the experimental group respondents were asked if they enjoyed Circle Geometry before they were introduced to CAI, E6 and E5 responded that they did not enjoy it because "*we don't use computers so often*", and "*circle geometry was difficult and complicated*".

Responding to the same question, after the treatment (implementation of CAI), E4 said "*it was difficult but with computers it was easy*". However, E2 said "*I was enjoying circle geometry before CAI was introduced because teachers explained and we understood*", suggesting that the motivation that E2 had towards the topic of Circle Geometry was not necessarily as a result of the treatment. When participants in the control group were asked if they enjoyed Circle Geometry before they were introduced to CTI (Conventional Teaching Instructions), C1, C4, C5, and C6 said they did. In particular, C2 said "*sometimes*", while C3 said "*it was difficult and challenging*".

In addition, when asked to provide their feelings about CAI the respondents in the experimental group provided the following responses:

> **E1:** "*Circle geometry was difficult but computers made it easy to understand, they do not waste time and they make the job easy*".
>
> **E2:** "*CAI is better than other methods, you are independent, you follow stuff and you develop skills*".
>
> **E3:** "*I prefer computers because it's easy, you have material the computer tells you what to do and you just click, unlike in class where you have to think*".
>
> **E4:** "*I used to think that I was a lower learner but CAI is the best way that is easier, simpler, it is different from the class and we can discuss with other learners*".
>
> **E5:** "*CAI has helped me to improve step by step, it attracts us, explains better than textbooks, and it is interesting*".
>
> **E6:** "*We are not used to computers, they are fun, enjoyable, understandable, and easier than in class because on the computer you just press and draw, the computer assists you in finding angles and lengths, than in class*".

In addition to the above responses, E3 alluded, "*it is much easier to explain to other learners using the computer because it is broad and clear*". When asked how they felt about using CTI and Circle Geometry (see, Appendix C), C1 seemed to suggest that it was fine but further emphasised that CTI could be improved. Responding to the same question C2 said CTI was "*good*" even though she did not get it right (referring to understanding this topic and also giving a good performance to it). In addition, C3, C4, C5 and C6 indicated that CTI was good and "*helpful*" as they felt it helped them to understand Circle Geometry better than it was the case before.

On the idea of using CAI to teach the topic of Circle Geometry in Grade 11, the following responses emerged from the experimental group:

E1: "*It should have started in Grade 8*".

E3: "*Computers should be used when writing tests*".

E4: "*For questions that you don't understand you can go to the computers, and discuss*".

E5: "*Teachers should take us to the computer laboratory to learn more circle geometry using computers*".

E6: "*I hope our teacher can continue to use CAI after this study has ended*".

Regarding the same question about using CTI to teach the topic of Circle Geometry in Grade 11, C1 said it was fine but could be improved if other teachers also came to teach them the sections of this topic which were difficult for them to understand. In addition to the initial response, C1 further proposed the "*use of the internet to improve CTI, group work, and motivating learners by showing them the importance of circle geometry*", thus acknowledging the value of using technology to enhance comprehension and performance in the topic of Circle Geometry. Responding and providing extra views to the same question C2 and C4 suggested for more learner participation in a CTI lesson, highlighting the

importance of placing learners in groups where the bright ones would teach their slow-learning group mates. The response of C3 to this interview item suggested that CTI could be more "*practical*" if real objects had been used to demonstrate situations. Finally, C6 suggested that learners had to use different textbooks for them to understand.

Data coding of participants' interview responses (Cohen *et al*., 2011; Gay *et al*., 2011; McMillan & Schumacher, 2010) emerged with the following patterns: E1, E2, E3, E4, E5, and E6 felt that computers made Circle Geometry lessons to be interesting, easier, and interactive. Similar results were obtained from studies carried out by Keaney (2012), Mansukhani (2010), Geiger *et al*. (2008) and D'Souza (2005). On the contrary, the pattern observed from C1, C2, C3, C4, C5, and C6's responses was that CTI needed some improvements.

4.4 SUMMARY AND CONCLUSION OF THE CHAPTER

The purpose of this study was to compare the performance and motivation of Grade 11 learners who received Computer Assisted Instruction (CAI) to those who received Conventional Teaching Instructions (CTI). Data were collected using a pre-test, a post-test, a questionnaire and an interview schedule. The pre-test and post-test scores were analysed using ANCOVA with the pre-test as the covariate and the post-test as the dependent variable. At a 0.05 level of significance, there was a statistically significant difference in the Circle Geometry performance of learners who received CAI and those who received CTI, with learners who received CAI performing better than those who received CTI. The Circle Geometry motivation scores and the interview responses pointed to the fact that CAI motivated learners more than CTI in the topic of Circle Geometry.

In other words, the socio-constructivist approach that used the computer software GeoGebra as its "cultural tool" proved to be superior to the one that did not use the computer software.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5.1 INTRODUCTION

In this chapter, a discussion on the summary of literature review, the study results, and conclusions for the study is presented. The results of the study are discussed and interpreted in terms of the theoretical framework and the research questions. The chapter is concluded by highlighting suggestions for future related research.

5.2 SUMMARY OF LITERATURE REVIEW

Many South African secondary school learners find Circle Geometry to be a difficult and challenging topic. While analysing the Grade 12 final examination paper 2 results for 2012 and 2011, Chauke (2013) and Cassim (2012) respectively observed that learners had challenges in solving problems that required them to interpret, explain or justify. Most of the errors that were made in answering some of the items in this paper could be traced back to poorly developed spatial perception impeding the solving of two-dimensional (2D) and 3D problems (Cassim, 2012; Chauke, 2013). Mansukhani (2010) attributes the low success rate in Geometry by learners to lack of confidence and competence in Mathematics.

The decreasing number of learners taking Mathematics in South African secondary schools and the poor quality passes in Mathematics over the years may be attributed to demotivation caused by teaching methods that are used to teach “difficult topics” such as Circle Geometry (Cassim, 2012; GDE, 2010; Ngobese, 2013). Beres (2011) proposed that one of the reasons for learner demotivation may be the teaching method used to teach a topic. Therefore, the aim of the current quasi-experimental study was to investigate the comparative effects of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on the performance and motivation of Grade 11 learners in the selected topic of Circle Geometry. According to D’Souza (2005), there are not many technology-related research studies in Mathematics.

Furthermore, the review of literature indicated mixed views on the effects of CAI and CTI on the performance and motivation of learners with more research being called for. Bayturan (2012), Jackson (2005), Lin (2008), Lindsey (2005) and Trexler (2007) in their studies concluded that CAI was more effective than CTI in improving learner performance. However, Rha and Richardson (1986), Shoemaker (2013), Spradlin (2009), Teal (2008) and Tucker (2009) in their studies concluded that there was no statistical difference between CAI and CTI in improving learner performance.

In their studies, Keaney (2012) and Teal (2008) concluded that CAI was effective in motivating learners, while Shoemaker (2013) and Bayturan (2012) concluded that there was no difference between CAI and CTI in motivating learners. The current study concluded that CAI that uses GeoGebra as a software is effective in motivating and improving Grade 11 learners' performance in Circle Geometry as compared to CTI.

5.3 FINDINGS

In the current study, n=136 learners participated. The experimental group consisted of n=71 learners while the control group consisted of n=65 learners.

5.3.1 Research question 1

How can Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) be used in the teaching of Grade 11 Circle Geometry?

Evidence from the interviews showed that experimental learners felt that CAI allowed them to discuss with each other; be more involved in solving Circle Geometry problems; and they felt more independent (see also, Section 4.3.3). E2 and E4 had this to say about CAI:

> **E2:** "*CAI is better than other methods, you are independent, you follow stuff and you develop skills*".

> **E4:** "*I used to think that I was a lower learner but CAI is the best way that is easier, simpler, it is different from the class and we can discuss with other learners*".

On the other hand, CTI learners felt that their participation in the class was limited. Therefore, it may be argued that CAI was better in implementing socio-constructivism as compared to CTI. In other words, CAI proved to be more appropriate in developing socio-constructivist habits of the mind (Cuoco *et al*., 1995) and Circle Geometry internal representational systems (Goldin, 2002, 1998) as compared to CTI (see also, Section 2.6.2).

