UNIVERSITY OF CAPE COAST

THE EFFECTS OF THE USE OF COMPUTERS ON STUDENTS' LEARNING OF TRIGONOMETRY IN MATHEMATICS IN SELECTED SENIOR HIGH SCHOOLS IN HO MUNICIPALITY

BY

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DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……………………………… Date: …………….

Name: Bernice Yawa Tsitsia

Supervisors' Declaration

I hereby declare that the preparation and presentation of this dissertation were supervised in accordance with the guidelines on supervision of dissertation laid down by the University of Cape Coast.

Supervisor's Signature: ……………………….. Date: ………………….

Name: Prof. Jonathan Fletcher

ABSTRACT

This study investigated the effect of the use of computers on students' learning of Trigonometry in Mathematics. A class was selected in each of two randomly selected schools. The pretest-posttest non-equivalent quasi experimental design was used.

The students in the experimental group learned Trigonometric concept through the Computer Based Instruction (CBI), whereas the students in the control group were taught the same concepts using the conventional approach. The conventional approach consisted of lecture, discussions and question and answer teaching methods.

T-test was used to analyse students' pre-test and post-test scores. Results determined that computer-aided instruction did have a significant effect on students' achievement in learning trigonometric concepts. The students also in the CBI group showed positive attitudes towards CBI when they were interviewed. It has therefore been recommended that the computer should be used to supplement the teacher's lessons delivery in classroom.

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DEDICATION

To my Parents and my Children.

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CHAPTER ONE

INTRODUCTION

Background to the Study

The most important technological event of our time is the ascendancy of the computer. Computers already play a prominent role in many aspects of our lives, from transportation and communication to personal bookkeeping and entertainment. Scarcely oblivious to these trends, many schools now have computers and networking capabilities. To some extent, these technological appurtenances have been absorbed into the life of the school, though often they simply deliver the old lessons in a more convenient and efficient format. In the future, however, education will be organized largely around the computer.

Computers will permit a degree of individualization personalized coaching or tutoring-which in the past was available only to the rich. All students may receive a curriculum tailored to their needs, learning style, pace and profile of mastery, and record of success with earlier materials and lessons. Indeed, computer technology permits us to realize, for the first time, progressive educational ideas of "personalization" and "active, hands-on learning" for students all over the world.

Paper-and-pencil manipulation has been the standard approach in the teaching and learning of mathematics for many years. However, technology has the potential to change that. Computers allow more powerful mathematical problem-solving and graphing opportunities in the learning and teaching of mathematics. They provide convenient, accurate and dynamic drawing, graphing and computational tools (National Council of Teachers of Mathematics, 2003), and give students opportunities to explore applications and concepts that would be too tedious and time consuming using paper-and-pencil techniques.

Computer-based instruction(CBI), which is becoming widely available as an instructional medium, seeks to individualize the teaching and learning process so that learning is more effective (Askar, Yavuz, & Koksal, 1992). The aim is to provide the learners with an environment that is tailored to their learning needs and goals. Current reforms in mathematics education have proposed infusing the mathematics curriculum with technology and creating technology-intensive instructional environments.

Lately mathematics educators have been looking at mathematics processes as a focus to improve the learning of mathematics. Previously, the teaching and learning of mathematics focused mainly on the objective knowledge of mathematics that is commonly found in textbooks and journals. Deductive reasoning was thus the main emphasis in classrooms. Formulas were taught and students learnt how to apply the formulas to solve problems.

It has been argued that much of the mathematics knowledge is not just constructed through acquiring this objective knowledge but rather built on informal discussions (Ernest P., 1991). It is through these informal discussions that more meaningful mathematics knowledge can be constructed by students themselves. Thus the focus of the didactics of mathematics should place more emphasis on mathematical processes such as mathematical thinking, reasoning, communication, connections and problem solving (National Council of Teachers of Mathematics, 2000).

In Ghana, mathematics is a compulsory subject at all levels in pre-university education. Due to its importance, each government is committed to ensuring the provision of high quality mathematics education. One of these is seen in the New Educational Reforms (Anamuah-Mensah, 2002) of which implementation started in September, 2007.

The new curriculum in Mathematics at the Senior High School (SHS) places emphases on skill acquisition, creativity and the arts of enquiry and problem solving. It aims at developing in the student the ability and willingness to perform investigations using various mathematical ideas and operations. As part of the reforms the curriculum places a lot of emphasis on Information and Communication Technology (ICT) as a tool for teaching mathematics (MOESS, 2007). It is therefore, designed to meet expected standards of mathematics in many parts of the world.

Trigonometry as a branch of mathematics deals with triangles, particularly triangles in a plane where one angle of the triangle is 90 degrees, Triangles on a sphere are also studied, in spherical trigonometry. Trigonometric functions are used in most technical subjects such as science, engineering, and architecture. One should know trigonometry thoroughly to make use of these functions. It is very useful in real-life applications as well as in pure mathematics. It relates angles to the side of triangles, allowing one to obtain information about lengths from angle measurements and vice versa.

Statement of the Problem

In my five years' experience in teaching mathematics, I have realized that basic trigonometry proves to be very difficult for many students. Trigonometry presents many first-time challenges for students: it requires students to relate diagrams of triangles to numerical relationships and manipulate the symbols involved in such relationships. Further, trigonometric functions are typically among the first functions that students cannot evaluate directly by performing arithmetic operations.

Lessons in trigonometry usually focus on recognizing right-angled triangles (possibly in complex figures), distinguishing the different sides, and using the mnemonic to identify which trigonometry function can be used to calculate a specified side or angle. This way, students learn to produce correct answers, but are not encouraged to develop a real insight in trigonometry problems. Often students fail to realise trigonometric functions are in fact, ratios and they do not recognise the relationship between the graphical depiction of a triangle and the corresponding values. Relating shapes and numbers is hard for students, who often view calculation as the only way to obtain knowledge about triangles (Blackett & Tall, 1991).

The development of technology, however, is a promising prospect to ease the difficulty of teaching trigonometry and to improve students' learning of trigonometric functions. Computer technology allows students to graph functions more easily, quickly and accurately; to manipulate the graphs; and to develop generalizations about the functions. It also allows students to form linked multiple-representations of mathematical concepts (Heid, 1998; Waits & Demana, 2000) and to explore, estimate and discover them graphically and to approach problems from a multi-representational perspective (Hennessy, Fung, & Scanlon, 2001; Hollar & Norwood, 1999).

In addition to this, Nicaise and Barnes (1996: 205-212) mention that “Once adept at using technology, students have quick access to multiple resources and tools for combining those resources. They can spend less time looking for answers and information and more time analysing, reflecting, and developing an understanding."

Furthermore, Fey (1989) notes that, when used wisely, technology can enhance student conceptual understanding, problem solving and attitudes toward mathematics.” Dunham and Dick (1994) also observed that students can improve their problem-solving abilities and attitudes when they use graphing technology. Yet in Ghana, no study has been done to determine the effect of the use of computers on students’ learning of trigonometry. It is this gap that the study seeks to fill

Purpose of the Study

The purpose of this study is to determine the effect of the use of computer Based Instruction (CBI) using dynamic mathematics software GeoGebra on students’ learning of trigonometry.

Research Question / Hypotheses

The study was guided by the following research question and hypotheses:

Research Question

The main research question of interest was:

1. What effect does the use of computers have on students’ learning of trigonometry?

The null and alternative hypotheses that can be derived from the research question are stated below:

$H_{o.}$ There is no significant difference between the mean scores of students taught trigonometry using computers and those taught without such medium.

$H_{a.}$ There is a significant difference between the mean scores of students taught trigonometry using computers and those taught without such medium.

Significance of the Study

It is anticipated that this study will shed light on the benefits of using computers in Mathematics learning in general, and in learning trigonometry in particular. This study also attempts to bridge the gap between the theoretical and practical sides of using CBI in teaching Mathematics. Thereupon, the findings of this study may be functional for different categories of people; it may help curricula designers and GES to develop teaching materials which suit various ways of teaching and match students' level of achievement in Mathematics in general. Moreover, this study may help teachers by facilitating their role as well as students by helping them absorb the concept of Mathematics quite easily and smoothly. Finally, this study may encourage other researchers to conduct further studies on the same topic, which will enrich both the local and international literature.

