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Effectiveness of Computer Assisted Instructions on Secretarial Studies Student's Performance on Linear Equations in Southern District Brigades in Botswana.

BY

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DECLARATION

The work contained in this dissertation was completed by the author at University of Botswana between 2016 and 2019. It is an original work except where due reference is made and neither has been nor will be submitted for the award of any other University.

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ABSTRACT

The use of technology in the pedagogical process is advancing at a phenomenal rate due to the vast availability of educational software and gadgets. The purpose of this study was to investigate the comparative effects of Computer Assisted Instruction (CAI) and Convectional Teaching Instruction (CTI) on the performance and motivation of secretarial studies learners in the topic of linear equations. The study followed a quasi-experimental design with a non-equivalent group approach consisting of pre-and post-test measures. The population of the study consisted of secretarial studies mathematics learners from 14 Brigades in the southern region of Botswana. Using convenience sampling technique two Brigades with n=41 secretarial studies learners and two teachers participated in the study. One Brigade formed the experimental group (n=21) and the other formed the control group (n=20).

The study lacked random selection of participants because the control group and the experimental group were made up of intact classes that already existed in Brigades that participated in the study. Both groups wrote a standardized pre-test to ascertain their performance status at the beginning of the study. CAI was implemented in the experimental group while CTI was implemented in the control group. A similar post-test was administered on both groups to measure the comparative effects of each teaching method on the performance of learners. A constructivist theory framed the study. A t-test with was used to analyze data with $\alpha = 0.05$ and findings showed a significant difference in the mean scores between the control group and the experimental group ($t = 2.188$, $p = 0.008 < \alpha$) in the post-test. These results indicated that students in the experimental group outperformed those in the control group. In addition, a questionnaire was also administered to both groups to measure the level of motivation of learners. Analysis of the questionnaire responses indicated a significant difference in the mean scores between the control group and the experimental group ($t = 7.238$, $p = 0.000 < \alpha$). These results indicated that students in the experimental group were more motivated to learn linear equations than those in the control group. On the overall, results of this study showed that CAI enhanced student performance in linear equations and triggered more motivation towards learning as compared to CTI.

Key Words

Computer Assisted Instruction , Conventional Teaching Instructions, Linear equations, Performance , Motivation.

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LIST OF ABBREVIATIONS

BGCSE	Botswana General Certificate for Secondary Education
BEC	Botswana Examination Council
CAI	Computer Assisted Instruction
CTI	Conventional Teaching Instructions
DSD	Department Of Skills Development
DTVET	Department of Technical Vocational Education and Training
JCE	Junior Certificate in Education
MELPSD	Ministry Of Employment Labor Productivity And Skills Development
MOBE	Ministry Of Basic Education
MOTERST	Ministry Of Tertiary Education, Research , Science And Technology
NCSS	National Certificate in Secretarial Studies
UB	University of Botswana
SPSS	Statistical Package for Social Sciences
QM	Quantitative Methods

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CHAPTER 1

INTRODUCTION

1.1 Background

For many years, the Botswana education system has been struggling with escalating decline in student performance as shown by overall poor results from Botswana Examination Council. This problem exist in primary and secondary schools as well as in Department of Skills Development (DSD) formerly known as Department of Technical Vocational Education and Training (DTVET) . Technical and Vocational Institutions in Botswana offer different courses and in most of them mathematics is a core subject. Though student performance appear to be unsatisfactory in most subjects, trade mathematics always falls at the bottom of the list. Many interventions to improve mathematics performance have been put in place but results continue to decline. Such interventions include the provision of an education system that is accessible throughout the entire nation providing opportunities for all. Critical to these interventions were the changes in teacher training (in larger, more cost effective colleges of education); expanding parental and community participation; school-based management, decentralization; curriculum reform; continually increasing funding and resources directed to education; attempts to improve accountability and achieve efficiency and new approaches to testing and assessment (Berman, 2015).

Since we live in the era where technology has taken an upper hand in people's lives, it is perhaps high time to prioritize technology as an intervention strategy to curb the ever declining performance to see whether the education system in general can be transformed. Technology has become a part of almost all areas of our lives. Recent information technologies are being integrated into learning environments as well. In Botswana ministries that are responsible for education and training; Ministry of Basic Education (MoBE), Ministry of Tertiary Education, Research, Science and Technology (MoTERST) and Ministry of Employment ,Labour Productivity and Skills Development (MELSD) all advocate for the use of technology in mathematics curriculum which is evident by the way computer based programs such as spreadsheet have been integrated in mathematics syllabi. The number of computers in schools has also been increased over the years and internet is accessible in almost all schools. Since there is such a significant effort and acceptance about information technologies in educational environments, there is a need to determine which way of using technology is more beneficial for learning mathematics comprehensively.

Computers provide extensive opportunities for supporting the learning of mathematics in schools. There are many types of computer applications in mathematics education including web based interactive learning objects, spreadsheets, graphing programs and Geogebra. GeoGebra is a dynamic mathematics software designed for teaching and learning mathematics in secondary school and colleges (Hohenwarter and Preiner, 2007). The software can be used to visualize mathematical concepts as well as to create instructional materials and has the potential to foster active student centered learning by allowing for mathematical experiments, interactive explorations, as well as discovery learning (Lasry, Charles, and Whittaker, 2014).

Since independence Botswana has been striving to improve the quality of mathematics and science education as it is viewed as one of the important key elements of economic development. However, its endeavors seem not to have been very successful to improve students' performance in these subjects, as it is the case with most of the African countries (Carnoy, Chisholm, and Chilisa, 2012). Although students' academic performance can be measured with a variety of indicators, one of the commonly used indices is the result of standardized achievement tests such as the national examinations set Botswana Examination Council (BEC) in the country, and poor performance in the national examinations in mathematics and science subjects have long been a controversial issue in secondary education in Botswana (Carnoy et al., 2012). According to DTVET results for the years 2010-2015, the average overall "pass rate" in quantitative methods, arithmetic and general mathematics which are all compulsory subject in the various courses offered have been over the years less than 50 % (Carnoy, Ngware, and Oketch, 2015). It is often claimed that there are students who do not understand basic concepts in mathematics and science in vocational institutions. For example, it was found in Botswana that a significant number of students in vocational institutions did not understand basic arithmetic operations and made mistakes such as 0 - 5 = 0 or - 9 - 3 = - 6 (Angrist, Pansiri, & Tsayang, 2014). The problem is excavated by the current political trend for rapid expansion of vocational education sector in Botswana, which may cause other adverse conditions such as increasing class size and further shortage of lecturers. In order to improve students' performance in mathematics and science subjects, it is of great importance to find practical ways to cope with the problem.

1.2 Computer Assisted Instructions

Computer assisted instructions (CAI) are now regarded to have promising features to enhance and support teaching learning practice in schools (Maketo & Balakrishna, 2015). There are efforts made to explore the use of CAI to support student learning and improve their performance in schools in Botswana .As in other countries, computers are now gradually spreading into vocational institutions, and in large cities it is not rare to find a computer in a school or institution. The government of Botswana is also encouraging schools to implement CAI in all levels of education, putting more emphasis on vocational education (Chikati, 2013). There is little doubt that computer technology is now regarded as a promising educational tool which may bring about new innovative practices in vocational education. Although at present the use of information and computer technology in institutions is still rather limited in Botswana, people are interested and eager to take advantage of the technology. In order to promote CAI implementation in vocational institutions, it is significant to facilitate lecturers' practice of using it in such a way that they can find relevance and usefulness of CAI in real school settings for themselves. The exploration of the possible benefits of practical use of CAI, particularly Geogebra software in mathematics classrooms in Vocational institutions in Botswana forms the focus of this study.

GeoGebra, created by Markus Hohenwarter in 2001, is a dynamic mathematics software which combines of computer algebra system (CAS) and dynamic geometry system (DGS). There are five representations for an equation, namely, daily life situation, concrete model, table, symbol, and graph. GeoGebra has three views; algebra view, spreadsheet view and graphic view. In algebra view , symbolic representations of constructions can be observed. Changes on these representations can be observed in the graphic view during the manipulations or vice versa (Figure 1). When a user plots a point or draws a line, symbolic representations of the input can be simultaneously seen on the screen. The functions can be ploted by just writing the equation on the algebra view. Furthermore, spreadsheet view provides with the opportunity to enter not only numerical data but also all types of mathematical concepts such as coordinate of points, equation or any command. Any data entered in spreadsheet can also be seen in graphic view immediately.

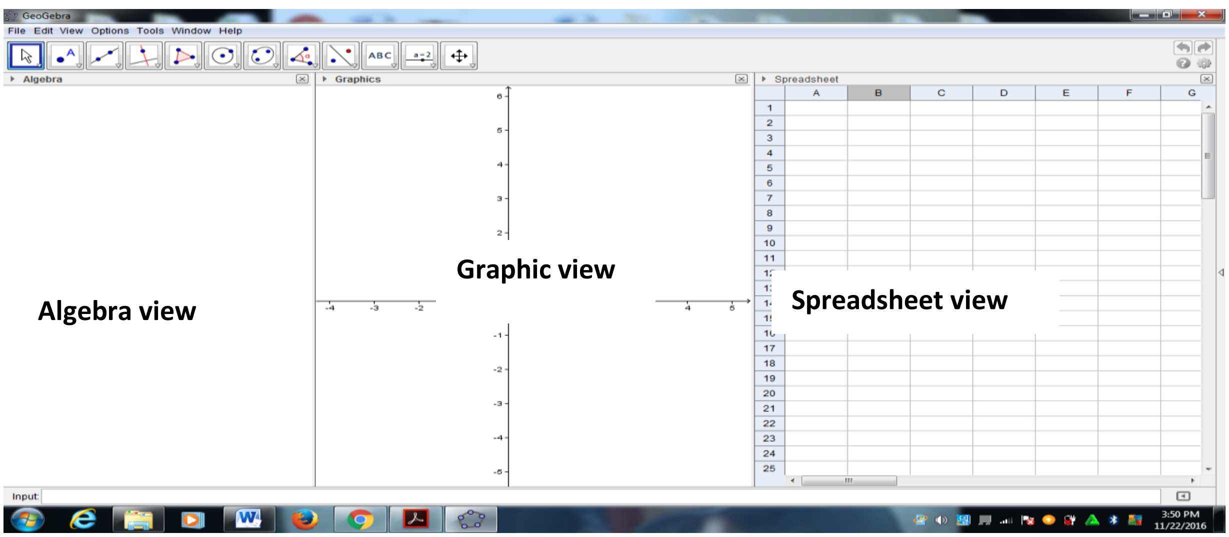


Figure 1 : A view of GeoGebra screen

1.3 Purpose of the study

The purpose of this study was to investigate the effectiveness of using CAI, specifically Geogebra on students' performance in linear equations. Further, the study aimed at investigating if this learning method surpasses the conventional traditional method (CTI) in terms of student performance and motivation.

1.4 Objectives of the study

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

i. To comparatively measure the statistical significance of teaching linear equations using CAI and CTI on the performance of Secretarial studies students
ii. To establish if Secretarial studies learners' motivation levels were affected by using either CAI or CTI in linear equations.

1.5 Research questions

The study addressed the following research questions:

i. Is there a statistically significant difference in the average pre-test scores of students taught linear equations using CAI and those taught using the CTI?
ii. Is there a statistically significant difference in the average post-test scores of students taught linear equations using CAI and those taught using CTI?
iii. Is there a statistically significant difference in the average pre-test and post-test scores of students taught linear equations using CAI and pre-test and post-test scores of students taught linear equations using the CTI?
iv. Is there a statistically significant difference in the average motivation scores of students taught linear equations using CAI and students taught linear equations using CTI?