In this regard, it may be argued that CAI that was used as a dynamic geometry technology (Olive, 2000), played an interactive role with the participants (Geiger *et al*., 2008), which made learning "enjoyable" (D'Souza, 2005), thus providing room for the creation of conceptual knowledge (Kilpatrick *et al*., 2001; Hiebert & Lefevre, 1986) and relational understanding (Skemp, 1976).

5.3.2 Research question 2

Is there a statistically significant difference in the average pre-test and post-test performance scores of Grade 11 learners taught Circle Geometry using CAI and those taught using the CTI?

The following were the null hypothesis and alternative hypothesis on Mathematics performance:

> **Null hypothesis on Mathematics performance (H_O):** There is no statistically significant difference between the average Mathematics performance scores of Grade 11 learners who participate in the Computer Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.
>
> **Alternative hypothesis on Mathematics performance (H_1):** There is a statistically significant difference between the average Mathematics performance scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI), in the topic of Circle Geometry.

The mean score of the experimental group increased by a bigger margin (25.79) as

compared to the mean score of the control group (21.67) (see, Section 4.3.1). This meant that from the pre-test to the post-test, learners in the experimental group improved more than learners in the control group.

In the pre-test, the standard deviations of both groups of learners were almost the same, (see, Section 4.3.1). However, in the post-test, the standard deviation of the control group (9.66) was bigger than that of the experimental group (7.64). This is an indication that the marks of the experimental learners were closer together than those of the control learners. In other words, the gap between learners who understood and those who did not understand was bigger in the CTI group as compared to the CAI group.

The Analysis of Covariance (ANCOVA) results showed that there was a statistically significant difference between the average Mathematics performance score of Grade 11 learners who were taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI), in the topic of Circle Geometry (see, Section 4.3.1). In another way, learners who received CAI performed better than those who received CTI.

The results of the current study complement those of Bayturan (2012), Jackson (2005), Lin (2008), Trexler (2007) and Lindsey (2005) who in their studies also concluded that CAI was more effective than CTI in improving learner performance. Therefore CAI may be argued to be a possible solution to the poor performance of learners in Geometry, and Mathematics as observed by Ngobese (2013), Chauke (2013), Cassim (2012), GDE (2010) and Mansukhani (2010).

5.3.3 Research question 3

How does CAI or CTI affect the motivation levels of Grade 11 learners in the topic of Circle Geometry?

The following were the null hypothesis and alternative hypothesis on motivation:

> **Null hypothesis on motivation (H_O):** There is no significant difference between the average motivation scores of Grade 11 learners who participate in the Computer

Assisted Instruction (CAI) program and those who do not, in the topic of Circle Geometry.

Alternative hypothesis on motivation (H_1): There is a significant difference between the average motivation scores of Grade 11 learners who are taught using Computer Assisted Instruction (CAI) and those taught using Conventional Teaching Instructions (CTI), in the topic of Circle Geometry.

Figure 4.3 shows that the experimental group had double (41%) the percentage of learners who had higher motivation than the control group (20%). The control group had a slightly higher percentage (65%) of learners who felt moderate motivation than the experimental group (56%) and five times (15%) the percentage of lowly motivated learners than the experimental group (03%). The mean motivation scores of both the experimental and control groups showed moderate motivation of 77% and 71% respectively. The standard deviations were almost the same, the experimental group having a standard deviation of 12.96 while the control group had a standard deviation of 15.17 (see, Section 4.3.2).

The results of the interviews agreed with the results of the questionnaire in that the experimental group felt that CAI was a better teaching method than CTI, and they enjoyed it. Learners in the control group felt that CTI could be improved if the teacher used groups, whereby bright learners assisted the slow learners. Other suggested improvements to CTI included the use of the internet by the teacher to continuously communicate with learners when they are at home, use of different textbooks and different teachers, allowing learners to go in front of the class and demonstrate their solutions to other learners, and motivating learners by showing them the importance of Circle Geometry in real life. Learners in the experimental group felt that CAI made Circle Geometry easier and understandable (see also, Section 4.3.3).

In accordance to the socio-constructivist perspective, learners in the experimental group felt "independent" to facilitate and develop their own solutions to Circle Geometry problems. They showed confidence and were more "interested" in Circle Geometry than before. This led them to request their teacher to continue using CAI after the end of the study. On the

other hand, learners in the control group felt that their participation during lessons was limited and they wished if it could be improved through peer teaching, group discussions, and using different teachers as they may come up with alternative teaching methods.

CAI proved to be effective in motivating learners in the topic of Circle Geometry. Similar results were obtained by Keaney (2012) and Teal (2008). Therefore, the teaching method used by a teacher is one of the reasons for learner demotivation in Mathematics (Beres, 2011).

5.5 CONCLUSIONS

The aim of the current study was to investigate the effect of Computer Assisted Instruction (CAI) and Conventional Teaching Instructions (CTI) on the performance and motivation of Grade 11 learners in Circle Geometry. The results of this investigation indicated that the use of the computer software, GeoGebra, in the teaching and learning of Circle Geometry improved the performance and motivation of Grade 11 learners. The software allowed learners to have an active role in solving Circle Geometry problems by drawing their own diagrams, measuring lines and angels, as they interacted with the computers and with each other. Computers provided a more socio-constructivist environment (see, Section 2.6.2) than CTI.

According to the results of the current study, the socio-constructivist learning environment provided by CAI improved learner motivation which in turn resulted in improved habits of the mind, conceptual knowledge and relational understanding, which then improved the Circle Geometry performance of learners.

5.6 RECOMMENDATIONS

The following recommendations were made:

5.6.1 More studies, using a bigger sample size, on the effect of CAI in teaching Circle Geometry in Grade 11 should be carried out so that the results can be generalised to all secondary schools in South Africa;

5.6.2 Computers in schools should be installed with Mathematical software that promote a socio-constructivist approach (see, Section 2.6.2), not just drill and practice;

5.6.3 Both teachers and learners should be trained on how to effectively use computers in Circle Geometry and other Mathematics topics with confidence; and,

5.6.4 Learners who would have used computers to solve Circle Geometry and other Mathematics problems should be allowed to use computers when writing Mathematics tests since it is these technologies that they will encounter at the workplaces.

5.7 SUMMARY AND CONCLUSION OF THE CHAPTER

The low performance of learners in Mathematics and Geometry has led the Department of Basic Education (DBE), teachers, and researchers to explore alternative methods of teaching to the CTI that have been used for many years in secondary schools. CAI, with appropriate software is one of the alternative methods of teaching that has the potential of improving the performance and motivation of learners in Circle Geometry and in Mathematics as it allows every learner to be actively involved in the creation of their own knowledge and understanding, as they draw lines and shapes, measure angles and lines, create, and solve their own Mathematical problems.

The study was conducted in township secondary schools, in Ekurhuleni North District of Gauteng province in South Africa. The purpose of the study was to investigate the effect of using CAI and CTI to teach Circle Geometry in Grade 11. The results of the study showed that learners who received CAI performed better and were motivated more than those who received CTI.

Teachers should vary their methods of teaching as a way of motivating and accommodating the post-modern learners, within heterogeneous classes. The five strands of Mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick *et al*., 2001), relational and instrumental understanding (Skemp, 1976), are intertwined and may only be develop in learners if

teachers first develop their own relational understanding of teaching methods, and knowledge of when and how to use a variety of teaching methods.

Recommendations for further studies include replicating the study with a larger sample and in other Mathematics topics; comparing the performance and motivation of males to females, rural schools to township schools; and investigating the effects of other new technologies such as tablets and *I pads* in teaching and learning of Mathematics. Just as calculators are used during examinations, the DBE should also consider developing ways of allowing learners who would have learnt using certain technologies to write examinations using them because they are the same gadgets that are used in the world of work.