Delimitation of the Study

The study focused on the effects of the use of computers, using software, on senior high school students' performance in learning trigonometry. However, it also looked at the interest of students toward the use of computers and difficulties associated with it. The study was conducted in the Ho Municipality in the Volta region of Ghana only.

Limitations of the Study

This study has the following primary limitations:

The subjects of the groups, which are, experimental and control were not assigned randomly and this is a limitation of the experimental design used in the study. The quasi-experimental nature of the study therefore makes generalisation of the results somewhat problematic.

Definition of terms

The following terms are defined for clarity of their use in this study.

1. Computer-Based Instruction (CBI) - A teaching method which incorporates the use of computer software programs (Uibu & Kikas, 2008).
2. National Council of Mathematics (NCTM) - An organization of teachers of mathematics of all levels in the United Sates of America whose mission is to promote qualityinstruction in mathematics for all students, based on research and adherence to the highest professional standards (National Council of Teachers of Mathematics, 2012).
3. Zone of Proximal Development – The optimal learning situation in which one can learn with support, as conceptualized by Lev Vygotsky (Powell & Kalina, 2009).
4. GeoGebra software - GeoGebra is free open-source dynamic software for mathematics teaching and learning that offers geometry and algebra features in a fully connected software environment. It was designed to combine features of dynamic geometry software (e.g. Cabri Geometry, Geometer’s Sketchpad) and computer algebra systems (e.g. Derive,

Maple) in a single, integrated, and easy to-use system for teaching and learning mathematics,(Hohenwarter, Jarvis, & Lavicza, 2009).

Organisation of the Rest of the Study

The second chapter of this dissertation is where the literature found to be relevant to the study has been presented. This includes literature on the use of computers in the teaching and learning process, theoretical framework underlying the basis of the use of computer technology and the effectiveness of computer in teaching maths.

The third chapter deals with the methodology used for this study. It presents the research design used for the study, population as well as the sample. It also looks at the development of the interventions used in this research, the instrument for data collection, the data collection as well as data analysis procedures.

Chapter four of the dissertation comes next. Here the results of the study and the discussions on them are presented. Test results are also analysed and the responses to the interview have also been presented.

In the fifth chapter, the overview and summary of the research problem and methodology are given. Also, summary of the key findings of the research are presented. Conclusions of the research have been drawn and recommendations as well as suggestions for further studies are presented in this chapter.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The purpose of this chapter is to present a literature review on the influence of the use of technology in the teaching and learning of mathematics. The focus was on the use of the computer as technological tool. A review of studies related to its use and the influence thereof in the teaching and learning of mathematics are reported. Theories of and approaches to mathematics learning and teaching are also discussed.

The Role of Technology in Teaching and Learning Mathematics

The great potential of computer technologies in mathematics instruction is increasingly believed to bring a transformation in mathematics education and has brought new possibilities to the teaching and learning of mathematics. (Goldenberg, 2000) points out that one of the strongest forces in the contemporary growth and evolution of mathematics and mathematics teaching is the power of new technologies. (Goldenberg thereupon, claims that\

> "In math, computers have fostered entirely new fields. In education, they have raised the importance of certain ideas, made some problems and topics more accessible, and provide new ways to represent and handle mathematical information, affording choices about content and pedagogy that we have never had before."(p.1)

Technology can enable students to explore relevant mathematical ideas through constructivist methods (Pugalee, 2001). It serves students as an information resource, a learning tool or a storage device that can support students to construct their own mathematical knowledge (Nicaise & Barnes, 1996) and allows students to actively participate and be responsible for their own learning. Technology supports exploration, which helps students set achievable goals, form and test hypotheses and makes discoveries of their own (Collins, 1991).

In an environment where computer technologies are available, students might be involved in running experiments, testing conjectures, solving and posing problems and exchanging ideas (Heid, 1998). In connection with this, (Lewis, 1999:142) writes, "Constructive learning stresses active, outcome-orientated and self-regulated learning, where meaning is negotiated and multiple perspectives are encouraged. The flexible interactive characteristics of computer technologies are enormously supportive of this." Thus, the availability of technologies in school mathematics may allow students to explore mathematics on their own. Computer technology offers students varieties of linked approaches to the same problem situation. It allows students to form linked multiple-representations of mathematical concepts (Heid, 1998) and to explore, estimate and discover them graphically and to approach problems from a multi representational perspective (Hennessy, S., Fung, P. & Scanlon, E., 2001).

Computer technology also helps students to make connections between mathematical ideas (Smith & Shotsberger, 1997), between a real world phenomenon and its mathematical representations and between a student's everyday world and his/her mathematical world (Heid, 1998).

One characteristic of computer-based instruction is interactivity. The availability of technological tools in mathematics instruction plays a role in facilitating interactions and cooperative group work among students and teachers (Heid, 1997). Technological tools provide an area that is rich in social interaction and facilitate students' communication with other students through formal presentations, cooperative activitiesand collaborative problem-solving, and interpersonal exchanges. Students can experience enjoyment and surprise and develop interest as they explore software, discuss what they are doing or ask someone for help (Haugland & Wright, 1997). Students' social development can benefit from group work when they are in a position to enquire about things that surprise them while exploring programs, and when they share their results with friends and teachers. The social interactions allow students to learn from several sources, not just the teacher.

Technological tools can also free teachers' time so they can interact with students more. Teachers can leave fact-finding to the computer and spend their time doing what they were meant to do as content experts: arousing curiosity, asking the right questions at the right time and stimulating debate and serious discussion around engaging topics (Hancock, 1997). Teachers are able to give students more control once they see what students are able to do with technology and how willing and able they are to take responsibility for their own learning (Means & Olson, 1995). While observing students working with computer applications, teachers can see the choices students are making on the monitor or printout, pose questions regarding students' learning goals and decision making and make suggestions for revisions when needed.

According to (NCTM, 2003), technological tools can increase both the scope of the mathematical content and the range of the problem situations that are within students' reach. Powerful tools for computation, construction and visual representation offer students access to mathematical content and contexts that would otherwise be too complex for them to explore. Using the tools of technology to work in interesting problem contexts can facilitate students' achievement of a variety of higher-order learning outcomes, such as reflection, reasoning, problem posing, problem-solving and decision-making (NCTM, 2003).

Theoretical framework

This study intends to examine the effectiveness of computer based instruction on student achievement in math specifically in trigonometry. A constructivist teaching framework helps to foster student motivation and achievement and this theory is easily married to the use of technology. The theory of constructivism states that students need to construct their own meaning based on a learning experience (Powell & Kalina, 2009). This mirrors Piaget’s theory of learning where students build and modify schema based on their exposure to new information. Piaget also stated that optimal learning takes place when a child experiences disequilibrium and has to change his thinking to accommodate the new information (Piaget, 1964). This can only take place if the new knowledge is within the child’s level of cognitive development. Dewey also believed that students should be actively involved in the learning process. Students should be observed and learning should be evaluated on an ongoing basis so that instruction can be changed and adapted to best meet their needs and interests. Building upon this theory, Jerome Bruner stated that lessons should be structured for ease of understanding. Teachers should provide the students with information that causes them to experience “disequilibrium” so that they want to explore and fill in the gaps created by the teacher’s instruction (Gutek, 2005).

In addition, Vygotsky found that learning requires a communication process, whether it is with another person or self-talk (Vygotsky & Kozulin, 2011). Social interaction is a critical piece of learning because communicating concepts and ideas helps students develop deeper understanding of the content (Powell & Kalina, 2009). By partnering students to have them share what they have learned or by having them debrief in writing after a lesson, this communication becomes an integral part of the learning process.

The constructivist theory is also supported by current research in the use of scaffolding for student learning. Scaffolding provides support and assistance when a concept is first introduced to give students a solid foundation. As the students become more confident and competent, the support is removed and the students are moved toward independence (Anghileri, 2006).

A constructivist approach to teaching helps to motivate students because it requires their active engagement in the learning process, delivers instruction at an appropriately challenging level, provides the support students need to succeed, and allows for social interaction. Both computer-aided instruction and traditional teaching can be implemented to support this type of learning.

