POTENTIAL FOR INCORPORATION OF COMPUTER SIMULATIONS IN THE TEACHING OF GEOGRAPHY IN SECONDARY SCHOOLS

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ABSTRACT

The issue of quality secondary school geography education has been of great concern in Kenya for several years. Several factors have been considered as being responsible for the low quality, such as poor teaching methods, lack of resources and negative attitudes of teachers and students. The use of new Information Communication Technologies (ICTs) in education is being seen as fundamental in developing student interest in performance in the subject. The use of technology in teaching and learning may have potential to improve performance of learners in Geography but this has not attracted the interest of researchers. In Kenya, there is pervasive lack of teaching and learning resources to improve the quality of geography education, especially those that incorporate new ICTs, hence poor performance in certain abstract concepts in Geography. The purpose of the study was to determine potential for incorporation of computer simulations in the teaching of Geography in secondary schools. The design of the study was descriptive surveys and completely randomized bock design that were conducted in Kisumu District of Nyanza Province, Kenya. The study targeted 240 secondary school geography teachers and 3500 form three students. Simple random sampling technique was used to select the respondents. The sample was 80 teachers and 1165 form three students. Questionnaire surveys and interviews were used to collect data from geography teachers and students on their attitudes towards the use of computer technology in teaching and learning. Analysis was done using both descriptive and inferential statistics. Quantitative data from questionnaire surveys were analyzed using descriptive surveys such as percentages, means and frequencies, and, presented in form of tables and graphs. Qualitative data from the interviews were organized into themes, categorized, coded, converted into percentages and presented in a narrative form. A test was given to find out the effect of computer use on learners' performance. The non-parametric Mann-Whitney U Test was used to determine statistical differences between the control and experimental groups at a confidence level of 0.05. The study concluded that many schools in Kisumu District did not have computers dedicated for geography education and use of the technology for teaching and learning Geography was non existent. It is of necessity to motivate, facilitate and equip secondary school geography teachers with requisite knowledge and expertise on innovative computer uses. The study revealed that both geography teachers (mean of 4.89) and students (mean of 4.81) had a positive attitude towards the use of computer technology in geographic instruction. It was also revealed that students had problems comprehending certain topics because of their abstract nature and teachers lacked knowledge on innovative uses of computer based resources. The study established that the most difficult topic for learners to comprehend and teachers to teach was 'The earth and the solar system'. The study concluded that computer simulations, used simultaneously with the traditional method of teaching were very effective in teaching and learning difficult topics in Geography. The study recommends that computer simulations be integrated in to the geography curriculum. The study also concluded that it was of necessity to consider sound educational practices and philosophies that underpin the use of interactive computer simulations, such as constructivism, and, relevant curriculum considerations. Design considerations for the simulations software to be considered ought to include friendliness in the user interface and ease of navigation, enhanced interaction and feedback mechanisms.

CHAPTER ONE

INTRODUCTION

1.1. Background to the study

Geography is a subject concerned with the description and explanation of spatial distribution of phenomena, including mankind and their interaction or interrelationships on the earth's surface. It involves the analysis of phenomena from the point of view of their reciprocal interactions and the utilization made of the inhabited and the habitable space (Pidwirny, 2006; UNESCO, 1980). Being a utilitarian discipline, learners need to study Geography in order to acquire skills necessary for survival such as global interdependence, graphicacy and spatial communication, the power of observation, imagination, judgment and reasoning, environmental conservation and optimal resource use.

There are certain guiding principles used to explain the necessity of Geography and emphasize the role of geographic inquiry. These include the content and skills for the high school Geography curricula such as asking geographic questions, acquiring, analyzing and presenting geographic information, developing and testing geographic generalizations; and, five key themes common in geographical study used to expand the perception of Geography, namely, Location, Place, Relationships within places, Movement, and Regions (Glyn, 2009; Natoli, 1994).

Considerable research (Rosenberg, 2010; Edelson, 2009; Risse, 2005 & Trivedi, 2002) in several regions worldwide, especially the developed economies such as the United States of America (USA) has established that there is need to eradicate geographic illiteracy and educate learners and the general public that Geography is more than place-name knowledge, and, to improve Geography performance of students (Natoli, 1994; Graves, 1980) in order to make them functionally literate graduates.