1.6 Research Hypothesis and Null Hypothesis

I. H_A: There is a significant difference between the pretest mean scores of the control group and the experimental group

H_0: There is no significant difference between the pretest mean scores of the control group and the experimental group

II. H_A: There is a significant difference between the posttest mean scores of the control group and the experimental group

H_0: There is no significant difference between the posttest mean scores of the control group and the experimental group

III. H_A: There is a significant difference between the pretest and post test scores of the control group and pretest and post test scores of the experimental group.

H_0: There is no significant difference between the pretest and post test scores of the control group and pretest and post test scores of the experimental group.

IV. H_A: There is a significant difference between the experimental group and control group in their level of motivation scores

H_0: There is no significant difference between the experimental group and control group in their level of motivation scores

1.7 Significance of the study

Information technologies continue to improve the 21st century classrooms. However, the effective way of using information technologies must be found in learning environments, otherwise just bringing technology in the class is not enough. There is a need to understand how technology should be integrated in learning environment. This study will provide some insight into how technology-based instruction influence students' achievement in mathematics.

The importance of multiple representations and the relation between representations in linear equations to comprehend the subject better is emphasized in Jacobson and Kozma (2012). CAI, Geogebra to be precise enables students to examine the relation between symbolic and graphical representation of linear equations by observing more than one representation on the same screen. Manipulating one of them and examining the changes on the others are also possible with the software. There is a need to understand how dynamic mathematics software contributes to teaching linear equations. This study will shed light on understanding of the contribution of dynamic mathematics software on teaching and learning linear equations.

Findings from this study will also serve to inform teachers about students' learning processes, particularly those related to using the GeoGebra software in relation to mathematics. The findings will reveal the processes involved as well as the challenges and issues teachers will need to consider when using GeoGebra software. The results shall outline how the different interactions with technology, peers and teachers affect learning. Consistent with the Vygotskian perspective, the role of social interaction in the learning process (Vygotsky, 1978) may become more evident. In other words, how learners interact with their peers and knowledgeable adults to advance their mental functions serve to inform educators about the use of GeoGebra software. In addition, the study will provide information on how learners of different abilities interact to perform assigned tasks. Such information is crucial in planning lessons for large classes and where learners are of varied abilities. The study will also reveal how technology integration facilitates the teaching and learning of linear equations; in particular, the findings will help to redefine the role of the teacher so that concepts such as “facilitator” and “guide at the side” may become more apparent.

According to Cakiroglu, Akkan, and Guven (2012) mathematics teachers evaluated themselves as incapable of designing, conducting and evaluating a technology supported environment. To conduct this study, appropriate lesson plans whose topics focused on linear equations were developed and were used with GeoGebra. These lesson plans might be considered as examples for the teachers who have concerns about technology usage in classroom. It was possible to understand how these lesson plans improve students’ achievement on linear equations through this study, which does not only contribute to the mathematics education literature but also provides teaching implications for teachers, curriculum developers, and educational policy makers.

1.8 Limitations of the study

It is acknowledged that the research design followed in this study posed some challenges to external validity of the study. A quasi-experimental design that was used 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 was therefore exercised when generalizing beyond participants. Therefore, conclusions that were drawn from this study were not extended beyond the southern district of Botswana, in which the experiment was conducted.

1.9 Definition of key terms

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

1.91 Computer Assisted Instruction (CAI)

A Computer Assisted Instruction (CAI) is the use of computers to interact instructionally with learners in the educational process (Ramani, 2012). While interacting with computers, learners were expected to recognize and construct relationships between both new and old pieces of information, thus developing conceptual knowledge. The term Instruction in CAI means that little or no interaction between the learner and the teacher was expected, thus allowing learners to create their own internal representational systems of mathematical concepts. In this study a computer program called GeoGebra was used as a tool to facilitate the teaching and learning of linear equations in secretarial studies students.

1.92 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 does not in any way involve the use of computers or any technological device but rather encompasses of symbols, algorithms, and step-by-step instructions provided by the teacher without explaining the reasons behind the steps, thus developing in learners, procedural knowledge (Karimi, 2016). The terms teaching and instruction in CTI means that the learners interact with the teacher and the teacher could give instructions during the learning process.

1.93 Motivation

(Wlodkowski, 2011) 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, 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).

1.10 Theoretical framework

The study draws upon the constructivist perspective.

1.10.1 Constructivist theory

The constructivist philosophy is based on the presupposition that learners should be actively involved in the processes of thinking and learning (Ornstein and 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 emphasizes 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. That is to say 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 this study, the constructivist approach of teaching and learning was adopted as participants were expected to become more actively involved in building their own dynamic Mathematical understanding of linear equations as they interact with the computers, each other, and with any other learning tool. The experimental group of learners used a computer program, GeoGebra, to solve linear equation problems while the control group used the traditional conventional teaching methods besides a computer program to solve linear equations problems. The computer was expected to be a teaching and learning tool that minimizes 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 knowledge while interacting with each other and with their learning tool, and internalize the constructed new knowledge as they solved linear equation problems.

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 internalize knowledge for themselves while interacting with their surroundings. Similar reasons justify the choice of constructivism to frame the current study.

1.10.2 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 alsoexplored in this 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 linear equations (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.

1.11 Conceptual Framework

The study adopted a conceptual framework called T2S4VU devised by Shadaan and Eu (2013) in their study that investigated the effectiveness of using Geogebra on student's understanding in learning circles.in this framework, technology, self-exploration, social interaction, visualization and understanding are advocated for. Social interaction between peers provides the students with opportunities to guide one another and reach a level of shared understanding. Here the higher ability students play a big role in helping the lower ability students. Students work in in groups to construct and visualize diagrams. This manner of learning enhances critical thinking skills as students contribute ideas and views to reach a common understanding. GeoGebra gives an opportunity for peer interaction to enhance understanding and visualization of the concept of linear equations. T2S4VU is presented below.

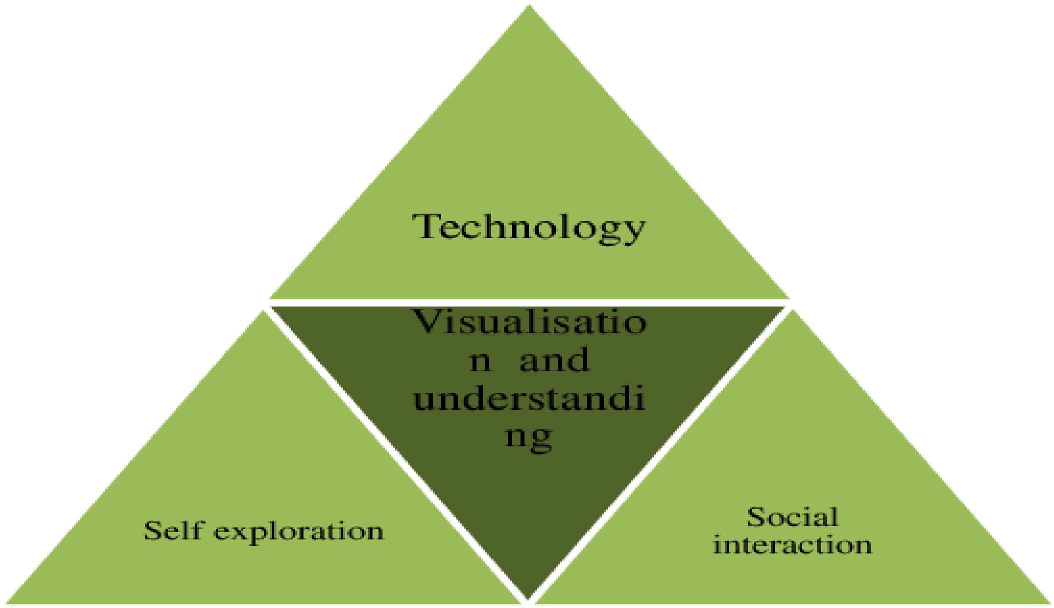


Figure 2: The T2SV4U Conceptual Framework (Shadaan and Eu , 2013)

The T2S4VU conceptual framework is explained in the following way:

T= Technology. Technology, in this respect the GeoGebra software

S= Self-exploration. This is a central concept in constructivism to enable students to project their actual learning level.

S= Social Interaction. This allows the learners to interact and learn from peers and knowledgeable others to reach their potential learning level.

V = Visualization. This is an important process in the learning of equations.

U = Understanding. Understanding is a crucial thinking skill to grasp any mathematical concept.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review is meant to put the study into proper perspective as it looks into the literature on computer technology used in mathematics education, as well as the related constructs of information and communication technology (ICT) that attempts to address the objectives and research questions of this study. The discussion begins with an insight on how technology has since been integrated into the teaching and learning of mathematics. It continues with an exploration of some potential, benefits, and most importantly reviews the effectiveness of using ICT as a form of multiple representations on student mathematics achievement. Both old and new literature has been found to be quite relevant in this study.

2.2 Infusing technology into mathematics teaching

Technology infusion in classroom instructional processes has attracted a lot of attention in recent years. Drijvers (2013) studied the role, beliefs and knowledge of a high school pre-calculus teachers, and the impact on student learning, concerning the use of graphing calculators and listed technology as one of the key principles to enhance the quality of mathematics, suggesting that teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing. After conducting a research on the use of interactive technology with elementary students, specifically targeting English Language learners' mathematical abilities López (2010) argues that there are at least three reasons for integrating ICT in mathematics teaching in schools, namely, desirability, inevitability and public policy. This is agreed upon by Nordin, Zakaria, Mohamed, and Embi (2010) who further defines that desirability can be supported in terms of students, teachers and schools where students are motivated, stimulated ,encouraged; teachers improve their efficiency, allow more time for student-work and gain better records of their students' progress and hence schools improve efficiency, educational inclusion and multilingual classrooms. In addition technology becomes inevitable at the time when conventional alternatives no longer exist (Nordin et al., 2010) and when its cost has been reduced to affordable amounts. As far as public policy in many countries there has been an acceptance of the educational benefits of ICT and thus governments promote its use wherever and whenever it is possible starting from the first grade of compulsory education.

Baki, Kosa, and Guven (2011) researched the impact of dynamic geometry software on spatial visualization skills of pre-service mathematics teachers and found out that technology is integrated into mathematics teaching and learning in two forms. First, there are virtual manipulatives which consist of specific interactive learning environments. In the virtual manipulatives settings students can explore mathematical concepts without having special computer skills or knowledge about specific educational software packages. Secondly, as also stated by Preiner (2008) there are mathematical software tools that are appropriate for educational purposes and can be used for a wide variety of mathematical content topics, thus allowing more flexibility and enabling both teachers and students to explore mathematical concepts .

Berman and Okubo (2015) studied the differences between ICT-integrated environment and paper-and-pencil environment and suggest that the paper-and-pencil environment is relatively passive in supporting learning. Current studies have found that there are changes in terms of active engagement with the implementation of ICT into mathematics education as ICT holds higher efficiency in mathematics manipulation and communication as well as interactivity between teachers, students and mathematics (De Witte and Rogge, 2014). Nevertheless, the paper-and-pencil environment has simplicity and convenience that cannot be ousted from classroom practices. It can be argued that inappropriate uses of ICT may potentially block teaching and learning processes in problem-solving and justifying, or perhaps create cognitive obstacles in understanding. Ellis and Loveless (2013); (Lee and Jin, 2015) concur and warn against underestimating the effect of the personal relationship existing between teacher and student. They cite it as an important factor in successful educational development. Since ICT and paper-and-pencil environments both have advantages and disadvantages, it is not necessary to separate them but to combine them. Considering the integration of both ICT and paper-and-pencil can be beneficial; the implementation of ICT into mathematics education has been the main direction of current research in the field of mathematics education and ICT (Baki et al., 2011; Drijvers, 2013). Despite official encouragement and enormous investment across the developed world, the global movement to integrate digital technologies into school mathematics has had limited impact on mainstream classrooms (López, 2010). Since the implementation of ICT in classroom practices has been slow, recent studies shift their attention to the role of the teacher as a mediator for appropriate integration of ICT into teaching practices (Lee and Jin, 2015). Teachers pedagogical knowledge in the use of ICT to bolster students learning requires them to tackle potential problems.