Vygotsky’s Zone of Proximal Development

Both computer-assisted instruction and traditional teaching allow teachers to level and structure the content so that it is within the child’s zone of proximal development. In this theory of learning, Vygotsky describes the optimal learning situation as one in which the student is able to understand the material with help (Powell &Kalina, 2009). This assistance could come from a computer program, a peer or a teacher. If the lower achieving students are struggling with problem solving, for example, the teacher can provide a framework for them to use with a partner or on the computer. On the other hand, a higher achieving student could be presented with more complex problems to solve in class or given the opportunity to work through more difficult problems on the computer.

Motivation to learn

Another crucial aspect of educating children is inspiring them to want to learn. Hannula (2006) defines motivation as the potential to affect behaviour by controlling circumstances in a way to affect the student’s emotions. He states that students need autonomy, a feeling of competence, and a sense of social connectedness. Maslow’s theory of motivation states that once a child’s basic needs are met, he is ready to strive to reach his fullest potential through learning that which sparks his interest (Hackman & Johnson, 1991).

In addition, Carl Rogers created an educational framework which relies heavily on student interest and progress (Szlarski, 2011). Setting learning goals is also very motivating to students (Hannula, 2006). Salanova, Llorens, and Schaufeli (2011) conducted research on teachers and college students to examine the connection between efficacy beliefs, affect and engagement. They found in both groups that efficacy beliefs influence engagement which in turn gives the individual a positive effect. Enthusiasm, in their results, showed the strongest impact on engagement in the activity. Most importantly, however, they found that a "gain spiral" exists so that when efficacy beliefs increase due to engagement, positive affect also increases. The key, therefore, is to determine how to help elementary students gain this confidence that they can learn mathematics and develop a positive attitude toward learning so that their engagement also increases. Both computer-aided instruction and traditional teaching can provide conditions for the child to be highly involved in the learning process and provide immediate feedback regarding his progress.

Computer programs are motivating in that they present levels to master and teachers can help motivate students by setting attainable goals for mastery in the traditional classroom. The question that remains, then, is which is more effective with today's learners?

Meeting the needs of today's learners

Students in classrooms today are quite different and have different learning needs than they did even 20 years ago. In the article, "Generational Changes and Their Impact in the Classroom: Teaching Generation Me," Twenge (2009) identifies several predominant characteristics of modern learners. She used a method she calls "cross-temporal meta-analysis" in which she examined the statistical results from a variety of psychological questionnaires across various periods of time to discover generational differences. The results show that Generation Me students have high expectations for themselves, exude a sense of entitlement, and exhibit more mental health problems than previous generations.

Most applicable to instructional practice is her assertion that today's students score higher on standard IQ tests, but have very little stamina for long-term concentration. Other studies show similar characteristics of this generation of students. Gorra, et al. (2010) stated that these "Digital Natives" view technology as an essential part of their everyday life. These authors surveyed college undergraduate students over a period of four years to identify trends in the technology preferences of these students. Their findings showed that 98% of these students carry some kind of communication device daily and most have devices for listening to music, viewing videos, and accessing the Internet. These students report that they appreciate options in modes of instruction, such as downloading lectures, content or other multi-media sources.

Schools are trying to determine what changes are needed to best meet the needs of this modern learner, and the U.S. Department of Education is encouraging professional development in the use of technology (Frye & Dornisch, 2008). Consequently, more and more teachers are implementing technology in all subject areas. Frye and Dornisch (2008) studied the consequences of increasing the use of technology in high school classes. They discovered that students perceive teachers who use technology as part of their instruction as more competent and knowledgeable, especially in the areas of mathematics and science. This again reflects the characteristics of this technologically geared generation because using technology involves more student interaction with the content and more active involvement.

Recommendations for reaching this type of learner, therefore, include more interactive learning, shorter instructional periods, and the incorporation of multi-media (McAndrew, 2010; Twenge, 2009). Both traditional classroom teaching and computer-aided instruction can accomplish this goal.

Issues about mathematics teaching

The efforts of national reform of mathematics teaching and learning have occurred in mathematics education over the past twenty years in Australia, Israel, the Netherlands, New Zealand, North America, Spain, and the U.K. (Battista, 1999; Kroesbergen et al., 2004; Matthews, 2000).

A driving force behind the reform in North America was the release of the report A Nation at Risk in 1983, which described mathematics education at that time as being a national crisis (National Commission for Excellence in Education, 1983). The National Council of Teachers of Mathematics (NCTM), which is the largest non-profit organization of mathematics education in the world, responded to the concerns by producing sets of standards for mathematics education reform. In 1989, they published the Curriculum and Evaluation Standards for School Mathematics, followed in 2000 by the Principles and Standards for School Mathematics (Draper, 2002).

The NCTM's Standards provide specific recommendations on how mathematics should be taught (Suydam, 1990). Suydam notes that changes to instructional approaches based on the Standards should help students learn to value mathematics, to reason and communicate mathematically, to become confident in their mathematical abilities, and to become strong problem solvers. The Standards also emphasize that mathematics instruction must be suitable to all students, regardless of learning styles and career goals (Draper, 2002). According to Chung (2004), the recommendations identified in the Standards are not consistent with the behaviourist approach to teaching mathematics, instead coincide rather well with the constructivist approach.

According to Abrams and Lockard (2004), behaviourists explain learning as a stimulus-response process, and emphasize rote memorization along with the drill-and-practice of basic skills. From a behaviourist perspective, school mathematics is comprised of a set of computational skills which students acquire by imitating demonstrations by teachers, and worked examples from textbooks. That is, students learn mathematics by absorbing information from different sources (Battista, 1999). Battista adds that for many students, the behaviourist approach portrays mathematics as an endless sequence of memorizing and forgetting facts, and of learning procedures that do not make sense. The National Research Council (1989) refers to this as “mindless mimicry mathematics”, while O’Brien (1999) calls it “parrot mathematics”.

Studies related to CBI effectiveness

CBI has been a significant part of educational technology, beginning with the first reported use of the computer for instructional purposes in 1957 (Saettler, 1990). Its emergence as a true multimedia delivery device occurred in the early 1980s with the coupling of videodisc players with computers. In recent years, the videodisc has been replaced by the CD-ROM. The combination of a computer controlling high quality video and/or audio segments was a compelling advancement in CBI, and the instructional effectiveness of this pairing has been well documented.

Fletcher (1990) conducted a quantitative analysis of the education and training effectiveness of interactive videodisc instruction. Specifically, empirical studies comparing interactive videodisc instruction to conventional instruction were segmented into three groups: higher education, industrial training, and military training. The various learning outcomes investigated include:

1. knowledge outcomes in terms of a student's knowledge of facts or concepts presented in the instructional program;
2. performance outcomes which assessed a student's skill in performing a task or procedure;
3. retention in terms of the durability of learning after an interval of no instruction; and
4. the time to complete the instruction.

The effect sizes, or the difference between the mean scores of the treatment and comparison groups divided by the standard deviation of the control group, were computed for each of the 28 studies identified.

The results of the Fletcher (1990) meta-analysis are presented in Table 1, broken down by learning outcome, and in Table 2, broken down by instructional group.

Table 1. Average Effect Sizes for Four Types of Knowledge Outcomes for CBI

Learning Outcome	Effect Size	Percentile
Knowledge	**.36**	**64th**
Performance	**.33**	**63rd**
Retention	**.65**	**74th**
Time to Complete	**1.19**	**88th**

Table 2. Average Effect Sizes for Three Instructional Groups Using CBI

Instructional Group	Effect Size	Percentile
Higher Education	**.66**	**74th**
Industrial Training	**.17**	**57th**
Military Training	**.39**	**65th**

Fletcher (1990) concluded on the basis of his analysis, that interactive video instruction was both more effective and less costly than conventional instruction.

In a later analysis of the effectiveness of CBI, Kulik (1994) took into account the conceptual and procedural differences in how the computer was used in the individual studies. In his analysis of 97 studies that compared classes that used CBI to classes that did not, Kulik (1994) computed the overall effect size as well the effect sizes corresponding to five categories of computer use relevant to the present report:

1. tutoring;
2. managing;
3. simulation;
4. enrichment; and
5. programming.

Kulik determined the overall effect size to be .32, indicating that the average student receiving CBI performed better than the average student in a conventional class, moving from the 50th percentile to the 61st percentile. However, when categorized by computer use, the effect sizes yielded somewhat discrepant results. Only the effect size for tutoring, at .38, fell into the category, according to Cohen (1988), of being noteworthy, between a small and moderate effect. All other effect sizes were .14 or lower.