6. REFERENCES

Artzt, A. F., & Armour-Thomas, E. (1998). Mathematics teaching as problem solving: A framework for studying teacher metacognition underlying instructional practice in mathematics. *Instructional Science, 26*(1-2), 5-25.

Barrow, L., Debraggio, E., & Rouse, C. E. (2008). Failing in mathematics. *Can computers help teachers teach math?* Retrieved February 2, 2012, from http://voxeu.org/index.php?q=node/2722.

Bayturan, S. (2012). The effect of Computer-Assisted Instruction on the achievement and attitudes towards mathematics of students in mathematics education. *International Journal of Global Education, 1*(2), 50-57.

Beres, P. J. (2011). *Project-Based learning and its effect on motivation in the adolescent mathematics classroom*. Master of Science in Education thesis. New York: State University of New York.

Berkhout, S. J. (2010). Curriculum futures in South Africa. In: Lemmer, E. M., & Van Wyk, J. N. (Ed). 2010*. Themes in South African education for the comparative educationist.* South Africa: Pearsons Education: pp. 1-20.

Brandt, C. (2010). Curriculum futures in South Africa. In: Lemmer, E. M. & Van Wyk, J. N. (Ed). 2010*. Themes in South African education for the comparative educationist.* South Africa: Pearsons Education: pp. 141-162.

Brent, E. P. (2008). *Practical use of Computer Assisted Instruction program to support teaching and learning Mathematics*. Master of Arts in Teaching Mathematics thesis: California State University Dominguez hills.

Bryan, R. R. (2009). *High-school students' motivation to learn science: validation of the science questionnaire*. Doctoral Dissertation. Athens: University of Georgia.

Cassim, I. (2012). Gauteng Department of Education (GDE). *Mathematics road show*. Grade 12 Mathematics Paper 2.

Center for Implementing Technology in Education (CITEd). (2005). K-8 Screen-based Technology to support Mathematics. Retrieved February 18, 2012, from http://www.cited.org/index.aspx?page-id=86.html.

Chauke, W. B. (2013). Gauteng Department of Education (GDE). *Mathematics road show*. Grade 12 Mathematics Paper 2.

Clarkson, P., & Atweh, B. (2003). In mathematics education research: Innovation, networking, opportunity. *Proceedings of the 26th Annual Conference of the mathematics education research group of Australasia*. Deakin University, Geelong, 6th – 10th July 2003. 1 238-244.

Cobb, P., Yackel, E., & Wood, T. (1992). A Constructivist Alternative to the Representational view of mind in mathematics education. *Journal for Research in Mathematics Education, 23*(1), 2-33.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. Seventh Edition. Routledge.

Creswell, J. W. (2012). Educational Research. *Planning, conducting, and evaluating quantitative and qualitative research.* Fourth Edition. Pearson Education, Inc.

Cuoco, A., Goldenberg, E. P., & Mark, J. (1995). Habits of Mind: *An Organising Principle for Mathematics Curriculum*. Retrieved April 3, 2013, from http://www2.edc.org/cme/showcase/HabitsOfMind.pdf.

Department of Basic Education. (2012). Curriculum Implementation and Quality Improvement. *CAPS orientation Grade 11. Mathematics.* Pretoria.

Department of Basic Education. (2011). National Curriculum Statement (NCS). Curriculum and Assessment Policy Statement*. Further Education and Training Phase Grades 10-12*. Mathematics. Pretoria.

Department of Education. (2003). National Curriculum Statement Grades 10-12 (General) Mathematics. Pretoria.

Dhlamini, J. J. (2012). *Investigating the effect of context-based problem solving instruction on the performance of learners.* Unpublished doctoral dissertation. University of South Africa, Pretoria, South Africa. Available from http://hdl.handle.net/10500/9739.

Diamond, R. W. (2012). *Middle school students' perceptions of how teacher practices affect their motivation to learn algebra 1*. Master of Science thesis*.* California: California State University, Chico.

D'Souza, S. M. (2005). *An examination into the effect of incorporating collaborative learning methods in a core first year mathematics subject*. Doctoral thesis. University of Technology, Sydney NSW, Australia.

Field, A. (2012). Discovering statistics: *Analysis of Covariance (ANCOVA).* Retrieved May 2,

2013, from http://www.statisticshell.com/docs/ancova.pdf.

Gauteng Department of Education. (2010). Gauteng Mathematics, Science and Technology Education Improvement Strategy 2009-2014. Retrieved April 23, 2013, from http://www.nstf.org.za.

Gay, L. R., Mills, E., & Airasian, P. (2011). Educational Research: *Competencies for analysis and application.* (Tenth Edition). Upper Saddle River. NJ: Pearson Education.

Geiger, V., Faragher, R., Redmond, T., & Lowe, J. (2008). Computer Algebra Systems (CAS) enabled devices as provocative agents in the process of mathematical modelling. *'Navigating currents and charting directions: proceedings of the 31st annual conference of mathematics education research group of Australia'*, 1, 219-226. Retrieved May 6, 2013, from http://www.merga.net.au/documents/RP232008.pdf.

Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. *Paper presented at the Midwest research to practice conference in adult, continuing, and community education*. Columbus, OH, 8-10 October.

Goldin, G. A. (2002). Representation in mathematical learning and problem solving, from *Handbook of International Research in Mathematical Education*, English, L. D (ed), pp. 197-218.

Goldin, G. A. (1998). Representational systems, learning, and problem solving in mathematics. *Journal of Mathematical Behaviour, 17*(2), 137-165.

Goldman, W. M. (2007). What is a projective structure? *Notices of the AMS*, 54(1), 30-33. Retrieved May 2, 2013, from http://www.ams.org/notices/200701/what-is-goldman.pdf.

Groom, D. (2012). Evolvability: *a world of persistent ambient digital culture,* 31(1), 14-17. Retrieved April 1, 2013, from http://o-search.informit.com.au.oasis.unisa.ac.za/fullText;dn=191033;res=AEIPT.

Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in Mathematics: An introductory analysis. In: Hiebert, J. (Ed). 1986. *Conceptual and procedural knowledge: The case of Mathematics.* Routledge. Taylor and Francis Group: pp 1-23

Hlalele, D. (2012). Exploring rural high school learners' experience of Mathematics anxiety in academic settings. *South African Journal of Education*, 32, 267-278.

Honan, E. (2012). 'A Whole New Literacy'*: teachers' understanding of students' digital*

learning and literacy, 35(1), 82-98. Retrieved April 1, 2013, from http://o-search.informit.com.au.oasis.unisa.za/fulText:dn=18991:res=AEIPT.

Jackson, B. J. (2005). *The impact of Computer-Assisted Instruction on the mathematics achievements of elementary school children grades three through to six*. Doctoral dissertation. Texas: Texas Southern University.

Johnson, B., & Christensen, L. (2000). *Educational Research. Quantitative and Qualitative Approaches.* United States: Pearson Education, Inc.

Johnson, B., & Christensen, L. (2012). *Educational Research. Quantitative, Qualitative, and Mixed Approaches.* Fourth Edition. United States: SAGE Publications, Inc

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *American Educational Research Association, 33*(7), 14-26.

Keaney, E. A. (2012). *Seventh Grade Students' Perceptions of Motivation Factors in the Mathematics Classroom*. Doctoral thesis. Mercer University.

Keengwe, J. (2013). Research Perspectives and Best Practices in Educational Technology Integration. I G I Global, Pennsylvania. Retrieved March 30, 2013, from http://my.unisa.ac.za.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds). (2001). Adding it up: Helping children learn Mathematics. *National Research Council.* Learning Study Committee, Centre for Education, Division of Behavioural and Social Sciences and Education. Washington, DC: National Academy Press.

Lin, C. (2008). Beliefs about using Technology in the mathematics classroom: Interviews with pre-service elementary teachers. *Eurasia Journal of Mathematics, Science, & Technology Education, 4*(2), 135-142.

Lindsey, B. H. (2005). *The effect of computers on the Mathematical achievement of American 8th Grade students.* Doctoral Dissertation. George Mason University.

Makgato, M., & Mji, A. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physics. *South African Journal of Education, 26*(2), 253-266.