An account of Geography education since its inception as a discipline of study can be found in the Library of Congress (Boorstin, 1991). He highlighted the geographic inquiries of early Greeks such as Eratosthenes and Ptolemy with their estimation of the Earth's circumference and other geographical writings. Another early geographer was Aristotle who analyzed data on the habits and settlement patterns (Mahony, 1988). From the second century until the fifteenth, the science of Geography was neglected due to ecclesiastical pressure. With the republishing of Ptolemy's works and the voyages of discovery by the Portuguese and Spanish people at the end of the 15th century, Geography began to resurface as an intellectual activity. Despite geography's re-emergence during the Renaissance, Greek and Latin were still the core subjects in education. This classical education was reflected in the courses of study on both sides of the Atlantic. It took dissenting voices like that of Rousseau to break the dominance of the classical subjects. Rousseau included geography as one of the subjects that should be a part of a complete education. By the end of the eighteenth century, Geography, and particularly field activities, was to be a major part of a new age in which scientific utility was an intrinsic element in Europe (Mahony, 1988).

In the U.S.A., even before national independence, Harvard University had instituted map and globe study. School teachers had students practice rote memorization of geographical facts for college admission tests (Libbee & Stoltman, 1988). Most geography texts were written from a British perspective which did not go over well in the U.S.A. (Mahony, 1988). In the 19th century secondary schools, some of the European educational techniques began to replace rote learning. By the turn of the 19th century, physical geography was established as *the geography* in the secondary school curriculum. Professional geographers began to favor regional geography. Physical geography's domain was being absorbed into the sciences. The vague status of geography in pre-collegiate education continued through the Depression and World War II (Mahony, 1988). When geography began to be strengthened in the social studies in the 1940s, it was predominantly regional and human in emphasis (Libbee & Stoltman, 1988). This chronology provides a rationale for studying Geography and illuminates its prominence as a utilitarian subject which cannot be relegated to obsolescence.

Geography provides a rich and varied context for the use of computer technology to enhance both learning in the subject and to reinforce ICT skills. Commonly, desktop publishing, word-processing and spreadsheets are used to enhance presentation and to organize geographical data, particularly for examination of coursework, and the Internet is used to research information (Crook, 1994; Collins, 1991; Brown & Atkins, 1988; Hawkridge, 1983). There is, however, limited use of specific software such as digital mapping programs in learning institutions, especially those in the developing economies such as Kenya. Where teachers are confident with the computer technology, it is possible to combine computer applications to provide students and teachers with the tools for

research, study and presentation (U.K., 2004). If computer based tools are used with innovation, educational standards are bound to improve. As observed, there is currently lack of innovation in the use of computers in education, occasioning the need for their exploration.

Although Computer Assisted Learning (C.A.L.) may still be evolving at all educational levels, there is no subject better suited to the many uses of computers than Geography (Fitzpatrick, 1990). His assertion that Geography is a natural discipline for making use of computers is based on arguments such as the Geography teacher having to deal with vast libraries of textual information, numerical data, and graphic displays, all of which need to be constantly updated and experienced from a range of perspectives.

Since human beings have a natural ability to process visual information quickly and efficiently, their capacity to readily understand spatial relationships facilitates interpretation of images that simulate geographic space. Visualization is increasingly used in geography to refer to both the ability to process visual information and the design of concrete visual representations meant to assist such processing. This is enhanced by the use of simulations. Cognitive Learning Theory postulates that an individual learns based on the ability to select, perceive, process and encode information, and to retrieve it from memory. According to this theory, a key component to learning is the transfer of information from short-term to long-term memory, a process that requires coding (Rieber, 2005; Rieber, 1996). Long-term memory consists of separate verbal (language) and non-verbal (imagery) codes. An individual who successfully codes both verbal and non-verbal information regarding the same concept into long-term memory will be twice

as likely to retrieve that information as a person who codes the information via one or the other (Paivio, 1986). Often, teachers are unaware of the range of innovative computer resources available to improve learning experiences for their students. Also, there are inconsistencies in the quality and use of ICT in Geography across schools as well as among staff within schools (U.K., 2004; Odera, 2002). As a result, it is observable that there is need for a clear framework on how to enhance Geography education by use of computer technology the incorporate simulations.