The effect size for computer-based programs used for tutoring (.38) is significantly higher than the rest, indicating that students who use computers for these purposes may achieve better outcomes than students who use CBI for management, simulation, enrichment, or programming purposes. In addition, it is clear from the table that basic programming and simulations had minimal effect on student performance. The conclusion of the Kulik (1994) analysis was that researchers must take into account all types of CBI when trying to assess their effects on student learning.

Liao (1999) also conducted a meta-analysis of 46 studies that compared the effects on learning of hypermedia instruction (e.g., networks of related text, graphics, audio, and video) to different types of non-hypermedia instruction (e.g., CBI, text, conventional, videotape). Results indicated that, overall, the use of hypermedia in instruction results in more positive effects on students learning than non-hypermedia instruction with an average effect size equal to 0.41.

However, the effect sizes varied greatly across studies and were influenced by a number of characteristics. Effect sizes were larger for those studies that used a one-group repeated measure design and simulation. In addition, effect sizes were larger for studies that compared hypermedia instruction to videotaped instruction than for studies that compared hypermedia instruction to CBI.

Funkhouser (1993) found that high school algebra and geometry students who used computers (problem-solving software) scored significantly higher on mathematics content tests than groups of students who did not use the software. The students using the software also made significant gains in problem-solving ability.

Kulik and Kulik (1991) found that students who were taught using computer technology had higher examination scores than students who were taught by conventional methods without computer technology. Quesada and Maxwell (1994), Alexander (1993), Chandler (1993), Durmus (2000) and Graham and Thomas (2000) also report that students who used this technology obtained significantly higher scores than those students who did not use it.

The Third International Mathematics and Science Study (TIMSS) provides evidence that students who were allowed daily use of calculators performed considerably better on the TIMSS tests than those students who rarely or never used calculators (The International Study Center, 1998).

Hollar and Norwood (1999) found that students in graphing approach classes demonstrated better understanding of functions than students in traditionally taught classes. In addition to this, research reports show that by using technology students increased their proficiency in relating functions to their graphical representations and decreased their dependence on memorized rules (Dugdale, 1993) and were able to visualize concepts more easily.

The Software Publishers Association (SPA) commissioned an independent meta-analysis of 176 studies focusing on the effectiveness of technology in schools. This report concludes that the use of technology as a learning tool can make a significant difference in, among other things, student achievement as measured by standardized tests (Sivin-Kachula & Bialo, 1996).

According to Dunham and Dick (1994), students who use graphing technology had more flexible approaches to problem-solving, were more willing to engage in problem-solving, worked longer on a problem, concentrated on the mathematics of the problem and not on the algebraic manipulation, solved non-routine problems inaccessible by algebraic techniques and believed calculators improved their ability to solve problems.

The use of technology was also found to increase student confidence and interest in mathematics and improve student attitudes (Dunham & Dick, 1994).

However, it should be noted that the discussion is never one sided in that, Hall (1993), Pankow (1994), Rich (1993), Ritz (1999) and Smith (1996) reported that there were no significant differences in achievement between students who used technology and students who did not use it.

Becker (as cited in Dunham and Dick, 1994:442) also found that the use of graphing technology did not improve students'understanding of functions in a college pre-calculus course while Giamati (1991) reported that the use of technology (graphic calculators) affected students'performance negatively.

According to Giamati's (1991) report, a control group ofstudents who did not use graphic technology better understood graphical transformations and curve sketching than an experimental group who used graphic technology.

A study by Chang (2000) also produced mixed results. While the CBI group performed better generally as compared to the traditional approach group, the traditional approach group performed better on test items involving application. Thus, while the CBI group did well on knowledge and comprehension level items, the traditional approach group did better on application level items.

Huxford (as cited by Jenks & Springer, 2002) indicated after a comparative study of traditional instruction modes with CBI modes that the results suggest CBI is not as useful for instruction as previously believed because students in the CBI group did not perform better than those in the traditional instruction mode.

Summary

In the review, studies of computer technology usage seem to indicate a need for a paradigm shift of the teacher from the role of instructor to a classroom coach or facilitator. The role of the teacher might become one of preparing the instructional environment, anticipating needs of students, and providing contingencies

In Ghana, however, there is little research to support or disapprove claims about the effectiveness of computer-based instruction in learning trigonometry. This study is thus useful in its potential contribution to realize the effects of computer-based instruction on students' achievement in learning mathematics.

CHAPTER THREE

METHODOLOGY

Research Design

The study employed a multi-method approach, which included quantitative and qualitative research to gather relevant data on the chosen topic. Quantitative research relies upon measurement and various scales to generate numbers that can be analyzed using descriptive and inferential statistics (Bless & Highson-Smith, 2000), and “aims mainly to measure the social world objectively, to test hypotheses and to predict and control human behaviour” (De Vos, 2002).

By contrast in qualitative research the emphasis is "… on the qualities of entities and on progresses and meanings that are not experimentally examined or measured in terms of quantity, amount, intensity and frequency” (Denzin & Lincoln, 2000:100-110), and “…aims mainly to understand social life and the meaning that people attach to everyday life” (De Vos, 2002:100). De Vos asserts that combining qualitative and quantitative styles of research and data in a study helps researchers to look at something from several angles so that they can see the different aspects of it. The triangulation technique in social science attempts to map out, or explain in detail, the richness and complexity of human behaviour by evaluating different viewpoints with the use of both quantitative and qualitative techniques (De Vos, 2002).

With reference to the advantages of the multiple method approach, Cohen and Manion (1980) argues that exclusive reliance on one method may bias or distort the researcher's picture of what is being investigated, therefore the more the methods contrast with each other, the greater the researcher's confidence and the more he can overcome the problem of being bound by methods. Thus, quantitative and qualitative research methods were selected to investigate what effect the use of computer based instruction using Geogebra has on Senior High School students' understanding of Trigonometry in the learning of Mathematics.

From the qualitative and quantitative nature of the investigation employed, it is believed that the study will allow for some form of generalizations to be made about a wider population after a small selected sample has been studied.

In the present study, a quasi-experimental (a pretest-posttest experimental and control group) design was used to investigate what effect the use of computers has on senior high school students' performances (achievements) in the learning oftrigonometric function. Two sample groups (i.e. experimental and control groups) of students were involved in the study. The design can be illustrated as follows:

Experimental group:	O_1	X	O_2
Control group:	O_1		O_2

Where:

'X' refers to the independent variable or the treatment given to the experimental group. 'O_1' is the first set of observations of the dependent variable (pre-test), 'O_2' is the second set of observations of the dependent variable (post-test). In this study, the academic achievement of students was the dependent variable while the teaching strategies (Conventional approach and CBI) constituted the independent variable

In order to verify the stated null hypothesis a pre-test and post-test were used. First, the same pre-test was given to the two groups before conducting the experiment. This was followed by a teaching course on the concepts of trigonometric functions, to both groups for five weeks (approximately 20 hours).

The experimental group was taught these concepts with the use of computer based instruction using mathematical dynamic software Geogebra. The control group was taught the same content using conventional approach. Later, after the teaching course (i.e. after the experimental period), the same post-test was given to the two groups.

Qualitative Research Aspects

Qualitative research, according to Hitchcock and Hughes (1995), enables researchers to learn at first-hand about the social world they are investigating. It provides a means of involvement and participation in that world through a focus on what individual actors say or do.

Qualitative research frequently utilizes observations and in-depth interviews. It involves a description in words, exploring to find what is significant in the situation. Crowl (as cited in Makgato, 2003) characterizes qualitative research as follows:

1. It takes place in a natural setting and uses the researcher as the key instrument.

2. It deals with descriptive data in the form of words and pictures rather than numbers.
3. It focuses on process, not merely product.
4. It relies on inductive rather than deductive data analysis; and
5. It focuses on how different people make sense of their lives.

In the present study, a qualitative approach was applied in conducting interviews with selected learners.

Population

A survey was conducted in Senior High Schools (SHSs) in Ho town of the Ho municipality to find out the state of their computer facilities. This was done to ascertain the number of schools with access to computers. The town has 8 senior high schools including government assisted SHSs and private SHSs; each with computer facilities. However, the facilities differ from school to school. While in some schools the computer supply is one per student in a class, in others a pair or more of students share a computer.