2.3 Effectiveness of using computer assisted instruction on student's mathematics performance

Computer assisted instruction (CAI) has over the years been investigated from different point of views. Banilower et al. (2013) investigated the probable advantages of a CAI curriculum on students' understanding of and transitions among graphical, tabular, and symbolic representations of algebraic concepts. In the study, eight students were taught with traditional algebra curriculum which emphasized symbolic representation. The other eight students were taught with reform-based algebra curriculum in which representations were introduced simultaneously without any priority. Interviews were done with these students. The results revealed that multi-representational curriculum could be effective for helping students to improve their conceptual knowledge of algebraic and functional concepts.

Shadaan and Eu (2013) conducted an experimental design study using a pre-posttest to evaluate the success of students learning using the GeoGebra software. It was a twelve hour course held for a period of two weeks involving two eighth grade classes. It was observed that computer based activities can efficiently be used in the learning process and the GeoGebra software encouraged higher order thinking skills. The software was also observed as having a positive effect in motivating students toward learning and retaining their knowledge for a longer period. This was proven based on a recall test conducted a month later. In another study, Bhagat and Chang (2015) found that high ability Grade 9 boys felt the lesson was interesting. Students explored their learning beyond what was assigned by the teacher and were happy and engaged in the lesson using GeoGebra software. The teacher was able to identify students who faced challenges in such a setting and did not engage in the lesson; therefore it was suggested that further strategies need to be incorporated to motivate most students.

Herceg and Herceg-Mandic (2013) conducted a study on two groups of students. One group used applets only, whilst the other used the GeoGebra software and applets. The study tested how to incorporate computer-based learning to reduce the working process of numerical integration. The results of this study showed that the GeoGebra experimental group gained more knowledge and skills than the control. This study also suggested that GeoGebra use is helpful for students who face difficulty in solving mathematical problems since they do not have to spend so much time solving by hand. According to Milovanovic, Obradovic, and Milajic (2013) dynamic software improves students' understanding of mathematics; students were able to explore and form conjectures and therefore had better overall scores.

Doktoroglo (2013) purposed to construct the concept of parabola with the relationship between its algebraic and geometric representation by using GeoGebra. A learning environment supported by GeoGebra including 4 phases was prepared and the lesson was implemented in one class hour. GeoGebra was used as a presentation tool and students examined the algebraic and geometric representation of a parabola in the fourth phase. The 11th grade level class including 23 students was videotaped during this hour. The students' important reactions were reported and interpreted. As a result, the 4 phases learning environment supported by GeoGebra was found practical and beneficial in terms of examining some advanced properties of a parabola. Baydas, Göktas, and Tatar (2013) also used GeoGebra in their case study to evaluate high school students' views about learning mathematics with GeoGebra. 23 students learned quadratic functions with GeoGebra. At the end of the study, evaluation form including seven open ended questions which was prepared by the researcher was administered. According to the results, it was concluded that learning with GeoGebra provided better learning and it was found as fun and interesting by the students.

Another research study involving the use of GeoGebra was conducted by Zulnaidi and Zakaria (2012).They examined the effects of GeoGebra use on students' conceptual and procedural knowledge of functions. The study sample composed of 124 high school students. The study used quasi-experimental non-equivalent pretest- posttest control group design. The results revealed a significant difference between groups. It was concluded that GeoGebra improved high school students' not only conceptual knowledge but also procedural knowledge. In addition, it was claimed that GeoGebra helped students to understand the relation between conceptual and procedural knowledge. Granberg and Olsson (2015) conducted a study to determine the effects of using the dynamic software, Geometer's Sketchpad (GSP) in the teaching and learning of graph functions. This study was conducted among Form Six students in a Malaysian secondary school. A quasi-experimental design using intact sampling was employed. A significant difference was observed in the achievement of the experimental group as compared to the control group as the mean score of the experimental group was higher than the mean score of the control group in the post test. The conclusion made from this study was that the dynamic software (GSP) had a positive effect on student achievement and attitude towards learning graphs of functions.

Beyranevand (2014) investigated the associations between students' achievement levels and two abilities regarding multiple representations and linear relationships. The two abilities were to recognize the same linear relationship represented in different ways to solve linear equations with one unknown presented multiple ways. The author also investigated students' preference toward particular representations. The sample was 443 seventh and eighth grade students. Data was collected by a survey and problem sets. Survey consisted of likert scale questions on attitudes toward different representations, and it was asked to the students to solve problems presented in verbal, pictorial and symbolic modalities. According to the responses, interviews were also made. Multiple regression/correlation and chi-square analyses were used to compare students' answers. The results revealed that students who managed to identify the same linear relationship with one unknown problem presented in different ways and solve linear equations with one unknown presented multiple ways were significantly more likely to perform a higher level. In addition, the results of this study revealed that low-achieving students were more likely to prefer using pictorial representations while high-achieving students prefer using verbal and symbolic representations when solving linear equations.

The effectiveness of some technological tools which enable to link multiple representations of equations such as Function Probe, Math Trax, TI-83 graphic calculator was examined for high school and middle school students in many studies. For example Schmidt-Thieme and Weigand (2012) investigated a 16-year-old student's constructions of transformation of function by using Function Probe. In that study, relation between graphs and tabular values and also relation between graph and algebraic representation were examined. The results pointed that visual reasoning is a powerful form of cognition. Moreover, multiple representations increased the student's motivation to complete the given investigation.

In a similar way, Beyranevand (2014) investigated the remedial freshmen students' attitudes towards to multiple representations, students' choice of representation when solving a problem, and the effects of computer settings on students' choices of representation. A four-part activity was implemented. In the first part, no suggestion was given to students. They were free to choose any representation. In the second, third, and final parts, students examined the problem in graphical, tabular and algebraic representation respectively. She observed students' usage of software, and administered a questionnaire to obtain students' attitudes towards multiple representations and mathematics. The results indicated that, the attitude towards mathematics were still negative. The researchers claimed that the reason for this was due to the fact that the students were remedial students. Moreover it was found that students' previous knowledge, experiences and personal preferences influenced their choices of representations. She suggested that instructors should prepare a multi-representational environment. In this way students could experience different representations and select the most appropriate one needed for a problem.

Jupri, Drijvers, and van den Heuvel-Panhuizen (2015) investigated five different types of function, namely polynomial, rational, exponential, logarithmic, and trigonometric were measured according to three components as modeling, graphing and problem solving. In this quasi-experimental design, experimental group students participated in five Calculator-Based Laboratory activities whereas the control group students' did not engage in any of these activities. The data collected from pre and post test results were evaluated by both quantitative and qualitative methods. Multivariate and univariate analyses results indicated that there were no significant differences between groups on three main components that were modeling, graphing and problem solving. On the other hand, qualitative analyses results showed that experimental group students outperformed control group students on graphing a function. In addition, the results revealed that experimental students were more successful on scaling and demonstration of the local and end behavior of a function. Moreover, graphical methods were used more often by the experimental group students to solve problems. Lastly, according to descriptive statistics, control group students could not give correct answer to the questions related sketching graph as twice as the number of the questions which were not answered by the experimental class. Overall, Jupri et al. (2015) suggested that Calculator-Based Laboratory activities can affect the students' performance positively. Moreover it was indicated that this positive effect of graphic calculator can be attributed to its ability of showing multi-representation of a function which are graphical and tabular to explore and analyze function. Another research conducted with middle school students was done by Birgin, Çatlıoğlu, Coştu, and Aydın (2009)**.** The effects of spreadsheet and dynamic geometry software, Autograph, on the achievement and self-efficacy of seventh grade students were investigated in this study. Three instructional methods which were spreadsheet-based instruction, Autograph-based instruction and traditionally based instruction were randomly assigned to three classes. Activity sheets including same questions but different directions with respect to the instruction method were prepared. The content of the questions included equations, symmetry, coordinate plane, graphs of linear equations and solving systems of linear equations by graphing method. Students in the spreadsheet-based and autograph-based instruction classes worked on the questions using spreadsheet and autograph individually without any guidance. Traditional-based instruction group students also worked on the same questions but they did not use any technological device. Mathematics achievement test, Mathematics self-efficacy scale and computer self-efficacy scale were administered both before and after the treatments. According to analysis of covariance results of mathematics achievement test, the autograph group students and traditional group students were performed better than the spreadsheet group students. In addition, no significant difference was found between autograph and traditional group students' test scores. Moreover, autograph students' mathematics self-efficacy test scores were significantly greater than scores of traditional group students and also there was no significant difference between autograph and excel group students' scores, and between excel and traditional group students' scores. Besides, a significant correlation was found between self-efficacy scores and mathematics achievement scores.

2.4 Motivation and CAI in mathematics lessons

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 this study asks how CAI or CTI affects the motivation levels of secretarial studies learners in linear equations.

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. 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 linear equations concepts may be presented, that may eventually lead to improved performance in the topic. If learners are motivated to learn linear equations, 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).

2.5 Summary of literature

The foci of reviewed studies on technology in mathematics education were the benefits of using CAI in learners performance and achievement. Most studies reported here were conducted with middle school students. A variety of data collection tools and data analysis were used in these studies. The results of these studies demonstrated that using CAI improved the conceptual understanding and achievement level of students in the domain of algebra.

The effectiveness of using technological tools in mathematics classrooms was demonstrated in many experimental studies. Technological tools such as graphic calculator and also GeoGebra were used in these studies conducted with both high school and college level students. The studies conducted with high school students focused mostly on multiple representations of functions such as algebraic, graphical and tabular. In all studies, the importance of making transitions between these representations was seen as a core skill for the comprehension of the concept. Also these experimental studies examined whether conducting mathematics lessons with the help of technological devices such as graphical calculators and some computer software such as Function Probe. Most of the studies showed evidences of positive effects of using these tools and software on both students' achievement in function concept and attitudes towards mathematics lessons. As most related to this study, the studies examining the effects of using GeoGebra for the function concept, the software was found to be practical and beneficial.

Apart from those studies, a limited number of studies investigated the effects of using GeoGebra software on students' achievement and attitudes. Yet, the common point of those studies was related to the effectiveness of GeoGebra software for the concept of linear equations, Cartesian coordinate system and slope. However, literature on dynamic mathematics software usage at vocational institution especially in Africa and most importantly Botswana for the teaching and learning of linear equations is still scares. The findings of the reviewed articles have predominantly reflected the European and American contexts. There is little evidence of similar research efforts in Botswana, particularly in light of major differences between western societies and the local society. Some differences exist in the mathematics curricula, school structure, and policies regarding the recruitment and training of school teachers. For one thing, there is a mix up in placement of trained teachers according to their respective areas of specialties in Botswana. This is one area that could possibly be an aid to student poor perfomance and has implications on the teaching and learning environment but have not been explored in this context. Therefore, there is a need to investigate the effectiveness of using GeoGebra on students' achievement in linear equation at vocational institutions in Botswana.