Getis and Jain (2003), summarizing research findings by a number of authors posit that in comparing animated images with static ones, animations and simulations are distinguished in their ability to demonstrate changes in both movement and direction. Therefore, animations and simulations can reduce abstraction in temporal concepts and better display changes over time (Rieber, 2005; Getis & Jain, 2003; Rieber, 1996). Simulations and animations free up cognitive resources, thereby reducing the demands on short-term memory and raising the success rate of accurate encoding (Rieber, 1996). Mayer and Gallini (cited by Getis & Jain, 2003), basing their conclusions in dual-coding theory, stated that the concurrent presentation of verbal and visual information allows students to build connections between the two concepts.

Getis and Jain (2003) contend that the acquisition of spatial knowledge in geography courses is a highly visual process and the computer can be a useful tool to deliver visual representations of both the physical and cultural environment. According to the two researchers, the ability to display animated graphics through the internet makes it a

stimulating instructional tool for explaining complex phenomena in physical geography. For instance, fundamental concepts such as differential heating and cooling, pressure gradients, the Coriolis effect and Hadley circulation need to be learned before a student can be expected to understand global atmospheric circulation. Although spatio-temporal in nature, these fundamental concepts have traditionally been taught using static images such as those found in introductory physical geography textbooks or their complementary overhead transparencies. Be that as it may, computers can be used to display animated graphics, allowing students to view moving simulations of these concepts (Getis & Jain, 2003). Even though these researchers established that the use of simulations in geographic instruction has a positive effect on the performance of learners, there is lack of such novel applications of the technology in developing countries such as Kenya. As such, there was need to explore the possibilities of using computer simulations in enhancing comprehension of abstract concepts in Geography in Kisumu District.

It is also worth noting that there is a wide range of simulation activities that can be carried out by computers. Many of these are in physical Geography such as modeling storm water discharge in a hydrologic network. Brusilovsky and Gorskaya-Belova (1992) in Moscow documented a computer-based model of landforms used with students of ages 13-14 in a physical Geography of oceans and continents course. The use of the landform modeling program nearly doubled the success rate of students in a test conducted by the same researchers. Simulations are, however, not a preserve for physical Geography. Various human Geography topics can also be simulated. Maguire (1989) documented examples such as a site selection process for a new factory, a fractal based simulation of urban land use, and a modeling environment for future relationships on a global scale

between population, agriculture, resource use, industry, and pollution. This also appeared to have a positive effect in informing abstract concepts in the topics in question. These research findings attest to the fact that even though the use of educational simulations has not been used by many teachers and learners, it has a positive effect in comprehension of abstract concepts. It was therefore necessary to explore possibilities inherent in computer simulations that would be beneficial to geography students and teachers. Even though there is evidence of use of computer simulations in Geography education in the developed economies, there is little or no corresponding evidence on the same in the developing countries. Inconsistencies abound in the use of computer technology in Geography education in Kenya that consequently impact negatively on the performance of learners in the subject (Odera, 2002). There are also cognitively difficult topics or concepts and misconceptions in learners which may be illuminated by use of appropriate software that incorporate computer simulations, necessitating this study in Kisumu District.

The computer, as it is currently used in Geography education in the developing economies such as Kenya, may not intrinsically motivate learners, nor be geared to their needs. It is worth noting that most learners and educationists in the developing economies regard this technology with apprehension if not aversion. It is not uncommon to notice that use of computers in such settings is incoherent or extraneous (Osodo, 2010). Currently, teachers of Geography in Kenya predominantly use educational resources that incorporate only two dimensions (2D), such as chalkboard illustrations, wall maps, charts, posters and so on (Odera, 2002). However, these are not able to help learners grasp certain abstract aspects of Geography, especially those that require spatial changes,

motion and changes in time, place and location. Geography as a unit of discourse is by its very nature utilitarian, encompassing several spatio-temporal dynamics. As such, the predominant use of 2D materials in teaching the subject may not have a positive and long lasting impact on students hence diminishing interest and performance in the subject. This lack of consistency and sound founding principles in the use of computer technology in education may impede cognitive development in learners thereby lowering educational standards in general as learners may be indisposed to comprehend cognitively difficult topics and misconceptions which abound in Geography.