Since the purpose of this study was to find out the effect of computer-based instruction on the academic achievement of Senior High School students, students in Senior High Schools with computer facilities formed the population of the study. The target population was the SHS Form Two business students in schools that have computers in the Ho Township irrespective of whether it was single sex school or co-educational.

The SHS Form Two students were chosen because trigonometry is one of the topics in their core mathematics WASSCE syllabus; they had also done ICT as a course of study and were therefore trusted to be familiar with the use of computer.

Sample and Sampling Procedure

Simple random sampling through the use of computer generated random numbers was used to select two schools (Mawuli School and Sunrise senior high school) from the 8 schools that had computer facilities in Ho.

This technique was used so that each school had equal opportunity of being selected to form part of the study (Sarantakos, 2005). The school that was selected first in this case, Sunrise Senior High School was termed the experimental school and the second school (Mawuli School) was the control. In each of the two schools, one Form Two General Arts class was selected randomly from 6 classes through the use of computer generated numbers to form the experimental and control groups.

In the selection of the subjects (students) for the study however, purposeful sample was used because an entire group of individuals was used (Cresswell, 1994). There were 30 students in the experimental group and 30 students in the control. Thus, the total sample size was 60. Eight students from the experimental group were randomly selected and interviewed individually by the researcher to investigate the influence the use of computer–based instructionusing dynamic mathematics software Geogebra had on them.

These students were chosen because the interview covered a range of issues as far as the use of computers in teaching mathematics is concerned and the views of the students were reported qualitatively.

Research Instruments

Data for this study were collected using a pre-test and a post-test and an interview schedule.

Pre-test

A pre-test was designed to investigate the equivalence of the experimental and control groups. This was administered to the students in both the experimental and control group prior to the experiment. If the means of the performances of the two groups do not differ significantly, it can be assumed that the two groups are comparable. (See Appendix A).

Students from each group were given 60 minutes to complete the pre-test. The scheme of evaluation (scoring) of marks for each question in the pre-test was as follows:

Table 3. Scheme of Evaluation (scoring) for the Questions in the Pre-test and Post-test

Mark in percentage per problem	Format of students solution to problems
0%	• No attempt (blank paper) • Numbers from problem recopied – no understanding of problem evidenced • Incorrect answer and no work shown • Inappropriate strategy - Problem not finished • Attempt failed to reach a sub-goal
20%	• Correct answer and no work shown
40%	• Showed some understanding of the

	problem • Reached a sub-goal but did not finish the problem • Ignored a condition in the problem • Incorrect answer for no apparent reason
60%	• Thinking process unclear • Appropriate strategy • Work reflects understanding of the problem
80%	• Incorrect answer due
100%	Correct process shown and correct answer given

Post-test

A post-test was designed and administered at the end of the experiment to students in both the experimental and control groups. If the mean performance of the experimental group is significantly different from the mean performance of the control group, it can be assumed that the performance of learners must have been influenced by the use of computers using geogebra software. (See appendix B).

Students from each group were given 150 minutes to complete the post-test. The same evaluation scheme that was used for the pre-test was used to evaluate each question in the post-test.

Interview Schedule

An interview schedule is an instrument that can be used to gather in-depth information from an individual. It is used to obtain in-depth information about a participant's thoughts, knowledge, reasoning, motivations, attitudes, perceptions, experiences and feelings about a topic (Johnson & Christensen, 2000).

An interview has the following advantages (Bailey, 1994; Sax, 1979).

1. The interview is flexible and applicable to many different types of problems.
2. It is flexible in the sense that the interviewer may change the mode of questioning if the occasion demands. If the responses given by the subject areunclear, questions can be rephrased.
3. It is useful in collecting personal information, experiences, attitudes, perceptions or beliefs by probing for additional information.
4. It promotes motivation and openness. Almost all interviews attempt to develop rapport between the interviewer and the respondent (interviewee). Once interviewees accept the interview as a non-threatening situation, they are morelikely to be open and frank. This openness adds to the validity of the interview.

In the present study, a semi-structured interview schedule, consisting of five open-ended questions, was designed and conducted after completion of the experiment. The participants in the interview were eight students from the experimental group, selected using purposeful sampling. The eight students were selected for interviews because of their computer skills and regular attendance during the experimental period. Each interview lasted about 10 - 15 minutes. The interviews were conducted by myself. (See appendix C for the interview schedule).

The purpose of the interview was to investigate the influence of the use of computers on students' motivation, attitude, problem-solving (engagement with and exploration of mathematical ideas) and the classroom environment (students' group work and participation, corporation and discussion among the students and discussion between the students and the teacher) in the learning of mathematics (trigonometric functions in particular).

Reliability

In this study, the reliability and validity of the instruments (and data collected) were considered. The description of quality instruments used to collect data typically deals with these two related concepts, reliability and validity.

Reliability means consistency of the research instruments used to measure particular variables. Obtaining the same results when the instruments are administered again in a stable condition guarantees reliable instruments (De Vos 2002; Mlangeni as cited in Makgato, 2003) According to Schuyler (in Makgato, 2003), researchers evaluate the reliability of instruments from different perspectives, but the basic question that cuts across various perspectives (and techniques) is always the same:. To what extent can we say that the data are reliable? To ascertain how reliable the measuring instruments that were used in this study are, reliability coefficients (Cronbach's alpha) were calculated.

Validity

According to Ary, Jacobs and Razavieh (1990), the term validity refers to the extent to which an instrument measures what it intends to measure. Validity addresses the following two questions (De Vos, 2002)... What does the research instrument measure? What do the results mean? The core essence of validity is captured nicely by the word accuracy. From this general perspective, a researcher's data are valid to the extent that results of the measurement process are accurate. The following process was implemented to ensure the validity of the research instruments:

The pre-test and post-test were based on West African senior high School Certificate Examination (WASSCE) core Mathematics Syllabus questions. The validity of the tests were also established by two experienced mathematics teachers who were also mathematics examiners as they reviewed the face validity, content, clarity, construct validity, correctness and standard of questions with regard to the students level.

Pilot testing is very helpful as it makes a researcher aware of any possible unforeseen problems that may emerge during the main investigation (Ntsohi, 2005). Based on the opinions and comments I got from the teachers and lecturers and the pilot testing, the instruments were amended. Therefore, after the wide consulting of experts, incorporating their opinions and comments as well as pilot testing, it may be concluded that the instruments portray the desired level of construct validity.

Treatments/Interventions

This study employed two different treatments. The treatment for the experimental group was the tutorials of the computer-based instruction using

Geogebra while the control group was taught by conventional approach of teaching. However, the material to be taught and learnt was the same for the two groups; it was the modes of delivery that were different.

The CBI was developed by me with the assistance of a computer programmer and two senior high school mathematics teachers from the schools that were selected for the study. The content material on the topic was given to two mathematics teachers for review. This was done to ensure that the content conformed to what has been prescribed by the senior high school mathematics syllabus.

Microsoft power point 2013 and its associated packages were used to develop the courseware. After the development of the courseware, it was again given to two mathematics teachers from the selected schools to review. They checked the general information and appearance of the courseware. The material was then refined per the recommendations and suggestions received. The final material was then used in the classroom.

Each student in the experimental group received an orientation on how to use the commands (menus and buttons of the toolbars) of the computer software.

The teaching for both groups lasted for five weeks (approximately 20 hours). During the five-week project, the activities and contents were the same for both groups.

Data Collection Procedure

Permission was sought from the Heads of the schools to conduct the research in their schools. Consent was also sought from the class teachers. The pre-test was administered to both the control and the experimental groups after permission had been given. There were two different treatment patterns that were applied during the experiment.

The control group was taught through the conventional approach by me, while the CBI was used for the experiment group. Right after the teaching of the control and experimental groups which lasted for five weeks, the post-tests was given to both groups.

After the post-test has been conducted, eight students in the experimental group were interviewed. The interviewees were given assurances of confidentiality and anonymity at the beginning of the interview session. The study took about five weeks to complete.

Data Analysis

Analyses on Data from the Pre-test:

The purpose of the pre-test was to determine whether there was any significant difference in achievement between students in the experimental group and their counterparts in the control group prior to the treatment. A t-test for independent samples test was used.

Analyses of Data from the Post-test

The post-test was used to test the hypotheses set for the research. The scores from the post-test were analysed to determine if there had been any significant difference in achievement between the control group and the experimental group after the treatment. The t- test was used for these analyses. The outcome of the analysis of the post-test was then compared with that of the pre-test and inferences were made accordingly.