Malkevitch, L. (2013). Finite Geometry? Feature column monthly essays on mathematical topics. American mathematical society. Retrieved May 2, 2013, from http://www.ams.org/samplings/feature-column//fcarc-finitegeometries.

Mamba, A. (2012). *Learners' errors when solving Algebraic tasks: A case study of Grade 12*

mathematics examination papers in South Africa: Masters Dissertation. Johannesburg. University of Johannesburg.

Manuel, O (Ed)., & Jose, B. (2002). Computers and Education in the 21st Century. Kluwer Academic Publishers/ Dordrecht/ Boston/ London. Retrieved March 30, 2013, from http://my.unisa.ac.za

Marsden, N., & Piggot-Irvine, E. (2012). Using Blogging and Laptop Computers to improve writing skills on a Vocational Training Course. *Australasian Journal of Educational Technology, 28*(1), 30-47. Retrieved March 31, 2013, from http://www.ascilite.org.au/ajet/ajet28/marsden.pdf.

Marr, B., & Hagston, J. (2008). Thinking beyond numbers: Learning numeracy for the future workplace. [online]. Literacy Link: v.28 n. 3 p. 8-9; June 2008. Retrieved August 4, 2014, from http://o-search-informit.com.oasis.unisa.ac.za/fullText:dn=169653:res=AEIPT>ISSN:158-3028.

Mansukhani, V. P. (2010). *Identifying with mathematics: the effects of conceptual understanding, motivation and communication on the creation of a strong mathematical identity.* Master of Arts thesis. San Diego: University of California.

May, H. (2012). Non-equivalent comparison group designs. *APA Handbook of research methods in psychology*, 2, 489-509. doi: 10.1037/13620-026

Mcmillan, J. H., & Schumacher, S. (2010). Research in education: *evidence-based inquiry*. 7th edition. International edition. Boston: Pearson Education Inc.

Middleton, J. A. (2004). Globalisation and identity in mathematics education research: An essay. *Eurasian Journal of Education Research*, 16, 8-14.

Namukasa, I. (2004). School mathematics in the era of globalization. *University of Alberta Journal,* 35(2), 209-227.

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

Ngobese, C. N. (2013). *Improving the quality of matric learner performance in mathematics and science in Gauteng*. Master's thesis. Witwatersrand University. South Africa.

Olive, J. (2000). Implications of using Dynamic Geometry Technology for Teaching and Learning. *Paper for Conference on Teaching and Learning Problems in Geometry*. Fundao, Portugal: 6-9 May 2000. The University of Georgia. USA.

Ornstein, A. C., & Hunkins, F. P. (2009). Curriculum: *Foundations, Principles, and Issues*. Fifth

Edition. United States: Pearson Education, Inc.

Paulsen, R. (2009). *The School Mathematics Curriculum and Effective Classroom Practice. Only Study guide for HBEDAIQ.* Pretoria: University of South Africa.

Pilli, O. (2008). *The effect of Computer-Assisted Instruction on the achievement, attitude, and retention of 4th grade mathematics course*. Doctoral thesis. Middle East Technical University.

Probyn, M. (2009). Smuggling the vernacular into the classroom. Conflicts in township/ rural school in South Africa. *International Journal of Bilingualism, 12*(2), 123-136.

Ramani, P., & Patadia, M. (2012). Computer Assisted Instruction in teaching of mathematics. *IOSR Journal of Humanities and Social Science, 2*(1), 39-42.

Rha, I., & Richardson, K. (1986). The Effect of Computer-Assisted Instruction on Mathematics Achievement of Fourth Graders. Retrieved February 27, 2012, from http://www.indiana.edu/~jeopeng/y603/rep2.html.

Shann, W. (2006). English Translation of Taiwan math curriculum guidelines for Grades 1-9, 2003. Taiwan.

Shoemaker, T. L. (2013). *The effect of computer-aided instruction on attitude and achievement of fifth grade math students*. Doctoral Dissertation. Liberty University, Lynchburg, VA.

Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20-26.

Skemp, R. R. (1962). The psychology of learning and teaching Mathematics. *United Nations Educational, Scientific and Cultural Organisation*. (UNESCO).

Slattery, P. (2006). *Curriculum Development in the postmodern era.* New York/ Abingdon: Routledge, Taylor & Francis Group.

Spradlin, K. D. (2009). *The effectiveness of Computer-Assisted Instruction in developmental mathematics*. Doctoral Dissertation. Liberty University.

Subrahmany, K., Greenfied, P., Kraut, R., & Gross, E. (2001). The impact of computer use on children's and adolescents' development. *Applied Development Psychology, 22*(2001), 7-30.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(1), 257-285.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design.

Learning and Instruction, 4(1), 293-312.

Tachie, S. A., & Chireshe, R. (2013). High failure rate in mathematics examinations in rural senior secondary school in Mthatha district, Eastern Cape: Learners' attributions. *Stud Tribes Tribals, 11*(1), 67-73.

Teal, B. D. (2008). *A comparative analysis of modes of instruction using student test scores in developmental mathematics*. Doctoral Dissertation. Morgan State University.

Trexler, A. W. J. (2007). *A study to determine the effectiveness of Computer-Assisted Instruction on the mathematics achievement levels of learning disabled elementary students*. Doctoral Dissertation. Orangeburg, South Caroline State University.

Tucker, T. H. (2009). *The relationship between Computer-Assisted Instruction and alternative programs to enhance 5th Grade mathematics success on the annual Texas assessment of knowledge and skills*. Doctoral Dissertation. University of North Texas.

Udofa, A. I., & Udo, I. E. (2012). Globalisation and its influence on mathematics education in secondary schools in Akwa Ibom state, Nigeria. *International Journal of Social Sciences and Education, 2*(4), 554-554.

University of South Africa. (2011). *Analyse Modelling in School Mathematics*. *Only study guide for HBEDAMU.* Pretoria.

University of South Africa. (2011). Teaching and Learning. *Tutorial Letter HBEDTL6/001.* Pretoria.

University of South Africa. (2011). Theory and Research in Education: *HBEDTRD, Tutorial Letter 001/2011*. Pretoria.

Van Niekerk, M. P. (2010). Values and Ideologies in Education. In Lemmer, E. M., & Van Wyk, J. N. (Ed). 2010. *Themes in South African Education for the Comparative Educationist*. South Africa. Pearsons Education: pp. 63-90.

Wells, C. S., & Wollack, J. A. (2003). An instructor's guide to understanding test reliability. Testing and evaluation services. University of Wisconsin. Retrieved 03 September 2014 from http://testing.wisc.edu/reliability.pdf.

Woolfolk, A. (2010). *Educational Psychology*. Eleventh Edition. Upper Saddle River: Pearson Education, Inc.

7. APPENDICES SECTION

7.1 Appendix A: Grade 11 achievement test for Circle Geometry

THE CIRCLE GEOMETRY TEST: GRADE 11

SCHOOL CODE: _____ **LEARNER CODE: _____**

TIME: 1 HOUR **MARKS: 50**

INSTRUCTIONS: 1. Answer ALL questions.