Many schools face escalating demands on access to finite computer resources, including computer suites, and, lack of access at required times often discourage Geography departments from using computers. There are also relatively few opportunities for continuing professional development in the use of computers in Geography education. In many schools, weaknesses in Geography education are associated with limitations in the use of computer technology and strategic management of cross-curricular ICTs (U.K., 2004). Good teaching ought to be based on clear expectations of geographical outcomes, with good preparation and planning which provide a number of linked activities to maintain pace and pupils' interest. This was demonstrated in the United Kingdom (U.K.) where high school Geography students used 'Kenya: the final frontier' Compact Disk Read Only memory (CD-ROM) to research aspects of the Maasai's way of life. The materials were used as a source of images alongside text at an appropriate level. This had a positive effect on learners' comprehension of the concepts taught (U.K., 2004)

Likewise, there is currently limited inclusion of real-world learning experiences in the traditional classroom setting (Duffy & Cunningham, 1996). Mostly, the content presented in the classroom is disconnected from its real-world context. This contextual dichotomy tended to have a negative impact on the learning process, adversely effecting learner motivation in particular (Henning, 1998). At the same time, real-world learning situated in real-world contexts has been shown to have positive impacts on learning and learner motivation (Papastergiou, 2009; Rieber, 2005; Duffy & Cunningham, 1996). Educational simulations have been found to provide a solution to this by providing some aspects of real-world learning in the traditional classroom. Therefore, this study sought to address the mismatch identified herein that even though computer simulations have been attested to have a positive impact on learners' performance, not many educators use them in teaching and learning innovatively. Likewise, in the few cases where they are used, they are mainly in the developed economies, emphasis being in science oriented subjects. Also, non of the approaches incorporate simulations with traditional teaching and learning methodologies. Even though students perennially experience problems in comprehending abstract concepts that could be addressed by integration of computer simulations in to the geography curricula, such endeavours have not received due redress. The poor performance in Geography in Kisumu District is attributable to suspect teaching methods, and, simulations, having been established to improve learner comprehension, needed to be investigated to establish its effectiveness in enhancing teaching and learning in Kisumu District.

The study focused on Kisumu district since it was realized that the performance in Geography in the national examinations for the past four years was relapsing as indicated in Table 1 below.

Table 1. Performance in Geography paper 2 national examination (Source: 2008 Kenya Certificate of Secondary Education (KCSE) Report

Year	Enrollment	Maximum mark	Mean score
2008	109,745	100	38.08
2007	103,288	100	48.14
2006	97,991	100	37.34
2005	106,869	100	45.90

From Table 1, it is instructive that even though candidature increased from 103,288 in the year 2007 to 109,745 in the year 2008, performance in Geography in the national examinations declined from 48.14 to 38.08 mean score respectively. Poor performance has been blamed on abstract teaching. Computer simulation design to improve teaching and learning of the subject was thus necessary.

1.2. Statement of the problem

There has been mounting concern about diminishing student performance (Table 1) in Geography subject in secondary schools in Kenya (Odera, 2002). Geography is used as a

key subject for selective advancement in notable areas such as urban planning, environmental studies, meteorology, geology and others. As such, it is imperative that the dwindling performance in the subject is checked in order that educational standards are raised. Geography is a utilitarian discipline and as such, graduates who perform well in the subject are consequently expected to be functionally literate.

As a result of low achievement in the subject (U.K., 2004), most of the students are technically out of the race for places in higher institutions of learning and careers. More specifically, they have little stake in professional courses such as climatology, remote sensing, Geographic Information Systems (GIS), environmental studies, earth science, urbanization which promise better economic rewards. This has come about as a result of persistent lack of knowledge and understanding of concepts such as the hydrological cycle, tectonic plate movements, glaciation, vulcanicity, the earth and the solar system, mass wasting, and their relationship to overall academic performance in Geography that might lead to persistent low achievement among Geography students (U.K., 2004). To overcome this problem, this study endeavoured to conduct an experiment to determine if computer simulations can improve learners' understanding of geographical concepts.

Based on the above presupposition, the study proposed the integrated use of the computer as a teaching and learning tool, and not merely as a unit of study "added" into the curriculum for science oriented learners. Particularly, the study focused on identifying cognitively difficult topics and misconceptions that could be addressed by use of computer generated simulations in line with the constructivists' instructional mode,

alongside traditional teaching modes in order to improve exit performances of the learners. Salient geographical concepts that may be life threatening or that are removed from the real life experiential dimension of learners such as various aspects of the earth and the solar system were considered for software design as a measure aimed at improving educational standards.