Analyses of Interview Data

The responses on the interview schedule were reported qualitatively. These views helped to bring out how the use of computers using, Geogebra software influence students' attitudes towards learning mathematics.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

In the preceding chapter, the research design and methodology that was followed in conducting the study was discussed. A pre-test and a post-test and an interview schedule were used. In this chapter results of the investigation will be presented, analysed and interpreted. (See Appendix A, B, and C respectively for the pre- test, post- test and interview schedule)

Pre-test

The students' solutions to questions posed in the pre-test as well as the post-test were marked in terms of the scheme of evaluation of full, partial and no mark as described in chapter three. From this, the scores of students and descriptive statistics were calculated and a null hypothesis was tested. This was followed by a reliability analysis.

Table 4 presents the scores of students in the experimental and control groups for the pre-test.

Table 4. Scores of Students in the Experimental and Control Groups for the Pre-test.

Experimental group		Control group	
Students	Scores (out of 60)	Students	Scores (out of 60)
1	19	**1**	17
2	14	**2**	20
3	24	**3**	32
4	26	**4**	17
5	18	**5**	12
6	16	**6**	19
7	25	**7**	33
8	17	**8**	14
9	16	**9**	33
10	16	**10**	16
11	27	**11**	10
12	26	**12**	16
13	9	**13**	12
14	16	**14**	20
15	25	**15**	26
16	15	**16**	12
17	28	**17**	29
18	33	**18**	33
19	22	**19**	27
20	16	**20**	20

Table 4. Scores of Students in the Experimental and Control Groups for the Pre-test (continued).

21	20	**21**	31
22	16	**22**	16
23	26	**23**	10
24	16	**24**	24
25	20	**25**	22
26	21	**26**	14
27	20	**27**	10
28	26	**28**	33
29	30	**29**	27
30	27	**30**	29

Table 5. Descriptive Statistics of the Experimental and Control groups for the Pre-test

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Experimental (1)	30	9.0	33.0	21.000	5.6446
Control (2)	30	10.0	33.0	21.133	7.9859
Valid N (listwise)	30				

Pre-test Hypothesis testing

The following null hypothesis was tested in terms of the results of the pre-test as well as the post-test:

Ho: There is no significant difference between the mean scores of students in the experimental and control groups.

In both cases the null hypothesis was tested at the 0.05 level of significance. That is, the null hypothesis was rejected if $t_{calculated} \geq t_{critical}$ and accepted if $t_{calculated} < t_{critical}$. Student's t-test for independent groups was used to compare the two mean scores of the groups.

The Student's t-test was used because the samples were small. Best (1977) points out that when small samples are involved, the Student t-test proves to be an appropriate test to determine the significance of the difference between the means of two independent groups. Table 6 shows the results of the t-test application on the pre-test scores.

Table 6. Results of Student's t-test Application on the Pre-test Scores

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Scores	Equal variances assumed	-.075	58	.941	-.1333	1.7855	-3.7073	3.4407
	Equal variances not assumed	-.075	52.189	.941	-.1333	1.7855	-3.7158	3.4492

From the output, T = -.075with 52.189 degrees of freedom. p-value = Sig.(2-tailed) = 0.941> 0.05. The results in Table 6 show that the null hypothesis cannot be rejected since the t-value = -.075is less than critical t-value at the 0.05 level of significance. This means that there is no significant difference between the mean scores of the experimental and control groups of students for the pre-test. Hence, we can conclude that the two groups of students were comparable at the pre-test stage.

Pre-test Reliability Analysis

Using the SPSS statistical software, reliability coefficients (Cronbach alphas) were calculated to determine the reliability of the instruments (the pre-test and post-test). A reliability coefficient of 0.7 or higher is a desired reliability coefficient that can lead us to say that the instrument (test) is reliable. The Cronbach alpha values that were calculated for the pre-test are indicated in Tables 7and table 8

Table 7. Reliability Analysis for the Pre-test: Item-total Statistics and Cronbach Alpha Values

	Scale Mean	Scale Variance	Item-Total Correlation	Cronbach's Alpha
Qt1	137.267	867.513	.512	.784
Qt2	136.633	821.757	.474	.792
Qt3	136.400	804.593	.637	.762
Qt4	136.900	730.024	.725	.741
Qt5	137.367	860.792	.543	.780
Qt6	136.900	808.231	.518	.783
Qt7	136.533	867.292	.392	.806

Table 8. Reliability Analysis for the Pre-test: Item-total Statistics and Cronbach alpha values

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.805	.807	7

The alpha value for the pre-test as a whole is 0.805 which is an excellent reliability coefficient. Therefore, the test can be considered as a reliable instrument to measure students' performances.

Besides the satisfactory item and item-total reliability coefficients (alpha values), all the items show acceptable correlations with the item-total. On the other hand, the range of item-total correlation coefficients shows that there is sufficient diversity among the items. These observations indicate, that the test items show adequate homogeneity but also sufficient diversity, is an indication that the instrument (pre-test) portray the required construct validity.

Post-test

Table 9 presents the scores of students in the experimental and control groups for the post-test (task 2).

Table 9. Scores of Students in the Experimental and Control Groups for the Post-test

Experimental group		Control group	
Students	Scores (out of 70)	Students	Scores (out of 70)
1	60	**1**	35
2	55	**2**	22
3	60	**3**	38
4	50	**4**	44
5	55	**5**	27
6	65	**6**	26
7	56	**7**	48
8	60	**8**	27
9	50	**9**	24
10	51	**10**	33
11	50	**11**	55
12	51	**12**	37
13	60	**13**	34
14	55	**14**	27
15	65	**15**	39
16	50	**16**	36
17	67	**17**	58
18	66	**18**	45
19	60	**19**	29
20	65	**20**	27

Table 9. Scores of Students in the Experimental and Control Groups for the Post-test (continued)

21	55	**21**	38
22	60	**22**	23
23	65	**23**	51
24	70	**24**	60
25	70	**25**	54
26	55	**26**	30
27	60	**27**	23
28	66	**28**	43
29	65	**29**	29
30	65	**30**	29

Table 10. Descriptive Statistics of the Experimental and Control Groups for the Post-test

Descriptive Statistics					
	N	Min.	Max.	Mean	Std. Dev.
Experimental	30	50	70	59.40	6.333
Control	30	22	60	36.37	11.174
Valid N	30				

Post-test Hypothesis Testing

The same null hypothesis that was tested in the pre-test was tested in the post-test. The same statistical test that was used for the pre-test was also used to test the null hypothesis for the post-test. Table 11 shows the results of the t-test application on the post-test scores.

Table 11: Results of Student's t-test Application on the Post-test scores

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Scores	Equal variances assumed	9.822	58	.000	23.033	2.345	18.339	27.727
	Equal variances not assumed	9.822	45.889	.000	23.033	2.345	18.313	27.754

The results in Table 11 show that the null hypothesis can be rejected (calculated t-value (= 9.822) is greater than critical t-value at the 0.05 level of significance). This means that there is significant difference between the mean score of the experimental and the control groups of students for the post-test.

Hence, we can conclude that the use of computers had a significant effect on students' performances in learning trigonometry

Reliability Analysis for Post-test

To determine reliability of the instrument (post-test), Cronbach alpha coefficients were calculated using the SPSS statistical software and the results are indicated in Table 12.

Table 12. Reliability Analysis for the Post-test: Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
QT1	419.433	4593.082	.615	.933
QT2	442.467	3830.326	.872	.919
QT3	419.433	4593.082	.615	.933
QT4	442.467	3830.326	.872	.919
QT5	419.433	4593.082	.615	.933
QT6	442.467	3830.326	.872	.919
QT7	419.433	4593.082	.615	.933
QT8	442.467	3830.326	.872	.919
QT9	419.433	4593.082	.615	.933
QT10	442.467	3830.326	.872	.919

Table 13. Reliability Analysis for the Post-test: Item-total Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.934	.939	10

The overall alpha value for the post-test is 0.934 which is an excellent reliability coefficient. Therefore, the test can be considered as a reliable instrument to measure students' performances.

Interview Data Analysis

The qualitative data derived during the interviews were analyzed based on the theme of the research question. The research question (Does the use of computers using Geogebra software influence students' attitudes towards learning mathematics?) seeks to find out if the use of computers using geogebra software influence students attitude towards learning the subject.