CHAPTER 3

METHODOLOGY

This section highlights the methods that the study used to collect data. Focus will be on the research design which aimed to investigate how the use of Geogebra software supports the teaching associated with linear equations, research population, sampling techniques, sample, instrumentation, variables, ethical considerations, data collection methods and procedures and data analysis methods.

3.1 Research Design

This study employed a quasi-experimental design with a non-equivalent group 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 secretarial studies students. This design lacked random assignment of participants to experimental group and control group. This design was preferred in order to preserve the normal running of the participating institutions and to reduce threats to the external validity of the study since natural environments were maintained. The design ensured that participating learners continue 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 did not disturb any of the schooling activities, by fitting into the schools' term plans.

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 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.

This study engaged two intact classes and two teachers, all selected by convenience sampling. The class at the school where the researcher teaches formed the experimental group because the researcher was the one who administered CAI while the other class at another selected school formed the control group and the teacher at that school administered CTI. The researcher administered CAI in the experimental class to preserve uniform conditions in the implementation of CAI. The teacher at the control school implemented CTI in the control class to preserve conventional conditions. A questionnaire that measured the level of motivation of students was administered to both the control and experimental groups to gauge if there was any significant difference in the level of motivation between the two distinct groups.

All activities such as writing the pre-test and post-test, teaching, interviewing and administering questionnaire that characterizes 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 first semester (August to December 2017) of schooling in southern district of Botswana. This arrangement was opted because it will preserve 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.

3.2 Description of the population

The population for the study consists of all secretarial studies Mathematics learners from 14 Brigades that are located in the southern region of Botswana. Most of the Brigades in the southern district share the same characteristics of having persistently performed poorly in mathematics over the years, and specifically in linear algebra which resulted in the decrease in the number of learners who have been graduating since 2010.

3.3 Sampling techniques

A convenience sampling method was used to select two Brigades and two teachers that participated in this study. This sampling method was opted for 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 Brigades with whom the researcher already had existing relations with and one that was willing to participate in the study

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: it is less costly; it is less time-consuming; it is easy to administer; it may secure higher participation; and, 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 generalize 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 The study sample

The sample of the study consisted of secretarial studies students (n=41) from two Brigades , which were drawn by convenience sampling methods from the population of the study.

Table 1: Composition of sample

Group	No of students	Percentage
Experimental (CAI)	21	51%
Control (CTI)	20	49%
Total	41	100%

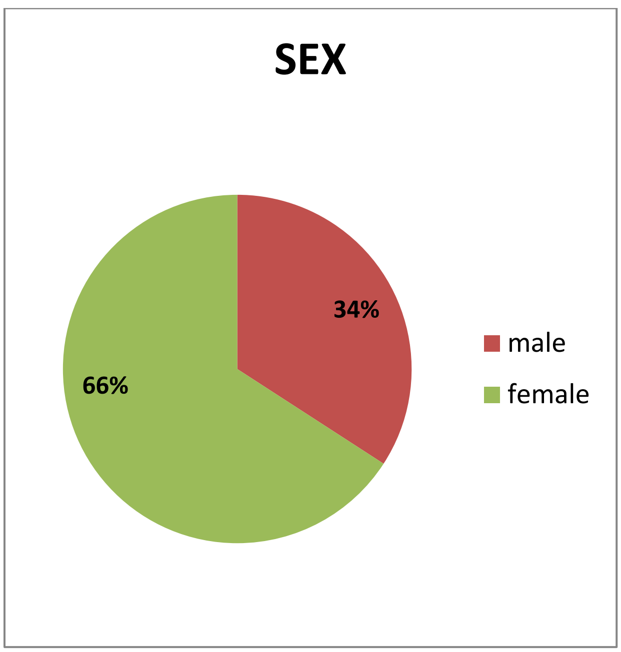


Figure 3 : Sex composition of the participants

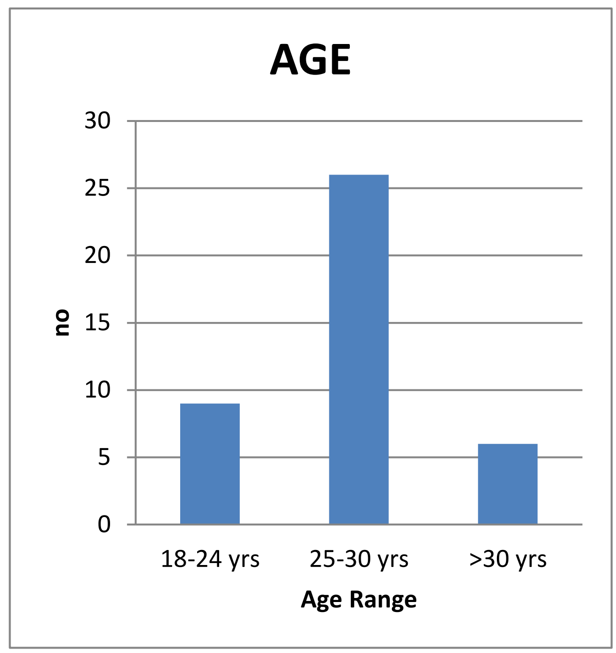


Figure 4: Age composition of the participants

Two Brigades 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 one class that participated in the study. Participants (n=21) from the Brigade in which Computer Assisted Instruction (CAI) was implemented formed the experimental group, while participants (n=20) from the Brigade in which Conventional Teaching Instructions (CTI) was implemented formed the control group. Secretarial studies students were chosen because they all undergo a computer skills subjects as a core subject and therefore would have a minimum required knowledge of computer use, which they needed during treatment.

The experimental school and control school are separated by almost 80km to minimise possibilities of contact and contamination between participants in both groups (Dhlamini, 2012). The distance between the participating schools ensures that threats to external validity such as treatment diffusion and participant effect are minimised (Gay et al., 2011; McMillan & Schumacher, 2010). However, non-randomisation of participants means 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).

3.5 Instrumentation

For this study, three instruments were used to collect data, those are the pre-test, post-test and the motivation questionnaire.

3.51 Pre-test

The pre-test (see appendix A) was developed and its mandate was to check the students' mathematics achievement levels before the treatment. The results gave information about the equal success of experimental and control group students. The pretest composed of 15 multiple choice items. Nine of these items were adopted from previous years BGCSE papers since all the participants in this study have sat for this particular examination. The rest of the items were developed by the researcher. Aspects of linear equations that made the test included: plotting points, drawing lines, finding the gradient of a line, solving equations with one unknown variable and solving simultaneous equations with two unknown variables. The items of the pretest were checked by two experienced teachers in terms of content coverage, language use in the test, clarity of items and difficulty level. They agreed on appropriateness of the test. The pretest was implemented to both experimental and control groups. The correct answers and the wrong answers were evaluated as 1 points and 0 points respectively. Maximum achievable points for the test was 15 while minimum possible points was 0 . Participants in both the experimental group and the control group wrote the same tests using pen and paper.

3.52 Post-test

The posttest (see appendix B) was the same as the pretest. The same test was used for pre-testing and post-testing so as to determine if there has been 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. Both the control group and the experimental group wrote the same posttest. The control group wrote their posttest in pen and paper because they were taught using CTI, which does not incorporate the use of computers whereas the experimental group completed the post-test using the computer to assist them in finding solutions just as they used a calculator in tests. This was done because the teaching method in the experimental group largely embraced the use of computers.

3.53 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 linear equations was determined. The questionnaire (see appendix C) was administered to the participants (n=41) in both groups after the interventions. 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 linear equations, 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 linear equations after using CAI and CTI. 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

linear equations. Bryan (2009) proved that the questionnaire was reliable and valid in Science. In this questionnaire , learners responed to each of the 15 linear equations motivation questionnaire items on a 5-point scale where 1=never, 2=rarely, 3=sometimes, 4=often, and 5=always. The linear equations motivation questionnaire maximum total score is 75 and the minimum was 15. A learner's total linear equations motivation questionnaire score was interpreted in the following way:
60-75 motivated "often to always" (high motivation); 45-60 motivated "sometimes to often" (moderate motivation); 30-45 motivated "rarely to sometimes" (low motivation); 15-30 motivated "never to rarely" (very low motivation).

3.6 Variables

The variables in this study are categorized as independent and dependent. The independent variables of the study were the treatments, CAI which is instruction through dynamic mathematics software versus CTI which is regular instruction (without using any dynamic mathematics software). The dependent variables were student performance and motivation

3.7 Validity

Some possible validity threats, such as subject characteristics, location, history, testing and implementation, are discussed for the present study.

Threats of location were minimized since the test was implemented to students in their regular classrooms at the same time. Selected learners were drawn from Brigades that share similar socio-economic and educational characteristics and therefore were affected by similar conditions. The accessible population of the study were secretarial studies student in southern district of Botswana. Since the Brigades were chosen conveniently, the results that were drawn from this study were not generalized to a larger population regarding external validity. However, the results could be applied to a larger population of samples which have similar characteristics with the sample of this study. The tests were administered in regular classroom settings during regular lesson hours. The conditions of the classrooms were made to be quite similar, the sitting arrangements and the lighting were equal in all classrooms, thus, the threats to the ecological validity were mitigated. Since the researcher was also the instructor, an observer was engaged who observed all lectures during the treatment to take notes meticulously in order to examine the researcher bias. The researcher personally collected assessment data from both schools.

To address the content validity of the test, questions were drawn from the Botswana National Certificate in Secretarial Studies (BNCSS) approved syllabus. In addition, the test was also given to an expert panel of experienced teachers. Content validity was ensured by giving selected teachers the tests prior to the onset of the pilot study so that they can identify typos and check whether the items make sense and are relevant to the stated objectives. Possible adjustments that were suggested by the panel were considered to strengthen the validity of the test.

To ensure validity of the motivation questionnaire, the constructed questionnaire was given to a panel of teachers who hold degrees in Mathematics education and further have experience in vocational education mathematics teaching and learning. This panel assisted productively in the validation process. These people were selected because they are knowledgeable about learner's 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 included 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.

3.8 Reliability

The consistency of items within the pretest (McMillan & Schumacher, 2010) was determined by the researcher by conducting a pilot study in a group of twenty conveniently sampled students to collect data to compute the reliability of the test. The pre-test that was administered during the pilot study was used to compute the Spearman-Brown reliability . 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 linear equations. The Spearman-Brown reliability was used because after the pre-test learners were taught using CAI before writing the post-test. The spearman Brown reliability coefficient was calculated to be 0.994 using SPSS. According to reliability statistic table the Spearman Brown Coefficient needs to be more than 0.80 to be acceptable.

The pilot study was also done to collect data to compute internal consistency reliability of the motivation questionnaire. This was administered a day after learners had written the post-test of the pilot study. The Cronbach's reliability coefficient was computed using SPSS. The Cronbach's Alpha value shows the degree to which items are interrelated (Johnson & Christensen, 2012), and it is normally used when each item in the questionnaire has several response options (Gliem & Gliem, 2003). The value was found to be 0.805 which indicated a high level of internal consistency for the questionnaire scale.

3.9 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 and was granted ethical clearance and permission to access participating schools from ORD (Office Of Research And Development), (see appendix E) in accordance with the UB policy on ethics . School principals of participating schools and the also gave permission (see appendix F) and signed informed consent forms. In the letters, the researcher assured principals, teacher, and participating learners of confidentiality, anonymity, protection, voluntary participation and exit, before taking part in the study. Participating learners also signed appropriate letters of assent.