There has been mounting concern about diminishing student performance in Geography in secondary schools in Kisumu District. Students are leaving school with manifest Geography illiteracy yet resources that could enhance their understanding of the subject are yet to be established and embraced. Computer simulations provide a rich platform for enhancing Geography education, if it could be explored. To overcome this problem, this study endeavoured to find out the most difficult topics and establish computer simulations that could improve learners' understanding of the most difficult geographical concept.

1.3. Purpose of the study

The purpose of the study was to determine if computer simulations would improve learners' understanding of geographical concepts and determine potential for incorporation of computer simulations in the teaching of Geography in secondary schools. The study could also inform the augmentation of knowledge concerning ICT integration in schools curricula in Kenya. This could be so because after the realization that the aggravating performance of learners in certain topics was attributable to lack of innovation in the application of computer technology in education, sound ICT policies

would be made and implemented. Likewise, the study would be of benefit to the Ministry of education as it would provide documentary evidence of the innovative uses of computer technology in education. Consequently, optimal use of the technology would be made possible in order to raise educational standards in the country. The study would also form a basis for further research on best practices with regard to ICT applications in teaching and learning.

1.4. Objectives of the study

Specific objectives of the study were:

1. To establish availability and extent of utilization of computer based resources in geography education in secondary schools in Kisumu District.
2. To find out the attitudes of teachers and students towards the use of computers in geography education in Kisumu District.
3. To identify cognitively difficult topics in secondary school geography that may be taught through computer simulations.
4. To determine the effect of computer simulations on students performance in the most difficult topic.
5. To establish computer simulations design that would be used to teach the most difficult topic in Geography.

1.5. Research Questions

The following research questions were deduced from the statement of the problem:

1. To what extent are computer based resources available and used in Geography education in secondary schools in Kisumu district?
2. What is the attitude of students and teachers towards the use of computer technology in Geography education?
3. What topics do students and teachers consider difficult that may be taught through computer simulations?
4. What is the effect of computer simulations on students' performance in the most difficult topic in Geography?
5. What computer simulations design is appropriate for use in teaching the most difficult topic in Geography?

1.6. Assumptions of the study

The assumptions of the study were:

1. The respondents were predisposed to provide candid responses to all the research questions.
2. That social, economic and environmental factors would not significantly influence teachers' and learners' attitudes in the processes of teaching and learning using computer technology.
3. That students' and teachers' apprehension towards computer technology would not significantly affect their attitudes towards its use in education.
4. That all of the respondents had superficial or working knowledge of computers for navigation or problem solving.

1.7. Scope and Limitations of the study

The study aimed at investigating issues aforementioned within various secondary schools in Kisumu District (Appendix 2) in Nyanza Province, Kenya (Appendix 2). Kisumu district in this study included the old administrative boundaries including the current Kisumu Town East district, Kisumu Town West district as well as parts of Nyando district. The study also focused on form three students within the district that took Geography as an examinable subject, as well as Geography teachers.

The study was not able to cover all schools within the district due to time, distance, financial and other logistical considerations. Since schools within the district share social, political and economic backgrounds, it was expected that the results would be replicable to all the other schools.

Another limitation to the study was that some schools did not have electricity as a source of power to facilitate use of computer simulations to teach difficult topics in Geography. In such cases, an alternative source of power such as a generator was used to power computers and projectors.

ICT in education in Kenya and other developing economies is in its nascent stage and there would be paucity in literature regionally and locally.

1.8. Conceptual Framework

Figure 1 shows the diagrammatical representation of conceptualization of the hypothesized model identifying the variables under study and their relationships.