2. Show ALL working.

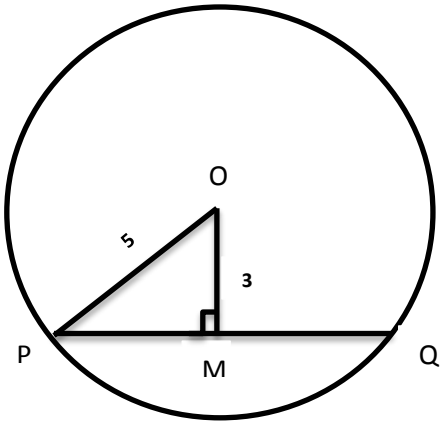
QUESTION 1

Prove the following theorem:

1.1 The opposite angles of a cyclic quadrilateral are supplementary. (4)

QUESTION 2:

O is the centre of the circle, OM ⊥ PQ, OP = 5mm, and OM = 3mm

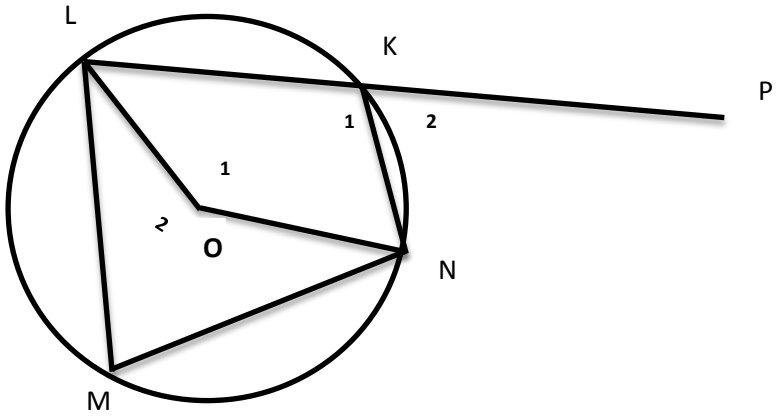


2.1 Calculate PM (2)

2.2 Determine the length of PQ (2)

QUESTION 3:

3.1 O is the centre of the circle below, LKP is a straight and $\hat{O}_1 = 2x$



3.1.1 Determine in terms of x:

3.1.1.1 $\widehat{O_2}$ (2)

3.1.1.2 $\widehat{M}$ (3)

3.1.1.3 $\widehat{K_1}$ (3)

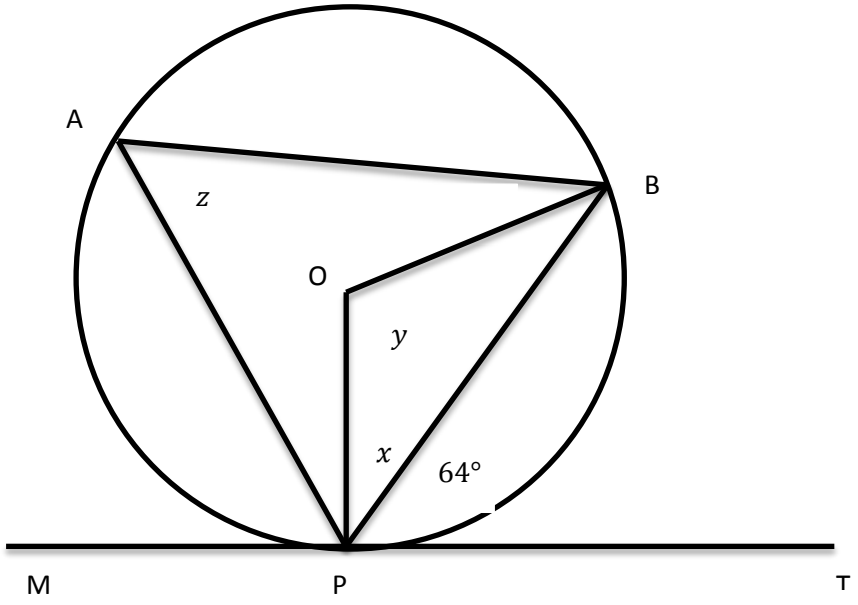
3.1.1.4 $\widehat{K_2}$ (2)

3.1.2 Determine $\widehat{K_1} + \widehat{M}$. what do you notice? (3)

3.1.3 Write down your observation regarding the measure of $\widehat{K_2}$ and $\widehat{M}$. (2)

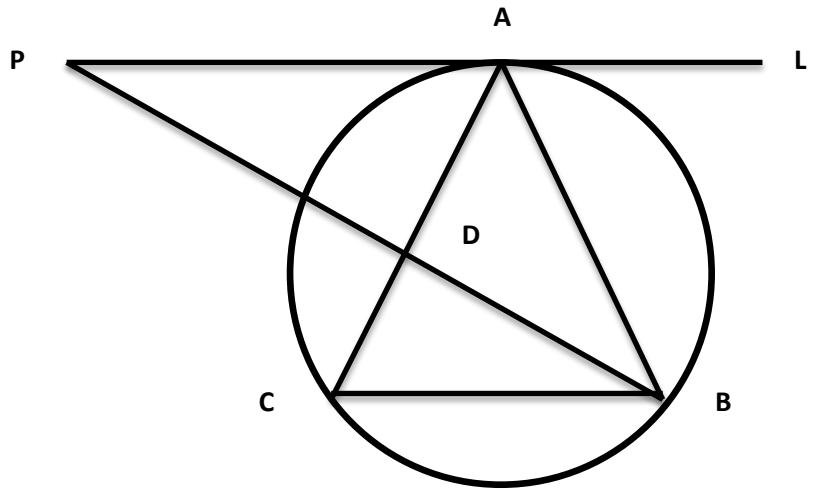
3.2 O is the centre of the circle below and MPT is the tangent.

Also, OP is perpendicular to MT. Determine, with reasons, x, y and z. (8)



QUESTION 4

4.1 Given that AB=AC, AP//BC, and $B\hat{A}C = C\hat{B}D$

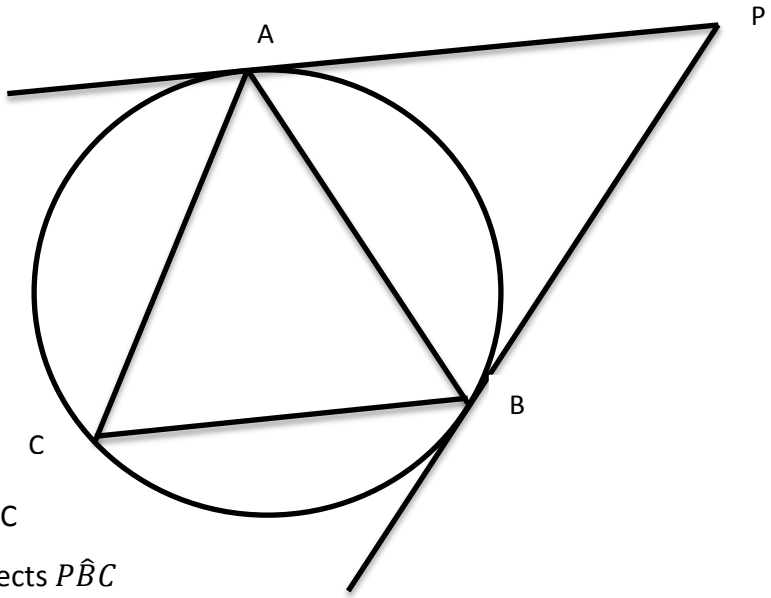


Prove that:

4.1.1 PAL is a tangent to the circle ABC (3)

4.1.2 AB is a tangent to the circle ADP (3)

4.2 PA and PB are tangents from P at A and B respectively to the circle ABC and PA is parallel to BC.



4.2.1 Prove that:

4.2.1.1 AB = AC (5)

4.2.1.2 AB bisects $P\hat{B}C$ (3)

4.2.2 If $A\hat{P}B = 40°, determine$:

4.2.2.1 $A\hat{C}B$ (3)

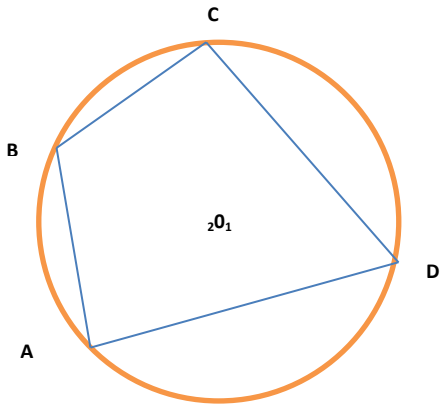
4.2.2.2 $B\hat{A}C$ (2)

7.2 Appendix B: Circle Geometry test memorandum

CIRCLE GEOMETRY TEST MEMORANDUM

QUESTION 1

1.1



RTP: $A\hat{B}C + A\hat{D}C = 180$

Construct lines AO and OC

Let $A\hat{D}C = x$

$\therefore A\widehat{O_2}C = 2x$ $\surd$ $(< at\ centre = 2 \times < at\ circum)$