3.10 Data collection process

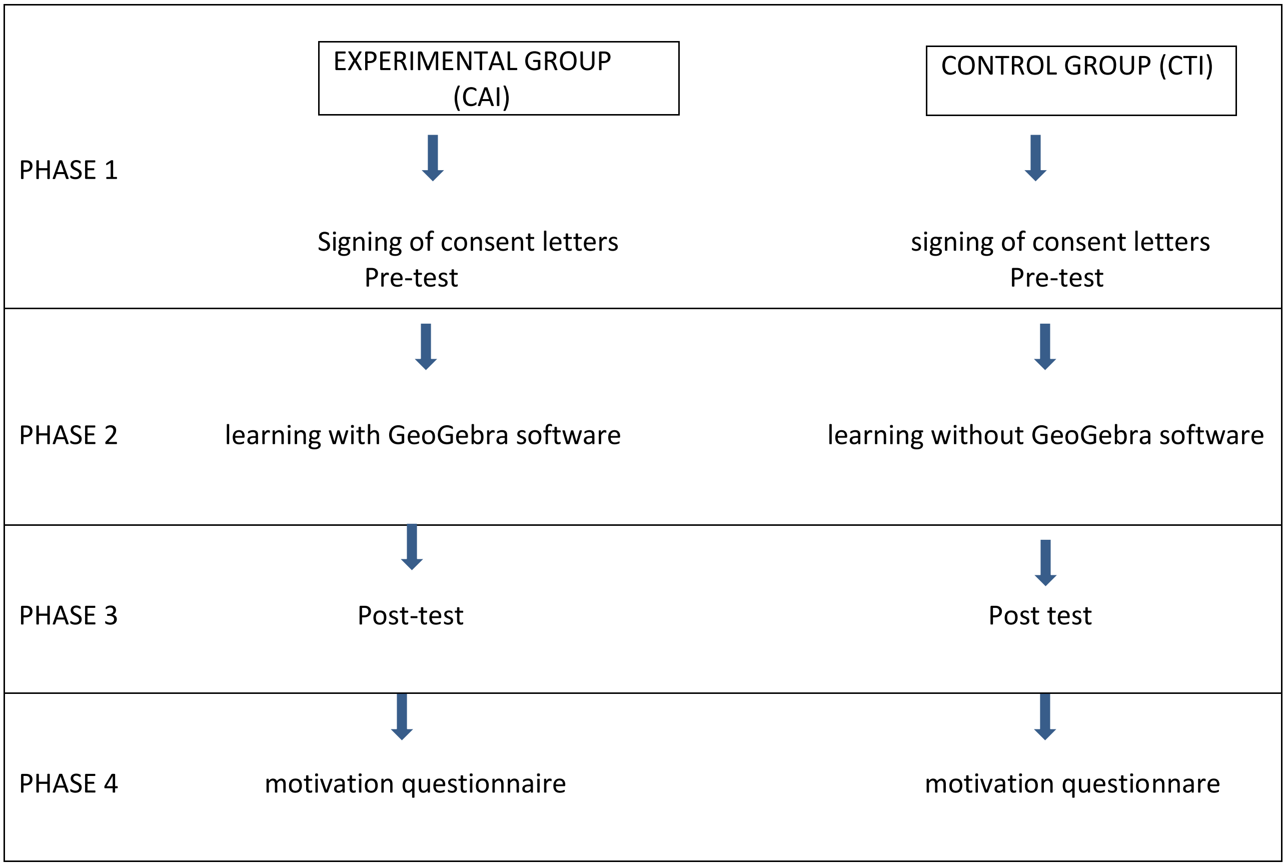


Figure 5: A summary of the research procedure

The research procedure was made up of four phases, as was also done by Bhagat and Chang (2015) when carrying out a research on a similar subject . The first phase was signing of consent letter by participants as a way of expressing their voluntarism in being part of this study (see appendix D). The researcher gave a brief verbal explanation of the mandate and objectives of the study to all participants and relevant stakeholders. This was on the same week followed by the administration of the pre-tests by the researcher on the experimental group and by the teacher who administered CTI at the control school. This test was administered simultaneously or at least on the same week for both the experimental group and the control group. The second phase was the intervention phase where CAI was implemented on experimental group by using the GeoGebra software while CTI was implemented on the control group (without using Geogebra or any computer software). The treatments were implemented in a period of three weeks, a total of twelve class hours for each group in the 2017 semester 1 of Botswana Brigades school calendar. Since linear equation was one of the topics for secretarial studies mathematics syllabus, the treatments were implemented during the normal school hours. The third phase was administration of the post-test to both groups after three weeks of treatment. After the respondents went through the three phases, the test results were evaluated to determine whether CAI was more effective than CTI in terms of student achievement in the topic of linear equations. The fourth phase was administering motivation questionnaire to both the control and experimental group to gauge their level of motivation in regards to the method of teaching they had been exposed to.

3.8 Data Analysis

Pre-test ,post-test and motivation scores were all analyzed using inferential statistics. Specifically, the T-test was executed using statistical package for social sciences (SPSS). The T-test was used to test for statistical significant difference between the control and experimental groups at the beginning of the study and at the end. This was done primarily by comparing the mean score of the pre-test and post score and motivation scores of both the groups. The null hypotheses were tested at 5% significance level i.e. $\alpha = 0.05$. A Parametric test was chosen because the assumption that was made was that the data for this study was normally distributed. The analysis also aimed at comparing means of two groups, each with a small sample size ($n>30$) , hence why the T-test was found to be more convenient.

Both independent T-test and Paired T-test were used in this study. The independent samples T-test is used when two separate sets of independent and identically distributed samples are obtained, one from each of the two populations being compared(Little, 2014). The independent sample T-test was used to compare the pre-test, post-test and motivation mean scores of the control group and experimental group. Paired samples T-tests typically consist of a sample of matched pairs of similar units, or one group of units that has been tested twice (a "repeated measures" *t*-test) (Pituch, 2015). The paired sample T-test was used to compare pretest mean versus the post-test mean of the control group and similarly those of the experimental group. The probability level, the critical t-value and the calculated t-value were all taken into consideration when analyzing data for this study. Type 1 and type 2 error were also taken into consideration during data analysis.

CHAPTER 4

PRESENTATION AND DISCUSSION OF FINDINGS / RESULTS

4.1 Presentation of results

4.1.1 Raw test results

The table below represents the pre-test and post test scores of both the control group and the experimental group. Both tests composed of 15 multiple choice items. The correct answers and the wrong answers were evaluated as 1 points and 0 points respectively. Maximum achievable points for each test were 15 while minimum possible points were 0.

Table 2: Raw test scores

	Control group (CTI)			**Experimental Group (CAI)**	
Student code	Pre-test	Post-test	Student code	Pre-test	Post-test
Cont1	9	9	Exp1	12	15
Cont2	10	11	Exp2	7	11
Cont3	8	7	Exp3	7	10
Cont4	7	11	Exp4	5	9
Cont5	9	11	Exp5	6	10
Cont6	7	10	Exp6	9	11
Cont7	6	6	Exp7	11	13
Cont8	7	9	Exp8	8	13
Cont9	5	8	Exp9	9	15
Cont10	9	10	Exp10	8	12
Cont11	10	12	Exp11	10	14
Cont12	11	13	Exp12	5	10
Cont13	8	11	Exp13	6	10
Cont114	8	10	Exp14	7	11
Cont15	9	11	Exp15	7	11
Cont16	7	10	Exp16	11	14
Cont17	7	8	Exp17	12	15
Cont18	8	11	Exp18	6	9
Cont19	12	11	Exp19	9	14
Cont20	10	13	Exp20	8	11
			Exp21	9	10

4.1.2 Results of the T-test

Results of this study are presented in the following chapter according to the research hypotheses and null hypotheses:

H_A: There is a significant difference between the pretest mean scores of the control group and that of the experimental group.

H_0: There is no significant difference between the pretest mean scores of the control group and that of the experimental group.

To determine whether any significant difference existed between the pretest mean score of both control and experimental groups, an independent sample t-test was done.

Table 3 & 4: Result of the independent t-test on the pretest of both groups

Table 3 **Group Statistics**

	TREATMENT	N	Mean	Std. Deviation	Std. Error Mean
PRETEST	Experimental group	21	8.19	2.136	.466
	Control group	20	8.35	1.725	.386

Table 4 **Independent Samples Test**

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
PRETEST	Equal variances assumed	-.262	39	.794	-.160	.608

t-value significant at $p < 0.05$

Table 3 show that the control group obtained a mean score of 8.35 while the experimental group obtained a mean score of 8.19. Table 4 indicates a mean score difference of 0.16 with a t-value of 0.262. The P-value is 0.794 ($P > 0.05$). Also critical value as observed from t- statistics table (2.022) is greater than the t-value (0.262). Both these comparisons indicates that the difference in the mean score of the two groups is not significant which calls for a failure to reject the null hypothesis which states that there is no significant difference in the pretest mean score of both the control and experimental group. This result illustrates that both the students in the control and experiment group were similar in abilities before treatment was administered.

H_A: There is a significant difference between the posttest mean scores of both the control group and the experimental group

H_0: There is no significant difference between the posttest mean scores of both the control group and the experimental group

To determine whether any significant difference existed between the posttest mean score of both control and experimental groups, an independent sample t-test was done.

Table 5 & 6: Results of the independent t-test on the posttest of both groups

Table 5 **Group Statistics**

	TREATMENT	N	Mean	Std. Deviation	Std. Error Mean
POSTTEST	Experimental group	21	11.81	2.040	.445
	Control group	20	10.10	1.832	.410

Table 6 **Independent Samples Test**

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
POSTTEST	Equal variances assumed	2.818	39	.008	1.710	.607

t-value significant at P < 0.05

Table 5 shows that the control group obtained a mean score of 10.10 while the experimental group obtained a mean score of 11.81. Table 6 indicates a mean score difference is 1.7 with a t-value of 2.818. The P-value is 0.008 ($P < 0.05$). The critical value from the t-statistics table (2.0226) is less than the t-value (2.818). Both these comparisons indicates that the difference in the mean score of the two groups is significant. These calls for a rejection of the null hypothesis and hence the alternate hypothesis which states that there is a significant difference in the post test mean score of both the control and experimental group. This finding illustrates that the students in the experimental group performed better in the post test by learning linear equations using Geogebra than the control group who were taught using the traditional teaching method.

H_A: There is a significant difference between the pretest and post test scores of the control group and pre test and post test scores of the experimental group.

H_0: There is no significant difference between the pretest and post test scores of the control group and pre test and post test scores of the experimental group.

To determine whether there is a difference in the pretest score and post test scores of both the control and experimental group, a paired sample test was carried out

Table 7 : Results of the paired sample t-test on the pretests and posttest of both groups

		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)
Pair 1	Posttest score – pretest score (control group)	1.750	1.410	.315	5.552	.000
Pair 2	Posttest score – pretest score (experimental group)	3.619	1.161	.253	14.286	.000

t-value significant at P < 0.05

Results in table 7 above shows that the mean score difference between the pretest and post test scores of the control group was 1.750 as compared to the mean score difference of the pretest and post test scores of the experimental group which was 3.619. For both the pair 1 and pair 2, P-value obtained was 0.000, (P < 0.05) indicating that the differences between the pretest scores and posttest scores of both groups was significant. For Pair 1, the critical value from the t-statistics table (2.093) is less than the t-value (5.552). Also for pair 2, the critical value from the t-statistics table

(2.0859) is less than the t-value (14.286). These calls for a rejection of the null hypothesis. From the above results, it can be seen that students gained knowledge and understanding from both approaches which is shown by a significant improvement in the scores of both the groups. It appears however, that students in the experimental group gained more knowledge as seen by their higher mean difference or improvement as compared of the control group.