Question one dealt with the helpfulness of computers (Geogebra software) in learning trigonometric functions. Some of the responses were:

Student A: *Previously, when we were learning mathematics using paper and pencil, most of the time, I was dependent on the teacher. I thought it is only the teacher who knows everything so he will give me exercise and correct me. I did not do anything by myself. But during the experiment, I worked on many other trigonometry problems in addition to the exercises which were given by the teacher. This was because the computer was helpful in creating tables of values quickly and drawing graphs easily when I was* *working on the problems.The computer removed the fear within me by hearing the name mathematics.*

Student B: *I always run away from mathematics class because it is boring seeing the same person always in front telling you what he knows.The computer was very helpful it enables me seen the reality in trigonometric functions the graphs are well understood. With the computer, I can repeat as many times as desired and go back and forth until I grasp the concept of what I did not understand, this I could not do when the teacher was teaching*.

Student C*: I interacted with other students and we share ideas computer usage has taken out from me the fear of mathematics.*

Student D*: Constructing graphs of trigonometric functions using paper and pencil was boring. Previously (using paper and pencil) when I draw the graph incorrectly, I was forced to draw it on another sheet of paper, which was tiresome. But now (during the experiment), I could automatically retry and check the result on the computer. The remaining four students gave similar responses as above.*

The responses to question one indicate that the use of computers can ease some of the difficulties that students are facing in learning trigonometry and improve their understanding of trigonometric functions. That is, the use of computers in the learning of trigonometric functions can give students the opportunity to engage with and explore the nature and properties of quadratic functions and their graphs actively and facilitate students to develop self-regulation (self-observation, self-evaluation and self-reaction).

Question two dealt with students' experience of learning trigonometry functions using computers. More specifically, the question aimed at determining what influence the use of computers had on non-cognitive dimensions of students such as motivation and attitude as well as the relationships they had with other students and with their teacher during the experiment. Some responses regarding their attitudes and motivation towards quadratic functions were:

Student A: *... I was working with full concentration. Everybody was also busy and doing something with the computer.*

Student B: *Learning using a computer uplifted my interest to learn mathematics and encouraged me to work on many trigonometric functions problems.*

Students C: *I enjoyed learning trigonometry using a computer ...I was encouraged to learn more about other topics in mathematics.*

Some other responses to interview question 2 were as follows:

Student A: *We were comparing and discussing the solutions of the problems that weworked on;*

Students B: *We were working individually and in a-group*.

Students C: *We were sharing views and giving comments to each other.*

Some students gave similar responses.

The responses to question two indicate that the use of computers can encourage and motivate students to learn trigonometry, produce positive attitudes in students toward trigonometric functions in particular and towards mathematics in general and facilitate students' group work and participation, cooperation and discussion among themselves and between the students and the teacher.

In question six, students were given the opportunity to convey, if any, additional views or suggestions. These were some of their suggestions:

Students A: *Computers are helpful to overcome the difficulties that we were facing in learning mathematics. So, they should be introduced in mathematics classrooms.*

Students B: *Computers are helpful in solving mathematical problems. So, they should be incorporated as learning tools in mathematics classrooms.*

Student C:…"*Pacing was okay. You could go back in this CBI but you can't ask the teacher to explain things to you again and again". … I now have a taste for mathematics*

Students D: *… I shared idea with friends, it has instil confidence in me …. I think it will be helpful for us to continue using it … mathematics is now my favourite.*

These and similar responses to question six indicate that students are motivated and want computers to be available in mathematics classrooms as learning tools. The availability of these tools in mathematics classrooms may encourage students to participate actively and explore mathematics on their own. (See appendix C for interview question).

Conclusion

The analysis of the post-test results indicates that the use of computers influenced students' performance (achievement) positively. In the post-test, the mean performance of the experimental group was significantly higher than the mean performance of the control group.

The responses to the questions in the interview confirmed the results obtained using the other measurements in the sense that the use of computers can positively influence students' attitude towards learning in terms of problem-solving (engagement with and exploration of mathematical ideas), motivation, attitude and the classroom environment. That is, the use of computers can ease some of the difficulties that students are facing in learning trigonometric functions and facilitate students to engage with and explore the nature and properties of trigonometric functions and their graphs, observe and evaluate their work.

It can also encourage and can facilitate students' group work, participation, cooperation and discussion among the students and between the students and the teacher.

CHARPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMENDATION

Overview

The purpose of this study was to investigate whether the use of computers in the teaching and learning of mathematics (trigonometric functions in particular) influences students' understanding of trigonometric functions as reflected in their achievement, motivation, attitude, problem-solving skills (engagement with and exploration of mathematical ideas), group work and cooperation and discussion among students and between students and the teacher. This chapter summarizes the findings, draws conclusions and makes recommendations.

Summary of the Findings

Summary of the Literature Review

Most of the findings reported in the literature indicated that technological tools such as computers and calculators have a positive impact on students' performances (achievements). Alexander (1993), Chandler (1993), Durmus (2000), Funkhouser (1993), Hollar and Norwood (1999), Kulik and Kulik (1991), Graham and Thomas (2000), Quesada and Maxwell (1994) and The International Study Center (1998) reported that students who used technology obtained higher scores than those students who did not use it.

In addition to this, research reports show that by usingtechnology students were able to visualize concepts more easily (Smith & Shotsberger, 1997), increased their performance on standardized test (Sivin-Kachela & Bialo, 1996), increased their understanding of mathematical concepts anddecreased their dependence on memorised rules (Dugdale, 1993).

Computer technology also allows students to learn by discovering facts independently through practical and powerful activities that endorse cognitive development and autonomous learning. Furthermore, it provides students with the freedom and opportunities to interact with complex mathematical objects (Nicaise& Barnes, 1996), facilitates students' ability to self-regulate (Nicaise& Barnes, 1996), affects students' attitudes positively (Dunham & Dick, 1994) and improves students' problem-solving skills (Dunham & Dick, 1994). The literature also revealed that a technologically rich classroom provides a good learning environment in which students are actively involved, share and participate in the learning of mathematics and work collaboratively.

According to constructivist learning theory, mathematical knowledge cannot be transferred ready-made from one person (teacher) to another (student). It ought to be constructed by every individual learner. This theory maintains that students are active meaning-makers who continually construct their own meanings of ideas communicated to them. This is done in terms of their own existing knowledge base. This suggests that a student finds a new mathematical idea meaningful to the extent that he/she is able to form a new concept (Bezuidenhout, 1998).

Kamii (1994) states that "Children have to go through a constructive process similar to our ancestors', at least in part, if they are to understand today's mathematics." Kamii (1994) goes on to say that, today's mathematics are the results of centuries of construction by adult mathematicians. By trying to transmit in a ready-made form the results of centuries of reflection by adults, we deprive children of opportunities to do their own thinking. Students today invent the same kinds of procedures our ancestors did and need to go through a similar process of construction to become able to understand adults' mathematics.

The constructivist use of computer allows the opportunity to change the nature of the material to be taught and learnt from routine-based to discovery-based activities. Knowledge is built up from personal experiences, and making these experiences more dynamic will assist in the development of cognitive structures (Tall, 2000).

Computer-based environments with visually compelling displays, together with facilities for interaction, can provide the setting for more dynamic, powerful experiences. These environments are filled with stimuli, which encourage rich constructions, by students (Nelson, 2000). Graphic representations, coupled with social interactions, are seen as leading to the development of an individual's knowledge, and are seen as leading to the adaptation of concepts (von Glasersfeld, 1996).

Vygotsky believes that social interaction guides students thinking and concept formation (schema). Conceptual growth occurs when students and teachers share different viewpoints and experiences and understanding changes in response to new perspectives and experiences (Nicaise & Barnes, 1996).

Although most of the findings from the literature indicated that technological tools such as computers and calculators have a positive impact on students' learning of mathematics, the findings of some researchers were not positive. Hall (1993), Pankow (1994), Rich (1993), Ritz (1999) and Smith (1996) reported that there were no significant differences in achievement between students who used technology (graphic calculator) and students who did not use it. Becker (in Dunham and Dick, 1994) found that the use of graphing technology did not improve students' understanding of functions in a college pre-calculus course. Giamati (1991) also reported that the use of technology affected students' performance negatively.