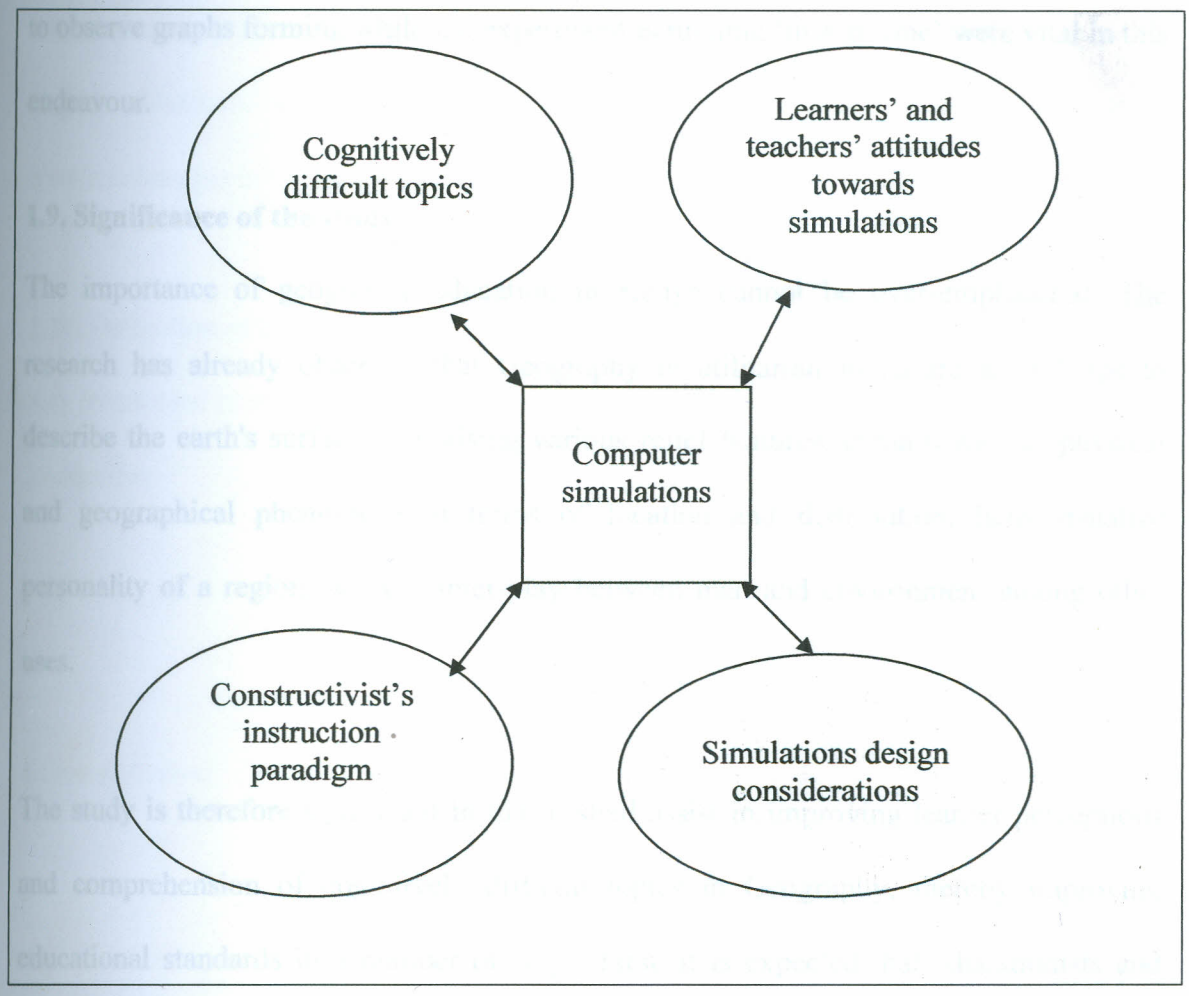

Figure 1. Factors considered for effective use of computer simulations in Geography education

It was vital to identify the topics in Geography that both teachers and students considered difficult to teach or learn. This would be identified through consideration of the teachers' and learners' attitudes regarding the topics as they were presented from the syllabus.

Based on the constructivist's instruction paradigm, a suitable simulations software would then be adapted as a remedial strategy. The constructivist approach puts a strong emphasis on the learner as an active agent in the process of knowledge acquisition. Apt design considerations such as use of multiple representations, graphs and an opportunity to observe graphs forming while the experiment is running 'in real time' were vital in this endeavour.

1.9. Significance of the study

The importance of geography education in Kenya cannot be over-emphasized. The research has already observed that Geography is utilitarian in nature as it helps to describe the earth's surface comprising various relief features, explain various physical and geographical phenomena in terms of location and distribution, help visualize personality of a region, analyze inter-play between man and environment among other uses.