H_A: There is a significant difference between the experimental group and control group in their level of motivation scores

H_0: There is no significant difference between the experimental group and control group in their level of motivation scores

To determine whether any significant difference existed between the motivation level mean score of both the control and experimental groups, an independent sample t-test was done.

Table 8 **Group Statistics**

	TREATMENT	N	Mean	Std. Deviation	Std. Error Mean
MOTIVATION	Experimental group	21	.86	.359	.078
	Control group	20	.10	.308	.069

Table 9 **Independent Samples Test**

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
MOTIVATION Equal variances assumed	7.238	39	.000	.757	.105

t-value significant at P < 0.05

Table 8 shows that the control group obtained a mean score of .10 while the experimental group obtained a mean score of .86. Table 9 indicates a mean score difference of .757 with a t-value of 7.238. The P-value is 0.000 (P < 0.05). The critical value from the t-statistics table (2.022) is less than the t-value (7.238) indicating that the difference in the mean score of the two groups in terms of their level of motivation was significant. This calls for a rejection of the null hypothesis and hence the alternate hypothesis which states that there is a significant difference in the motivation level mean score of both the control and experimental group. This finding illustrates that the students in the experimental group were more motivated by learning linear equations using Geogebra than that of the control group who were taught using the traditional teaching method.

4.2 DISCUSSION OF FINDINGS

In the current study, n=41 learners participated. The experimental group consisted of n=21 learners while the control group consisted of n=20 learners.

I. Research question 1

Is there a statistically significant difference in the average pre-test scores of students taught linear equations using CAI and those taught using the CTI?

The following were the null hypothesis and alternative hypothesis on the pre-test mathematics performance:

Null hypothesis on pre-test mathematics performance H_0: There is no statistically significant difference between the average Mathematics performance scores of students who participate in CAI and those who participate in CTI , in the topic of linear equations.

Alternate hypothesis on pre-test mathematics performance H_A: There is a statistically significant difference between the average Mathematics performance scores of secretarial students who participate in CAI and those who participate in CTI in the topic of linear equations.

Results of the pre-test (Table 3) showed that the control group obtained a mean score of 8.35 while the experimental group obtained a mean score of 8.19. Table 4 indicated a mean score difference of 0.16 with a t-value of 0.262. The P-value was 0.794 ($P > 0.05$) indicating that the difference in the mean score of the two groups was not significant. Statistically speaking, CAI and CTI on average both had more or less the same conceptual understanding of linear equations as portrayed by the results of the pre-test at the beginning of the experiment. This is to say that it can be concluded that both the control and experiment group were similar in abilities before treatment was administered. The results support the notion by Bhagat (2015) that pretest outcome plays a special role in bias reduction compared to other covariates as well as the hypothesis that two pretest waves is preferable to one

II. Research question 2

Is there a statistically significant difference in the average post-test performance scores of students taught linear equations using CAI and those taught using CTI?

The following were the null hypothesis and alternative hypothesis on the post-test mathematics performance:

Null hypothesis on post-test mathematics performance H_0: There is no statistically significant difference between the average Mathematics performance scores of students who participated in CAI and those who participated in CTI , in the topic of linear equations.

Alternate hypothesis on pre-test mathematics performance H_A: There is a statistically significant difference between the average Mathematics performance scores of students who participated in CAI and those who participated in CTI , in the topic of linear equations

Results of the post-test (Table 5) shows that the control group obtained a mean score of 10.10 while the experimental group obtained a mean score of 11.81. Table 6 indicates a mean score difference is 1.7 with a t-value of 2.818. The P-value is 0.008 ($P < 0.05$) indicating that the difference in the mean score of the two groups is significant. The results of the post-test indicate an improvement in performance in both CAI and CTI which indicated that learning took place despite the use of different teaching methods. However, CAI did make a bigger difference regarding general performance (as measured by the post-test) both in absolute and differential terms

III. Research question 3

Is there a statistically significant difference in the average pre-test and post-test scores of students taught linear equations using CAI and pre-test and post-test scores of students taught linear equations using the CTI?

The following were the null hypothesis and alternative hypothesis on the pre and post-test mathematics performance:

Null hypothesis on post-test mathematics performance H_0: There is no statistically significant difference between the pre-test and post-test averages students who participate in the CAI and pre-test and post-test scores of students taught linear equations using the CTI.

Alternate hypothesis on pre-test mathematics performance H_A: There is a statistically significant difference between the pre-test and post-test averages scores of students who participate in the CAI and pre-test and post-test scores of students taught linear equations using the CTI

Results from the paired sample t-test (table 7) shows that the mean score difference between the pretest and post test scores of the control group was 1.750 as compared to the mean score difference of the pretest and post test scores of the experimental group which was 3.619. For both pair 1 and pair 2 (see table 8) , P-value obtained was low ($P < 0.05$) indicating that the differences between the pretest scores and posttest scores of both groups was significant.. 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, table 7). However, in the paired sample t-test (see table 7), the standard deviation of the control group (1.410) was bigger than that of the experimental group (1.161). This is an indication that the marks of the experimental 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 therefore, learners who received CAI performed better than those who received CTI. It can be seen that students gained knowledge and understanding from both approaches which is shown by a significant improvement in the scores of both the groups. It is evident however, that students in the experimental group gained more knowledge as seen by their higher mean difference or improvement as compared of the control group. 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).

IV. Research question 4

How does CAI or CTI affect the motivation levels of secretarial students in the topic of linear equations?

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

Null hypothesis on motivation H_0 **:** There is no significant difference between the average motivation scores of learners who participated in the CAI and those who participat in CTI , in the topic of linear equations

Alternative hypothesis on motivation H_A**:** There is a significant difference between the average motivation scores of learners who participate in CAI and those who participate in CTI , in the topic of linear equations

Results of the motivation questionnaire (Table 8) shows that the control group obtained a mean score of 0.10 while the experimental group obtained a mean score of 0.86. The standard deviations were almost the same, the experimental group having a standard deviation of 0.359 while the control group had a standard deviation of 0.308 (see table 8). Table 9 indicated a mean score difference of 0.757 with a t-value of 7.238. The P-value was 0.000 ($P < 0.05$) indicating that the difference in the mean score of the two groups in terms of their level of motivation was significant. This finding illustrates that the students in the experimental group were more motivated by learning linear equations using Geogebra than those of the control group who were taught using the traditional teaching method.

Statistics and numbers do not tell the whole story. So it is useful to briefly relate the researcher’s informal experiences. The researcher felt throughout the course that CAI students were more active and interested than the traditional ones. It is believed that an important component of the CAI process is not necessarily related to computers per se, but to the more active part played by CAI students, who had a larger proportion of their classroom time devoted to active participation than passively listening to lectures. It is also plausible that (though at this stage there is no hard evidence to support this claim) that computers did play a positive role, in making mathematics fun (which, must be admitted is an unpopular course with secretarial students). In other words, the fact that computers played a prominent role in the CAI course, may have taken the students' attention away from mathematics and made them more receptive. As a converse to the above observation, it was found that, exactly because the CAI class developed so much momentum, it is particularly important to plan class activities and teaching strategies very carefully so that the learning process does not degenerate into an exercise of computer gaming . In addition, it was observed that some lecturing was still necessary, even in the CAI course in order not to revert to 100% lab course. In accordance to the socio-constructivist perspective, learners in the experimental group felt “independent” to facilitate and develop their own solutions to linear equations problems. They showed confidence and were more “interested” in linear equations 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 linear equations.

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).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

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 secretarial studies learners in linear equations. Findings of this experimental study led to the following conclusions: (i) computer aided instruction proved as more effective method as compared with traditional method of instruction to enhance student learning at knowledge, comprehension and application levels of the cognitive domain in the subject area of linear equation; (ii) learner's active participation in instructional process resulted in better achievement and improved motivation. The results of this investigation indicated that the use of the computer software, GeoGebra, in the teaching and learning of linear equations improved the performance and motivation of secretarial studies learners. The software allowed learners to have an active role in solving linear equations 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 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 linear equations performance of learners. Students were able to experience a hands-on method of learning which had a positive effect in enabling them to understand the concepts better rather than just being passive learners. The software also gave the teacher and students the opportunity to work through the concepts together through exploration and visualization. This encouraged a more interactive teacher-student interactional environment where everyone worked as a team to guide, help and assist one another to reach the required goals. The cognitive aspect of learning linear equations was represented by visualization and understanding. Overall, GeoGebra is an effective tool in assisting the teacher and students in the mathematics classroom to achieve the principles of constructivist learning. Based on the findings of the current study, it is highly recommended that teachers be encouraged to use GeoGebra software in teaching Mathematics. This should be coupled with research to establish better findings to conclusively ascertain whether GeoGebra does actually have an effect on learning of broader mathematical concepts and on different levels of students.

5.2 Recommendations

From the results obtained, a number of implications can be forwarded in the interest of improving linear equations teaching in the classroom. Firstly, the significant differences in the post-test of the experimental groups as compared to the control groups indicate that students who were taught using Geogebra performed better than those taught using conventional methods. This observation can therefore encourage mathematics teachers and even curriculum developers of the potential of the Geogebra as an effective tool in learning linear equations. To face the challenges of present and future, to compete the nations in this information age, every nation will have to enhance the quality of its education systems, which is possible only by exploring the new dimensions and benefitting from latest means of communication. This study will explore new dimensions for the enhancement of quality education in Botswana. Findings of this study may be a source of encouragement for the widespread use of CAI at various grade levels and in varied subject areas. The study revealed that computer aided instruction was better than the traditional method. Therefore, the study suggested number of points for improving the widespread use of CAI. Those were:

1. More studies, using a bigger sample size, on the effect of CAI in teaching linear equations should be carried out so that the results can be generalized to all Brigades or any other institution in Botswana.
2. Future researchers should undertake researches to determine the effectiveness of various types of computer aided instruction for various subject areas and at different levels.

3. Both teachers and learners should be trained on how to effectively use computers in linear equations and other Mathematics topics with confidence.

REFERENCES

Angrist, N., Pansiri, N. O., & Tsayang, G. T. (2014). The Cont-Age-Ious Effect of Age on School Performance: Evidence from Botswana. Gaborone:Macmillian

Baki, A., Kosa, T., & Guven, B. (2011). A comparative study of the effects of using dynamic geometry software and physical manipulatives on the spatial visualisation skills of pre-service mathematics teachers. *British Journal of Educational Technology, 42*(2), 291-310.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). Report of the 2012 National Survey of Science and Mathematics Education. *Horizon Research, Inc.*

Baydas, Ö., Göktas, Y., & Tatar, E. (2013). The use of geogebra with different perspectives in mathematics teaching. *Çukurova University. Faculty of Education Journal, 42*(2), 36.

Berman, A., & Okubo, K. (2015). *Issues Surrounding Teaching Linear Algebra.* Paper presented at the The Proceedings of the 12th International Congress on Mathematical Education.

Beyranevand, M. L. (2014). The Different Representations of Rational Numbers. *Mathematics Teaching in the Middle School, 19*(6), 382-385.

Bhagat, K. K., & Chang, C.-Y. (2015). Incorporating GeoGebra into Geometry learning-A lesson from India. *Eurasia Journal of Mathematics, Science & Technology Education, 11*(1), 77-86.

Birgin, O., Çatlıoğlu, H., Coştu, S., & Aydın, S. (2009). The investigation of the views of student mathematics teachers towards computer-assisted mathematics instruction. *Procedia-Social and Behavioral Sciences, 1*(1), 676-680.