$A\widehat{O_1}C = 360 - 2x$ $\surd$ $(< s\ at\ a\ point = 360)$

$= 2(180 - x)$

$A\hat{B}C = \frac{1}{2}\ A\widehat{O_1}C$ $(< at\ centre = 2 \times < at\ circum)$

$= \frac{1}{2} \times 2(180 - x)\surd$

$= 180 - x$

$A\hat{B}C + A\hat{D}C = 180 - x + x\surd$

$= 180$ [4]

OR $\widehat{O_1} = 2\hat{B}$ $(< at\ centre)$

$\widehat{O_2} = 2\hat{D}$ $(< at\ centre)$

$\widehat{O_1} + \widehat{O_2} = 2(\hat{B} + \hat{D})$

$\widehat{O_1} + \widehat{O_2} = 360$ $(< s\ at\ a\ point = 360)$

$2(\hat{B} + \hat{D}) = 360$ $(both = \widehat{O_1} + \widehat{O_2})$

$\hat{B} + \hat{D} = 180$

QUESTION 2

2.1 $PM^2 = PO^2 - MO^2$

$PM = \sqrt{5^2 - 3^2}\ \surd$

$PM = 4mm\ \surd$ (2)

2.2 $PQ = PM + MQ\surd$ (line from centre ⊥ to chord bisects chord)

$PQ = 4mm + 4mm$

$PQ = 8mm\surd$ (2)

[4]

QUESTION 3

3.1

3.1.1

3.1.1.1 $\widehat{O_1} = 2x$ (Given)

$\widehat{O_2} = 360° - 2x\surd$ (Revolution is 360°)$\surd$ OR (angles at a point) (2)

$= 2(180° - x)$

3.1.1.2 $\widehat{M} = \frac{1}{2}\widehat{O_1}$ ($< at\ centre\ is\ 2 \times < at\ circumf$)$\surd$

$= \frac{1}{2}(2x)\surd$

$= x\ \surd$ (3)

3.1.1.3 $\widehat{K_1} = \frac{1}{2}\widehat{O_2}$ ($< at\ centre\ is\ 2 \times < at\ circumf$)$\surd$

$= \frac{1}{2}2(180° - x)\surd$

$= 180° - x\ \surd$ (3)

OR $\widehat{K_1} + \widehat{M} = 180\surd$ ($opp\ < s\ of\ cyclic\ quad\ add\ up\ to\ 180$)

$\widehat{K_1} + x = 180\surd$

$\widehat{K_1} = 180 - x\surd$

3.1.1.4 $\widehat{K_2} = 180° - \widehat{K_1}$ ($strt\ line\ is\ 180°$)

$= 180° - (180° - x)\surd$

$= x\ \surd$ (2)

3.1.2 $\widehat{K_1} + \widehat{M} = 180° - x + x$ √

$= 180°$ √

opposite angles of a cyclic quadrilateral add up to $180°$ √ (3)

3.1.3 $\widehat{K_2} = \widehat{M}$ √

exterior angle of a cyclic quadrilateral is equal to the interior opposite angle √ (2)

3.2 $x = 90° - 64°$ √ $(tangent \perp radius)$ √

$= 26°$ √

OR $x = \frac{180-128}{2}$√ $(< s\ in\ isosc\ \Delta\ add\ up\ to\ 180°)$ √

$= 26°$√

$y = 180° - 2(26°)$ √ $(< s\ in\ isosc\ \Delta\ add\ up\ to\ 180°)$ √

$= 128°$ √

0R $y = 2x$ $(< atcentreis\ 2 \times < atcircumf)$ √

$= 2 \times 64°$√

$= 128°$√

$z = \frac{1}{2}(128°)$ $(< at\ centre\ is\ 2 \times < at\ circumf)$ √

$= 64°$ √

OR $z = 64°$ √ $(tangent\ and\ chord)$ √ (8)

[23]

QUESTION 4

4.1

4.1.1 $RTPP\hat{A}C = A\hat{B}C$

$P\hat{A}C = A\hat{C}B$ √ $(alternate\ angles)$

$A\hat{C}B = A\hat{B}C$ √ $(isosc\ \Delta\ ABC)$

$\therefore P\hat{A}C = A\hat{B}C$ √ (3)

OR $L\hat{A}B = A\hat{B}C$√ $(alt\ < s)$

$A\hat{B}C = A\hat{C}B\surd$ $(isosc\ \Delta\ ABC)$

$L\hat{A}B = A\hat{C}B\surd$ $(Both = A\hat{B}C)$

OR $P\hat{A}D = A\hat{C}B\surd$ $(alt\ < s)$

$A\hat{B}C = A\hat{C}B\surd$ $(isosc\ \Delta\ ABC)$

$P\hat{A}D = A\hat{B}C\surd$ $(Both = A\hat{C}B\ )$

4.1.2 $RTP\ \ B\hat{A}C = B\hat{P}A$ OR $RTP\ \ B\hat{A}C = D\hat{P}A$

$B\hat{A}C = C\hat{B}D\ \surd$ $(given)$

$C\hat{B}D = B\hat{P}A\ \surd$ OR $C\hat{B}D = D\hat{P}A$ $(alternate\ angles)$

$\therefore B\hat{A}C = B\hat{P}A\ \surd$ OR $B\hat{A}C = D\hat{P}A$ (3)

4.2

4.2.1

4.2.1.1 $AP = PB$ $(tangents\ from\ same\ point\ outside\ circle\ are =)\ \surd$

$P\hat{A}B = P\hat{B}A$ $(isosc\ \Delta\ PAB)\ \surd$

$A\hat{B}C = P\hat{A}B$ $(alternate\ < s)\ \surd$

$A\hat{C}B = P\hat{A}B$ $(tangent\ and\ chord)\ \surd$

$\therefore \Delta ABC = isosc\ \Delta$ $(2\ < s =)\surd$

$AB = AC$ $(isosc\ \Delta ABC)$ (5)

OR $P\hat{A}B = A\hat{C}B$ $(\tan, chord)\surd$

$P\hat{A}B = A\hat{B}C$ $(alt\ < s)\surd$

$\therefore A\hat{C}B = A\hat{B}C\ \surd$ $\left(both = P\hat{A}B\right)$

$\therefore AC = AB\surd$ $(sides\ opp =< s)\surd$

4.2.1.2 $RTP\ \ A\hat{B}P = A\hat{B}C$

$A\hat{C}B = A\hat{B}P\ \surd$ $(tangent\ and\ chord)$

$A\hat{C}B = A\hat{B}C\surd$ $(isosc\ \Delta ABC)$

$\therefore A\hat{B}P = A\hat{B}C\ \surd$ (3)

OR $P\hat{A}B = A\hat{B}C$ $(alt\ < s)\surd$

$P\hat{A}B = P\hat{B}A$ $(tans\ from\ same\ pt)\surd$

$\therefore A\hat{B}C = P\hat{B}A$ $(both = P\hat{A}B)\surd$

OR $P\hat{A}B = A\hat{B}C$ $\surd$ $(alternate < s)$

$P\hat{A}B = A\hat{B}P$ $\surd$ $(isosc\ \Delta ABP)\ OR\ (\ tangents\ from\ same\ point)$

$\therefore A\hat{B}P = A\hat{B}C$ $\surd$

4.2.2

4.2.2.1 $P\hat{A}B = \frac{180°-40°}{2}$ $\surd$ $(isosc\ \Delta\ APB)$

$= 70°$ $\surd$

$A\hat{C}B = P\hat{A}B$ $\surd(tangent\ and\ chord)$

$= 70°$ (3)

4.2.2.2 $B\hat{A}C = 180° - 2 \times A\hat{C}B(isosc\ \Delta ABC)$

$= 180 - 2 \times 70°$ $\surd$

$= 40°$ $\surd$ (2)

[19]

<u>TOTAL = 50 MARKS</u>

7.3 Appendix C: A post-intervention learner questionnaire

The Circle Geometry Motivation Questionnaire

INSTRUCTIONS: 1. Answer ALL questions.
2. Put a cross (X) in the circle that represents your choice in the provided options.