Summary of the Design Findings

1. The findings from the post-test (see Table 10) showed that the mean performance of the experimental group was significantly higher than the mean performance of the control group. This indicated that the use of computers had a positive impact on students' mastering of trigonometry concepts.
2. The findings from the pre-test (see Table 5) showed that the mean performance of the experimental group wasn't significantly different from the mean performance of the control group. This indicated that the two groups were comparable before the experiment started in terms of their understanding of functions as measured by a performance test.
3. Also the interviews analysis showed that the use of computers can positively influence students' learning (understanding) of trigonometry in terms of problem-solving.

Conclusions

The aim of the study was to investigate the effect the use of computers using mathematics dynamic software geogebra has on students' understanding of trigonometric functions in the learning of mathematics.

The results of this investigation (see table, 10) indicated that the use of computers has a positive impact on students' achievement, problem-solving skills or exploration of mathematical ideas, motivation, attitude and the classroom environment which are similar to the findings reported in the literature. Students can analyze trigonometric functions and their graphs quickly, represent functions in different ways and solve real life problems using computers.

Students can be encouraged to explore the nature and properties of trigonometric functions on their own, work in a group, discuss concepts, make conjectures and verify their findings using computers.

Thus, if provided with computers, students can learn trigonometry through constructivist methods better than the traditional paper-pencil way of teaching and learning trigonometric functions.

Recommendations

Based on the findings and conclusion it is recommended that:

1. More studies should be done to investigate the effect the use of computers has on students' learning of trigonometric functions and other mathematical concepts across all levels in the senior high schools.
2. School mathematics curriculum designers and teachers should be made aware of the role and influence of the use of computers in mathematics instruction so that students can improve their mastery of mathematical concepts.
3. A majority of the study schools mathematics teachers are not trained to use computers in their teaching and assessment. Thus, they need to be

trained to use computers as tools in mathematics classrooms in order to have confidence in incorporating computers into their mathematics programs.

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APPENDICES

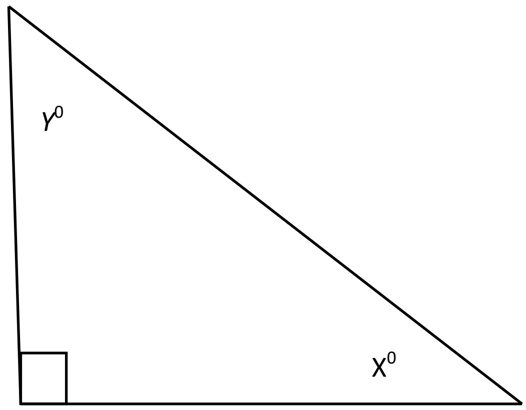
Appendix A

Pre-test Questions for the study

Instruction: Answer all questions clearly (show all your works).

1. If 9 cos x – 7 = 1 and $0° \leq x \leq 90°$, find x. **(6 points)**

2. In the triangle *PQR*, cos$x^{0}\frac{15}{17}$. Find tan y^0 **(5 points)**



3. A ladder 5 m long, leans against a vertical wall at an angle of 70^0 to the ground. The ladder slip down the wall 2 m. find correct to two significant figures;

   i. The new angle which the ladder makes with the ground; **(6 points)**

   ii. The distance the ladder slipped back on the ground from its original position. **(6 points)**

4. Solve the equation sin θ = $-\frac{1}{2}$ for values of θ from 0^0 to 360^0 inclusive. **(4 points)**

5. Sketch the following curves for values of θ from 0^0 to 360^0.

   i. 2Sin θ **(5 points)**

   ii. 1 – cosθ **(5 points)**

iii. Tan3θ **(5 points)**

6. A little boy is flying a kite. The string of the kite makes an angle of 30^{o} with the ground. If the height of the kite is *h* = 24 m, find the length (in meters) of the string that the boy has used. **(8 points)**

7. On the same set of axes from 0 to(2π), graph: $y = 2\cos\left(\frac{1}{2}x\right) and\ y = \sin\ (2x)$. **(10 points)**

Appendix B

Post-test Questions for the study

Instruction: Answer all questions clearly (show all your works).

1. If sinx = ½, where 0° ≤ x ≤ 90°, evaluate $\frac{sinxcosx}{cosx+tanx}$ **(6 points)**

2. If 0° ≤ θ ≤ 90°, and tan $\theta = \frac{3}{4}$, find:

   i. $sin\ \theta$ and **(2 points)**

   ii. $cos\ \theta$. **(2 points)**

3. Draw the graph of y = $sinx + cosx$ for values of x from 0^{0} to 360^{0} using intervals of 30^{0}. **(4 points)**

   Find:

   i. The values of x correct to the nearest degree for which $sinx + cosx = 0.75$. **(2 points)**

   ii. The minimum and maximum values of y, stating the values of x for which they occur. **(2 points)**

4. A helicopter is flying at a constant height from the ground. It makes an angle of 45^{0}, when seen from a fixed point on the ground. After some time, when helicopter moves 2000 feet ahead, it is noted that it makes

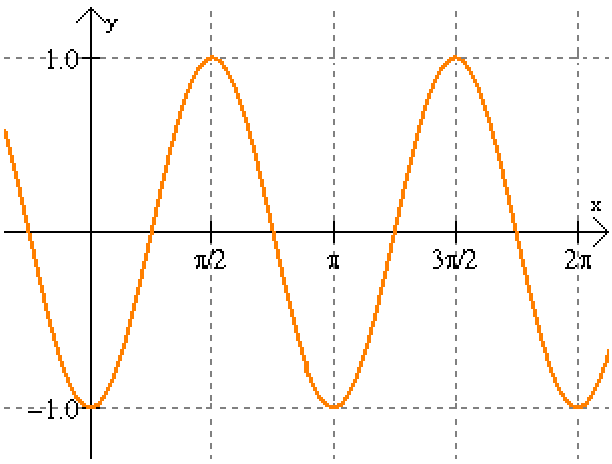
an angle of 60^0 from that fixed point. Calculate the height of the helicopter. **(8 points)**

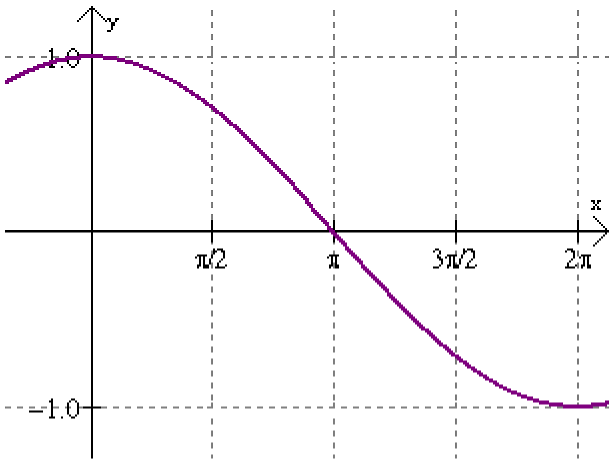
5. Solve the equation $\cos\theta = \frac{1}{2}$ for values of θ from 0^0 to 360^0 inclusive. **(5 points)**

6. Two towers face each other separated by a distance d = 15 m. As seen from the top of the first tower, the angle of depression of the second tower's base is 60^0 and that of the top is 30^0. What is the height (in meters) of the second tower? **(8 points)**

7. Determine the equations for these graphs: **(3 points each)**

i.



ii. 

8. On the same set of axes, $-\pi \leq x \leq \pi$, graph y = *3cosx and y = sin(2x).* **(8 points)**

   i. Find all values for which *3cosx –sin(2x) = 0* **(2 points)**

9. A ladder of length 10 m is placed against the wall. At what distance from wall it should be kept to make it inclined at an angle of 60∘ from the ground? **(6 points)**

10. Express in terms of the trigonometric ratios of acute angles ,

    i. Sin 330^0 **(3 points)**

    ii. Cos 330^0 **(3 points)**

    iii. Tan 330^0 **(3 points)**

Appendix C

Interview schedule for the Experimental group

1. What were your experiences in learning trigonometric functions (using computers)?
2. What do you see as the importance of computer in learning mathematics?
3. What about the pacing of the material?

4. Can the use of computer engage you in learning mathematics?
5. What difference did the computer bring about in learning?
6. Do you have any other contribution to?