Cakiroglu, U., Akkan, Y., & Guven, B. (2012). Analyzing the Effect of Web-Based Instruction Applications to School Culture within Technology Integration. *Educational Sciences: Theory and Practice, 12*(2), 1043-1048.

Carnoy, M., Chisholm, L., & Chilisa, B. (2012). *The low achievement trap: Comparing schooling in Botswana and South Africa*: Pretoria : HSRC Press.

Carnoy, M., Ngware, M., & Oketch, M. (2015). The Role of Classroom Resources and National Educational Context in Student Learning Gains: Comparing Botswana, Kenya, and South Africa. *Comparative Education Review, 59*(2), 199-233.

Chikati, R. (2013). An Assessment Of The Impact Of High School Digital Divide To Students Performance At Tertiary Education In Botswana. *International Journal of Technology Enhancements and Emerging Engineering Research, 2*(9), 68-72.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches.* New York: Sage publications.

De Witte, K., & Rogge, N. (2014). Does ICT matter for effectiveness and efficiency in mathematics education? *Computers & Education, 75*, 173-184.

Doktoroğlu, R. (2013). *The effects of teaching linear equations with dynamic mathematics software on seventh grade students'achievement.* Citeseer.

Drijvers, P. (2013). Digital technology in mathematics education: why it works (or doesn't). *PNA, 8*(1), 1-20.

Ellis, V., & Loveless, A. (2013). *ICT, pedagogy and the curriculum: Subject to change*: Routledge.

Granberg, C., & Olsson, J. (2015). ICT-supported problem solving and collaborative creative reasoning: Exploring linear functions using dynamic mathematics software. *The Journal of Mathematical Behavior, 37*, 48-62.

Herceg, Đ., & Herceg-Mandic, V. (2013). GeoGebra in a geography class. *Acta Didactica Napocensia, 6*(1), 61.

Hohenwarter, M., & Preiner, J. (2007). Dynamic mathematics with GeoGebra. *AMC, 10*, 12.

Jacobson, M. J., & Kozma, R. B. (2012). *Innovations in science and mathematics education: Advanced designs for technologies of learning*: Routledge.

Jupri, A., Drijvers, P., & van den Heuvel-Panhuizen, M. (2015). Improving Grade 7 Students' Achievement in Initial Algebra Through a Technology-Based Intervention. *Digital Experiences in Mathematics Education, 1*(1), 28-58.

Karimi, S. (2016). Do learners' characteristics matter? An exploration of mobile-learning adoption in self-directed learning. Computers in Human Behavior, 63, 769-776.

Lasry, N., Charles, E., & Whittaker, C. (2014). When teacher-centered instructors are assigned to student-centered classrooms. *Physical Review Special Topics-Physics Education Research, 10*(1), 010116.

Lee, J., & Jin, S. (2015). *Developing ICT Competencies of Students who are gifted in Math and Science*.

López, O. S. (2010). The digital learning classroom: Improving English language learners' academic success in mathematics and reading using interactive whiteboard technology. *Computers & Education, 54*(4), 901-915.

Macdonald, C., & Pinheiro, M. (2015). Working in the Zone of Proximal Development (ZPD) in the English classroom: a case study on the teaching of literature. *Journal for Language Teaching, 49*(1), 141-159.

Maketo, L., & Balakrishna, C. (2015). *Is Rural Botswana Stuck to the" Chalkboard Only" Era while Others Make Strides in Mobile Learning?* Paper presented at the Next Generation Mobile Applications, Services and Technologies, 2015 9th International Conference on.

Milovanovic, M., Obradovic, J., & Milajic, A. (2013). Application of Interactive Multimedia Tools in Teaching Mathematics-Examples of Lessons from Geometry. *TOJET: The Turkish Online Journal of Educational Technology, 12*(1).

Nordin, N., Zakaria, E., Mohamed, N. R. N., & Embi, M. A. (2010). Pedagogical usability of the Geometer's Sketchpad (GSP) digital module in the mathematics teaching. *TOJET: The Turkish Online Journal of Educational Technology, 9*(4).

Preiner, J. (2008). *Introducing dynamic mathematics software to mathematics teachers: The case of GeoGebra*: na.

Ramani, P., & Patadia, H. (2012). The Effectiveness of Computer Assisted Instruction in Teaching Arithmetic. International Journal of Scientific and Research Publications, 2(11), 52-91.

Schmidt-Thieme, B., & Weigand, H.-G. (2012). *Choosing adequate digital representations.* Paper presented at the Proceedings of the International Conference on Mathematics Education.

Shadaan, P., & Eu, L. K. (2013). Effectiveness of Using Geogebra on Students' Understanding in Learning Circles. *The Malaysian Online Journal of Educational Technology, 1*(4), 1.

Volkmar, F. R. (2013). Zone of proximal development (zpd) *Encyclopedia of Autism Spectrum Disorders* (pp. 3421-3421). Springer: London

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children, 23*(3), 34-41.

Wlodkowski, R. J. (2011). Enhancing adult motivation to learn: A comprehensive guide for teaching all adults: John Wiley & Sons.

Zengin, Y., Furkan, H., & Kutluca, T. (2012). The effect of dynamic mathematics software geogebra on student achievement in teaching of trigonometry. *Procedia-Social and Behavioral Sciences, 31*, 183-187.

Zulnaidi, H., & Zakaria, E. (2012). The effect of using GeoGebra on conceptual and procedural knowledge of high school mathematics students. *Asian Social Science, 8*(11), 102.

APPENDIX A

PRE TEST/POST TEST

Please note that this test is sorely for the purpose of the study you have given consent to engage in and the marks will remain confidential. Thank you for taking part.

NAME________________________________ SURNAME___________________________

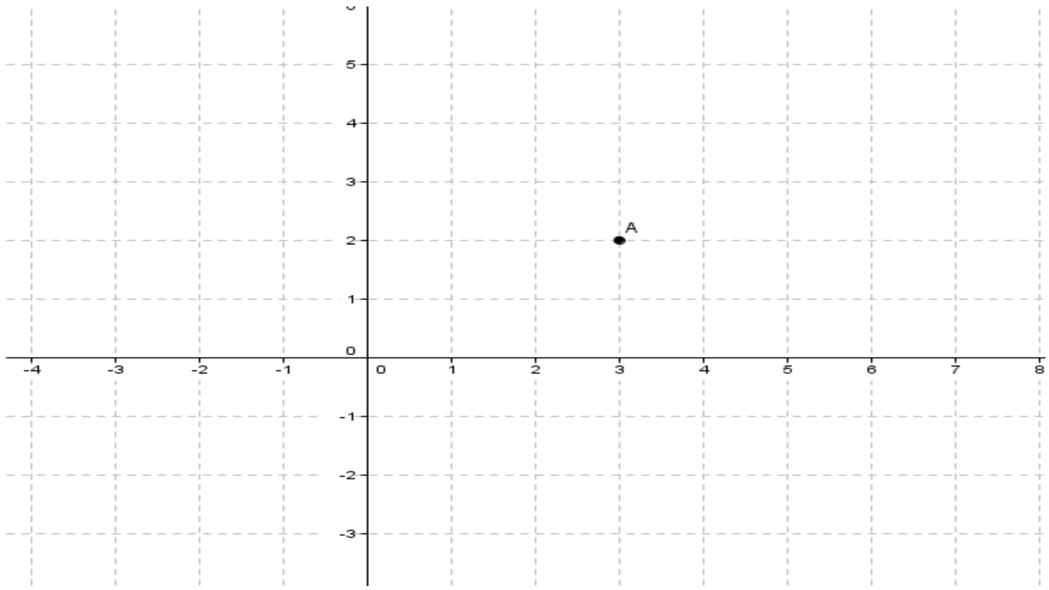
INSTITUTION__________________________ DATE______________________________

SEX___________________________________ AGE________________________________

INSTRUCTIONS

- There are 15 multiple choice questions. Answer all questions
- Circe the letter of the correct answer

1. What are the Cartesian coordinates of point A



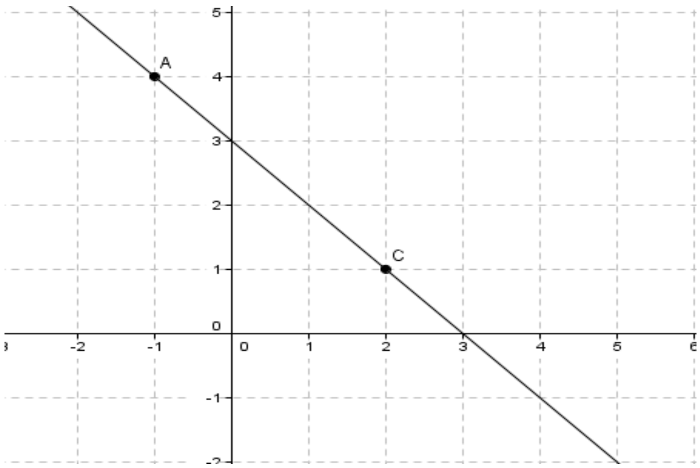
   A. (2,3)
   B. (3,2)
   C. (2,-3)
   D. (3,-2)

2. Which of the following equations represents an equation of a straight line
   A. $y = mx + c$
   B. $y = m + xc$
   C. $x = 2my + c$
   D. $x = 3m + xc$

3. Find the equation of a line given two points D(2,4) and E(0,0)
   A. $y = 3x + 2$
   B. $x = 2y$
   C. $y = 2x$
   D. $y = 2$

4. What is the gradient of the line $y = -3x + 5$
   A. 5
   B. 3
   C. -3
   D. -5

5. Where does the line intercepts the y-axis

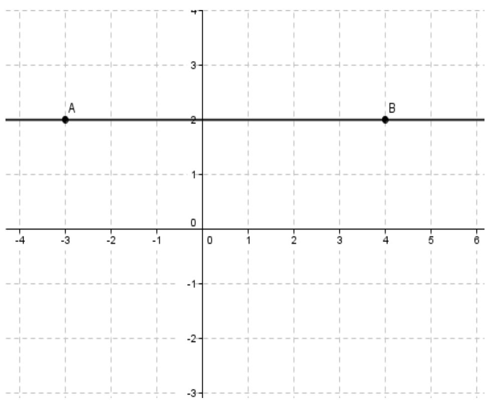


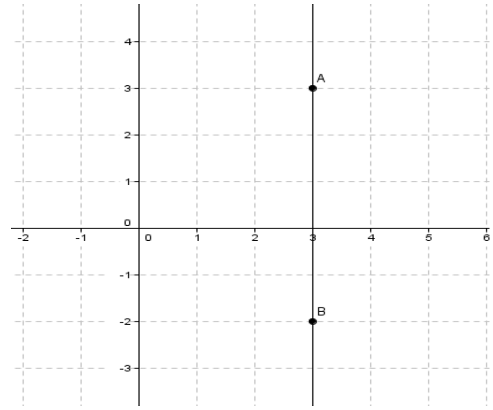
A. $y = 3$
B. $y = -3$
C. $y = 2$
D. $y = -2$