School code: _____ **Learner code: _____**

01. I enjoy learning the topic of circle geometry.
O Never O Rarely O Sometimes O Usually O Always

02. The circle geometry I learn relates to my personal goals.
O Never O Rarely O Sometimes O Usually O Always

03. I like to do better than other learners on the circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

04. I am nervous about how I will do on the circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

05. If I am having trouble learning circle geometry, I try to figure out why.
O Never O Rarely O Sometimes O Usually O Always

06. I become anxious when it is time to take a circle geometry test.
O Never O Rarely O Sometimes O Usually O Always

07. Earning a good circle geometry mark is important to me.
O Never O Rarely O Sometimes O Usually O Always

08. I put enough effort into learning circle geometry.
O Never O Rarely O Sometimes O Usually O Always

09. I use strategies that ensure I learn circle geometry well.
O Never O Rarely O Sometimes O Usually O Always

10. I think about how learning circle geometry can help me get a good job.
O Never O Rarely O Sometimes O Usually O Always

11. I think about how the circle geometry I learn will be helpful to me.
O Never O Rarely O Sometimes O Usually O Always

12. I expect to do as well or better than the other learners in circle geometry.
O Never O Rarely O Sometimes O Usually O Always

13. I worry about failing the circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

14. I am concerned that the other learners are better in circle geometry.
O Never O Rarely O Sometimes O Usually O Always

15. I think about how my circle geometry mark will affect my overall mathematics mark.
O Never O Rarely O Sometimes O Usually O Always

16. The circle geometry I learn is more important than the mark I receive.
O Never O Rarely O Sometimes O Usually O Always

17. I think about how learning circle geometry can help my career.
O Never O Rarely O Sometimes O Usually O Always

18. I hate taking circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

19. I think about how I will use the circle geometry I learn.
O Never O Rarely O Sometimes O Usually O Always

20. It is my fault if I do not understand circle geometry.
O Never O Rarely O Sometimes O Usually O Always

21. I am confident I will do well on circle geometry assignments and projects.
O Never O Rarely O Sometimes O Usually O Always

22. I find learning circle geometry interesting.
O Never O Rarely O Sometimes O Usually O Always

23. The circle geometry I learn is relevant to my life.
O Never O Rarely O Sometimes O Usually O Always

24. I believe I can master the knowledge and skills in the circle geometry topic.
O Never O Rarely O Sometimes O Usually O Always

25. The circle geometry I learn has practical value for me.
O Never O Rarely O Sometimes O Usually O Always

26. I prepare well for circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

27. I like circle geometry that challenges me.
O Never O Rarely O Sometimes O Usually O Always

28. I am confident I will do well on circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

29. I believe I can get a distinction “A” in circle geometry tests.
O Never O Rarely O Sometimes O Usually O Always

30. Understanding circle geometry gives me a sense of accomplishment.
O Never O Rarely O Sometimes O Usually O Always

7.4 Appendix D: Post-intervention interview schedule for the learners

School code: _____ **Learner code: _____**

1. Before you were introduced to the Computer Assisted Instruction/ conventional instruction, would you say you were enjoying yourself when learning circle geometry in a Grade 11 class? Explain your answer.
2. What makes you feel in the way that you have described in the previous questions?
3. Do you think the way you are feeling about circle geometry is related to the way in which it is taught in your class?
4. How would you like to be taught circle geometry in your class?
5. If your teacher were to ask you about the ideas on improving the teaching of circle geometry in your class, what would be your advice?
6. What is your view about the idea of using Computer Assisted Instruction/ conventional instruction to facilitate the teaching of circle geometry in Grade 11?
7. In the past few days, you have been introduced to the idea of Computer Assisted Instruction/ conventional instruction in a circle geometry class. How do you feel about this teaching approach?
8. Would you say the Computer Assisted Instruction/ conventional instruction has motivated you to work harder in circle geometry? Explain your answer.
9. Do you think the Computer Assisted Instruction/ conventional instruction has helped you to want to do more circle geometry problem?
10. Do you think the Computer Assisted Instruction/ conventional instruction has motivated you to want to explain and discuss circle geometry with other learners?
11. How would you advise your teacher to use the Computer Assisted Instruction/ conventional instruction in a way that will make learners to perform better in circle geometry?
12. How would you compare Computer Assisted Instruction/ conventional teaching instruction to other methods that you have been using in your class to learn circle geometry?

7.5 Appendix E: Request letter to the school principals

Unity Secondary School
P. O. Box 118
Daveyton
1520
Date: _____

RE: Request to conduct research at your school

Dear Sir/Madam

My name is Lovejoy Comfort Gweshe. I am registered with the University of South Africa (UNISA) for a degree of Master of Education (MEd), with a specialisation in Mathematics Education. My supervisor is Dr J. J. Dhlamini. As part of completing the Med, I am required to conduct a school-based research. The topic of my research is, "*The effect of using a Computer Assisted Instruction on teaching Geometric Circles in Grade 11*". The purpose of my research is to work with a group of Grade 11 Mathematics learners to determine the effectiveness of a teaching method, which is called a Computer-Assisted Instruction. The idea is to find ways to help learners improve their performance in Mathematics, particularly in the topic of Geometry.

Learners will write a performance test, they will complete a questionnaire, and some will be selected for the interviews which will be recorded. The collection of data for the research will take place between July 2014 and September 2014. The aim of this research is to contribute in improving the performance of Grade 11 learners in your district.

The participation in this research is voluntary. If your school, or a child from your school, decides to withdraw from participation during the course of this research, there will be no penalty incurred. All names of participants and those of participating schools will not be revealed, and pseudonyms will be used instead. There shall be no incentives given to those who will choose to participate in this research. There are no foreseen risks to those who decide to participate in this research.

In case you decide to allow your school to participate in this research, the researcher will call a meeting in which the objectives of the research will be explained. Every participant will be given a chance to ask question. You are free to contact me on the following number in case of further questions: 0710869200.

Please sign and complete the consent slip below, and return it to me if you agree.

Your assistance is greatly appreciated.

Yours faithfully
Mr Lovejoy Comfort Gweshe

Signature: _____

7.6 Appendix F: Informed consent form for the school principals

Dear Mr Gweshe

I, _____, the principal of _____, agree to have read and understood the content of the letter that was sent to me by Mr Lovejoy Gweshe. I have read and understood the purpose of the research entitled: *The effect of using a Computer Assisted Instruction on teaching geometric circles in Grade 11.* I therefore **agree/ do not agree** to allow my school to participate in the research.

Signature of the principal : _____

Date : _____

Signature of researcher : _____

Date : _____

7.7 Appendix G: A consent letter of request to the Grade 11 mathematics teachers

Unity Secondary School
P. O. Box 118
Daveyton
1520
Date: _____

Dear Sir/Madam

My name is Lovejoy Comfort Gweshe. I am registered with the University of South Africa (UNISA) for a degree of Master of Education (MEd), with a specialization in Mathematics Education. My supervisor is Dr J. J. Dhlamini. As part of completing the MEd I am required to conduct a school-based research. The topic of my research is, "*The effect of using a Computer Assisted Instruction (CAI) on teaching geometric circles in Grade 11*". The purpose of my research is to work with a group of Grade 11 Mathematics learners and teachers to determine the effectiveness of a teaching method, which is called a Computer-Assisted Instruction. The CAI will be compared with traditional (usual) methods of teaching Mathematics. To achieve this, I have to divide classrooms into an experimental group (where the CAI will be implemented) and the control group (where traditional methods will be implemented). The idea is to find ways to help teachers and learners improve their performance in Mathematics, particularly in the topic of Geometry of Circles. I therefore request you to assist me in the control group. Therefore, your role in this research will be limited to the teaching of Geometry using traditional instruction.

Learners in both groups will write a performance test (at the start and end of the research); they will complete a questionnaire; and some will be selected for the interviews which will be recorded. The collection of data for the research will take place between July 2014 and September 2014. The aim of this research is to contribute in improving the performance of Grade 11 learners in our district, namely, the Ekurhuleni North District of the Gauteng province.

Participation in this research is voluntary. If you decide to withdraw from participation during the course of this research, there will be no penalty incurred, and your relationship with the researcher will not be jeopardised. All names of participants and those of participating schools will not be revealed, and instead pseudonyms will be used. There shall be no incentives given to those who will choose to participate in this research. There are no foreseen risks to those who decide to participate in this research.

In case you decide to participate in this research, the researcher will call a meeting in which the objectives of the research will further be explained. Every person in the meeting will be given a chance to ask questions. You are free to contact me on the following number in case of further questions: 071 086 9200.

Please sign and complete the consent slip below, and return it to me if you agree.

Your assistance is greatly appreciated.

Yours faithfully
Mr Lovejoy Comfort Gweshe

Signature: _____

7.8 Appendix H: An informed consent form for Grade 11 mathematics teachers

Dear Mr Gweshe

I, _____, the teacher for Grade 11 Mathematics teacher, agree to have read and understood the content of the letter that was sent to me by you. I have also read and understood the purpose of the research entitled: *The effect of using a Computer Assisted Instruction on teaching geometric circles in Grade 11.* I therefore **agree/ do not agree** to participate in the research.

I also **give consent/ do not give consent** to provide conventional instruction, that is, my own usual method of teaching Mathematics, in the control school in which I am employed.

Signature of the teacher : _____

Date : _____

Signature of researcher : _____

Date : _____

7.9 Appendix I: Request letters to parents

Unity Secondary School
P. O. Box 118
Daveyton
1520
Date: _____

RE: Request for your child to participate in a research

Dear Sir/Madam

My name is Lovejoy Comfort Gweshe. I am a Mathematics teacher at the above mentioned school. I am enrolled at the University of South Africa (UNISA) for a Master of Education programme in which I am required to carry out a research study in a school. My supervisor is Dr J. J. Dhlamini. My research topic is "*The effect of using a Computer-Assisted Instruction on teaching Geometric circles in Grade 11*". The purpose of my research is to work with a group of Grade 11 Mathematics learners to determine the effectiveness of a teaching method, which is called a Computer-Assisted Instruction. The idea is to find ways to help learners improve their performance in mathematics, particularly in the topic of geometry. Your child happens to be in the group of learners I wish to work with in this research.

I am therefore requesting you to allow your child to take part in this research, which will take place between July 2014 and September 2014. If you allow your child to participate in this research, he/ she will write a test in the geometry of circles, and might be selected to participate in the completion of a questionnaire and providing some responses in an interview session which will be recorded. The participation of your child in this research will contribute in helping high schools to find ways and means to improve the performance of learners in Mathematics, which is the aim of this study.

Please note that the participation in this research is voluntary. This also means that if your child decides to withdraw his/ her participation during the course of this research, your child will not be penalised, and his/ her relationship with me will not be jeopardised. All names of participants and those of participating schools will not be revealed, and pseudonyms (not real names) will be used instead. There shall be no gifts or rewards given to those who will choose to participate in this study. Also, the research is not going to expose your child to any danger or risk. In case you decide to allow your child to participate in this research, the researcher will call a meeting in which the objectives of the research will be explained. Every participant will be given a chance to ask question. You are free to contact me on the following number in case of further questions: 071 086 9200.

Please sign and complete the consent slip below, and return it to me if you agree.

Your assistance is greatly appreciated.

Yours faithfully
Lovejoy Comfort Gweshe

Signature: _____

7.10 Appendix J: Informed consent form for parents

I, _____ the parent of _____, who is in Grade 11, have read and understood the content of the letter that was sent to me by Mr Lovejoy Gweshe. I give/ do not give permission for my child to participate in the research that is explained in the letter. I give consent for my child to participate in the following research activities:

- To write a geometry performance test

  Choose: YES ☐ or NO ☐

- To complete a questionnaire in case my child is selected to do so

  Choose: YES ☐ or NO ☐

- To participate in the interviews in case my child is selected

  Choose: YES ☐ or NO ☐

- To be voice-recorded recorded during the interviews

  Choose: YES ☐ or NO ☐

Signature : _____

Date : _____

7.11 Appendix K: An assent letter to Grade 11 learners

Title of research: The effect of using a Computer-Assisted Instruction on teaching Geometric circles in Grade 11

Researcher: Lovejoy Gweshe

Supervisor: Dr. J. J. Dhlamini

Dear Learner

I am doing a research study in order to find out the following: If I introduce computers in the teaching of Circle Geometry, how will this change influence your performance and motivate you to learn mathematics? This research will be conducted in Grade 11 Mathematics classes, and because you are in one of these classes I request you to participate in my research. This research aims to find results that will help Mathematics teachers to use computer-assisted teaching methods to create mathematics classrooms that will benefit learners. The title of my research is: The effect of using a Computer-Assisted Instruction (CAI) on teaching Geometric circles in Grade 11.

Although I encourage you to be part of this research, participation is voluntary. This means your decision to exclude yourself from this research will not harm or disadvantage your academic progress, as well as your relationship with me. Also, your decision to participate in this research does not entitle you to receive any special benefit or gift from me. Therefore, it means you can be a member of the class but not be part of the research. So, it is up to you. If you say okay now, but you want to stop later, that is still fine and acceptable too. If you choose to participate in this research you will be expected to do the following research activities: (1) write a pre-study achievement test in geometry of circles to help the researcher to measure the effect of CAI on your performance; you may also be requested to: (2) complete a questionnaire to give some opinion on your motivation to do geometry; and, (3) be interviewed and voice-recorded on your views about CAI. At the end of my teaching you will also be requested to write another test (a post-test) to help me see the influence of my teaching on your performance.

There is no risk in deciding to be part of this research. When I complete the research I will write a report about what I found out. Your name will not be used in the report and I promise to share the report of my findings with you. If you want to participate in this research, please discuss with your parent(s)/ guardian first. After that discussion I will request you to complete the reply slip that I have included in this letter. Your reply will indicate to me whether you want to be in this research or not. Your parent/guardian will be asked for their permission on behalf of you in a separate document.

In case you have any questions about this research you are free to talk to me or to ask your parents/ guardian to talk to me. My cell phone numbers is: 071 086 9200.
I thank you in advance.

Yours sincerely
Mr Gweshe

Signature: _____

7.12 Appendix L: Assent form for the learners

Dear Mr Gweshe

I have read and understood your letter inviting me to participate in your research. After speaking to my parent/ guardian, I have decided **to participate/ not to participate** in your research. My participation in the following research activities is as follows:

	YES	**NO**
1. Write a pre-test		
2. Write a post-test		
3. Complete a questionnaire		
4. To be interviewed		
5. To be audio-recorded during interviews		

Name of learner: _____

Signature of learner: _____

Date: _____

Signature of researcher: _____

Date: _____

7.13 Appendix M: Letter of permission from the Department of Basic Education (DBE) to conduct research in schools

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. D2014/297 A

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	14 November 2013
Validity of Research Approval:	10 February to 3 October 2014
Previous GDE Research Approval letter reference number	D2014/123 dated 19 July 2013
Name of Researcher:	Gweshe L.C.
Address of Researcher:	60892 Thobejane Street
	Daveyton Extension 3
	1520
Telephone Number:	071 086 9200
Fax Number:	011 424 1662
Email address:	lovejoyg376@gmail.com
Research Topic:	The effect of using computers in teaching Geometry.
Number and type of schools:	FIVE Secondary Schools
District/s/HO	Ekurhuleni North

Re: Approval In Respect of Request to Conduct Research

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

30/3/11/19

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

1

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506

7.14 Appendix N: Research Ethics Clearance Certificate

UNISA | college of education

Research Ethics Clearance Certificate

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

LC Gweshe [47103531]

for a M Ed study entitled

The effect of using a Computer-Assisted Instruction on teaching geometric circles in Grade 11

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

Prof KP Dzvimbo
Executive Dean : CEDU

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

Reference number: 2014 MAY /47103531/MC

19 MAY 2014