6. Find the midpoint of two points A(6,4) and B(-2,-2)
   A. (1,2)
   B. (4,2)
   C. (2,1)
   D. (3,2)

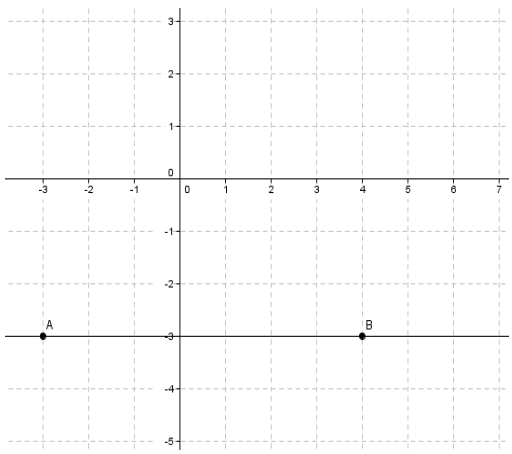
7. What is the distance between point (0,0) and point (3,4)
   A. 3 units
   B. 5 units
   C. 1 unit
   D. 7units
8. Which of the following points is NOT on the line $y = x - 4$
   A. (3,-1)
   B. (2,-2)
   C. (1,-3)
   D. (0,0)

9. Which of the following graphs represents the line $y = -3$
   A. B.

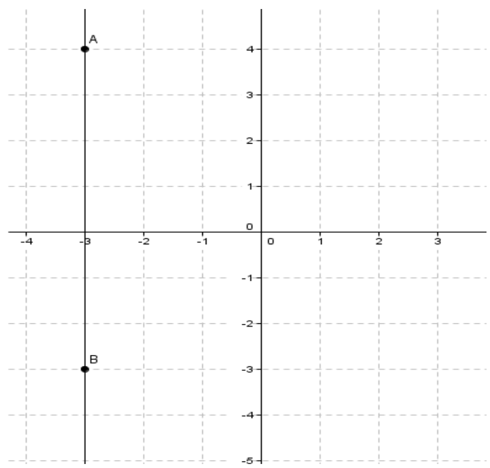




C



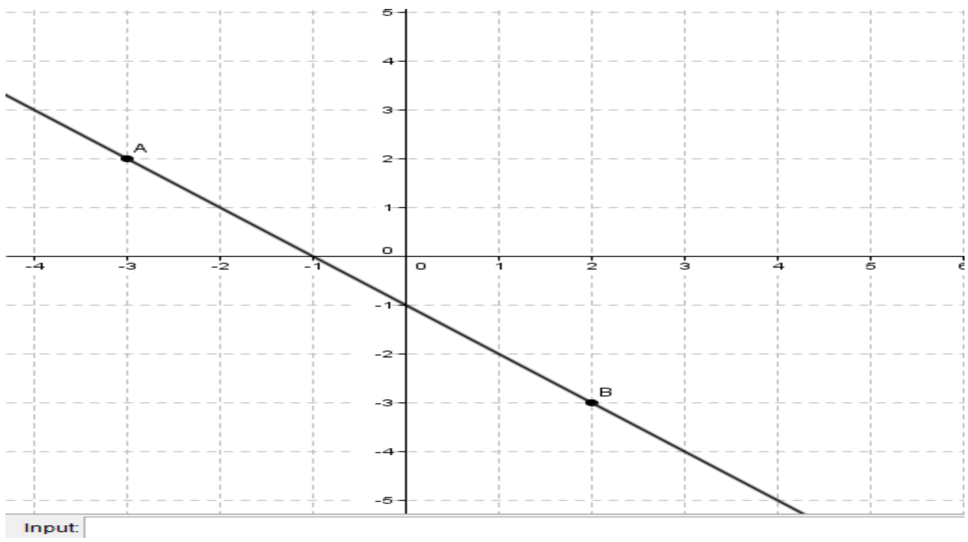
D.



10. Which of the following is not an equation of a linear graph?
   A. $x^2 + 2 = 2y$
   B. $x + 2 = y$
   C. $y = 3x - 1$
   D. $3x + 2 = y$

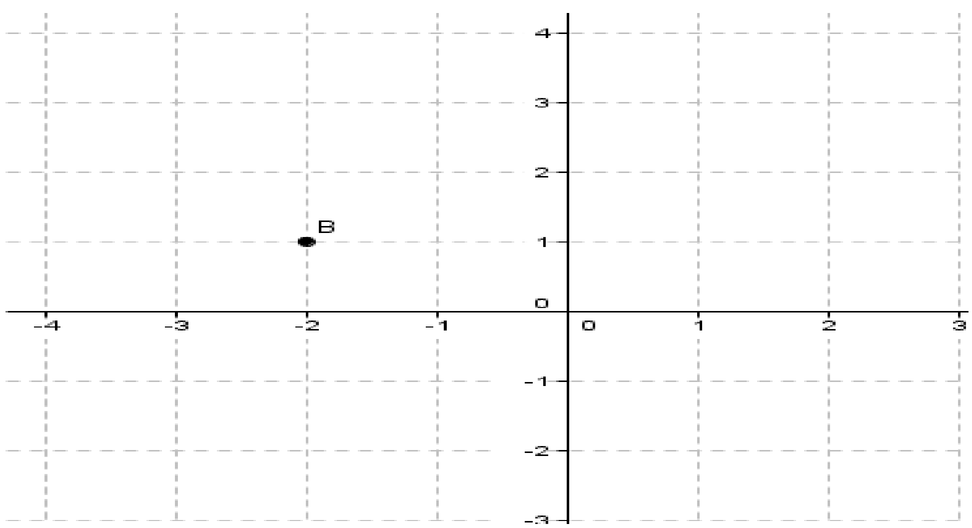
11. Which of the following equations has the same gradient as $y = -4x + 4$
   A.$y - 2 = 4x$
   B.$2y = -4x + 16$
   C.$-4x = y + 1$
   D.$y = 4x + 4$

12. Calculate the gradient of the following line



A. -2
B. $\frac{1}{2}$
C. $-\frac{1}{2}$
D. 1

13. What are the Cartesian coordinates of point B



A. (1,2)
B. (1,-2)
C. (-1,2)
D. (-2,1)

14. At which point do the line $y = 1$ and $y = 3x + 4$ intersept?

A. (0,0)
B. (-1,1)
C. (1,4)

D. (3,4)

15. Which of the following equations has a gradient of zero

A. $y = x$

B. $y = -5$

C. $y = 2x + 1$

D. $y = x + 0$

APPENDIX B

A POST-INTERVENTION LEARNER QUESTIONNAIRE

The linear equation Motivation Questionnaire

My name is Amantle Kereeditse, a master's student at University of Botswana undertaking a research on the effectiveness of using computer aided instructions as compared to conventional teaching methods in the performance and motivation of learners in Brigades in Botswana. I kindly request you to complete the following questionnaire.

Please be informed that the information that you shall provide will only be used for the purposes of the study and responses will remain anonymous.

PERSONAL INFORMATION (please tick where applicable)

Sex: male_______ female_________

Age: 18-24 yrs______ 24-30 yrs_____ above 30 yrs____

INSTRUCTIONS: 1. Answer ALL questions.

2. Put a tick (√) in the box that represents your choice in the provided options

Item	**Description**	**Never**	**Rarely**	**Some times**	**Usually**	**Always**
1	I enjoy learning the topic of linear equations					
2	The equations I learn relates to my personal goals					
3	I like to do better than other learners on linear equations tests					
4	I am nervous about how I will do on the linear equations tests.					
5	If I am having trouble learning linear equations, I try to figure out why.					
6	I become anxious when it is time to take linear equations test.					
7	Earning a good linear equation mark is important to me					
8	I put enough effort into learning linear equations					
9	I use strategies that ensure I learn linear equations well.					
10	I think about how learning linear equations can help me get a good job.					
11	I think about how linear equations I learn will be helpful to me.					
12	I expect to do as well or better than the other learners in linear equations.					
13	I worry about failing linear equations tests.					

14	I am concerned that other learners are better in linear equations.					
15	I think about how my linear equations mark will affect my overall mathematics mark.					
16	The linear equations I learn is more important than the mark I receive					
17	I think about how learning linear equations can help my career.					
18	I hate taking linear equations tests.					
19	I think about how I will use linear equations I learn					
20	The linear equations I learn is relevant to my life.					

APPENDIX C

INFORMED CONSENT FORM

PROJECT TITLE: Effectiveness of Using Computer Assisted Instructions On Students' Perfomane In Linear Equations on Secretarial Studies Students in Southern District Brigades in Botswana.

Principal Investigator: Amantle Mico Kereeditse
Phone number: 74005348

What you should know about this research study:

- We give you this informed consent document so that you may read about the purpose, risks, and benefits of this research study.
- You have the right to refuse to take part, or agree to take part now and change your mind later.
- Please review this consent form carefully. Ask any questions before you make a decision.
- Your participation is voluntary.

PURPOSE

You are being asked to participate in a research study of seeking the effectiveness of using computer assisted instructions on students' understanding of linear equations on Secretarial Studies Students in Southern District Brigades in Botswana. The purpose of the study is to contribute to the knowledge and understanding of how technology can enhance the teaching and learning of mathematics in vocational institutions in Botswana. This will assist the curriculum designers when designing the curriculum, thus leading to improved overall performance in National certificate in secretarial Studies**.** You were selected as a possible participant in this study because you are Secretarial Studies student in a Brigade in southern district in Botswana, therefore you meet the basic requirements of which this study can draw viable results from. Before you sign this form, please ask any questions on any aspect of this study that is unclear to you. You may take as much time as necessary to think it over.

PROCEDURES AND DURATION

If you decide to participate, you will be invited to a brief orientation a day before the commencement of data collection procedure to explain to you in detail what will be required of you. The data collection procedure will commence with you writing a pre-test, followed by a three week classroom teaching and learning of linear equations using either conventional teaching instruction or computer assisted instruction depending on whether you brigade forms the control or experimental group. The last stage will be writing of a post test, completion of a questionnaire and a voluntary semi structured interview. All the above mentioned is to take place in a period of four weeks.

RISKS AND DISCOMFORTS

You will not be exposed to any risks or discomforts as data collection will take place in your normal school and classroom hours and you will be dealing with your day to day mathematics lecturer.

BENEFITS AND/OR COMPENSATION

From this study, you will benefit a better understanding of linear equations which forms a trial part of your syllabus/ curriculum. You will also experience the privilege of learning mathematics through modern technological devices (computers) and unique software (geogebra), something that you do not often experience. Taking part in this study will also make you part and parcel of the results that will contribute to the knowledge and understanding of how technology can enhance the teaching and learning of mathematics in vocational institutions in Botswana, which will in turn assist the curriculum designers when designing the curriculum, thus leading to improved overall performance in National certificate in secretarial Studies. Stationary goodies will also be availed to you.

CONFIDENTIALITY

The data from this investigation will only be used for the purposes of this study. The names of the participant will remain confidential and none of these will be used for commercial use. The data will be kept in a safe trunk in the investigator's work office and only the investigator and research assistant will have access to the data.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you decide not to participate in this study, your decision will not affect your future relations with the University of Botswana, its personnel, and associated institutions**.** If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. Any refusal to observe and meet appointments agreed upon with the central investigator will be considered as implicit withdrawal and therefore will terminate the subject's participation in the investigation without his/her prior request.

AUTHORIZATION

You are making a decision whether or not to participate in this study. Your signature indicates that you have read and understood the information provided above, have had all your questions answered, and have decided to participate.

____ ____________

Name of Research Participant (please print) Date

______________________________ ___________

Signature of Staff Obtaining Consent Date
(Optional)

YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

If you have any questions concerning this study or consent form beyond those answered by the investigator, including questions about the research, your rights as a research participant; or if you feel that you have been treated unfairly and would like to talk to someone other than a member of the research team, please feel free to contact the Office of Research and Development, University of Botswana, Phone: Ms Dimpho Njadingwe on 355-2900, E-mail: research@mopipi.ub.bw, Telefax: [0267] 395-7573.