The study is therefore significant in that it shall assist in improving learner perceptions and comprehension of cognitively difficult topics in Geography, thereby improving educational standards in a number of ways. First, it is expected that educationists and learners may acknowledge the computer as a cognitively "enhancing" or "enabling" tool imperative in their educational practices. Second, both learners and teachers are likely to have an attitude change in order to optimize potential innovative educational values of the computer as well as recognize the value of its robust nature in learning and teaching. Active involvement of all stakeholders is expected to result in the demystification of the

computer so as to be used in education for cognitive development and not just as another state-of-the-art tool reserved for science oriented students or members of the elite society.

In tandem with the observations and findings, this study undertook to establish design considerations and evaluate software that integrate simulations in order to gauge its impact on learners' academic performance with the aim of improving comprehension of abstract concepts in Geography herein hitherto identified.

1.10. Definition of significant terms

Key terms used in the study are defined as follows:

Animation: The rapid display of a sequence of images of 2D or 3D artwork or model positions in order to create an illusion of movement, that is, an optical illusion of motion due to the phenomenon of persistence of vision.

Constructivism: Learning is seen as a dynamic process in which learners construct new ideas or concepts on their current/past knowledge and in response to the instructional situation. Constructivism implies the notion that learners do not passively absorb information but construct it themselves through active participation.

Geographic Information System (GIS): A system for capturing, storing, checking, manipulating, analyzing and displaying data which is spatially referenced.

Kisumu District: Includes the current Kisumu Town East, Municipality and Kisumu Town West districts as well as parts of Nyando district.

Simulation: Involves dynamic relationships of two or more variables based on activities in imaginary contexts of real world models. It is the technique of representing the real world by a computer program.

Real time: Relates to computer systems that update information at the same rate as they receive data, enabling them to direct or control a process.

Visualization: A tool or method used to interpret image data and for generating images from complex multi-dimensional data sets.

CHAPTER TWO

LITERATURE REVIEW

2.1. Availability and extent of utilization of computer based resources in secondary schools

The ability of existing educational approaches to impart knowledge, skills and values appropriate to a rapidly changing world has been questioned by educationists, researchers as well as employers. Such concerns are stimulating a growth in the application of educational technology and hence need to be addressed. There is evidence that a change is taking place that involves placing students and technology, rather than instructors and curricula, at the center of educational practice. The computer has been identified as the most efficient 'stand-alone' technology that is able to make teaching and learning situations more meaningful and fruitful than it has ever before (Osodo, 2010; Wabuyele, 2006; Amory, 1997).

Over the last few years, there has been growth in the range and sophistication of new I.C.T.s (such as radio, video, television and so on) in teaching and learning Geography within the developing economies. In particular, computer technology has been used to improve the quality of Geography education in schools because of its robust nature in displaying graphics and simulations (Castleford, 1998). Positive outcomes of using technology in education has led many governments to initiate programs for the integration of technology into schools. In the US, around $8 billion was spent by school districts in the 2003-2004 school year alone to equip schools with necessary technology, primarily in the form of computers. Similarly, in the US, the computer-to-student ratio

was 1:3.8 and the internet-connected computer-to-student ratio was 1:4.1 in 2004. The computer-to-student ratio in schools was around 1:7 in Canada and the UK in 1999 and the same ratio in those countries is close to that of the US (Demirci, 2009).

It is worth noting that supplying schools with a high number of computers does not necessarily mean that educational goals to integrate technology into the curriculum may be automatically accomplished, nor does it mean that the presence of computers in schools translate to their optimal use in teaching and learning. Many studies report failure in different countries to incorporate ICT into educational systems (Eteokleous, 2008; Keengwe & Onchwari, 2008; Ottesen, 2006; Russell, 2003; Dooley, 1999; Scheffler, 1999). Despite reports of an increased number of computers in schools, computers are not extensively used in classrooms in many countries (Eteokleous, 2008; Scheffler, 1999). Even though teachers may appear to own and use computers for their administrative work, many of them never use computers in their classrooms (Demirci, 2009).

Information and Communication Technology skills play a key role in promoting economic development of a country. Many of the productivity gains in the developed world economies over the past two decades are attributable to the impact of I.C.Ts. Information and Communication Technologies have a direct role to play in education and if appropriately used, can bring many benefits to the education sector (Republic of Kenya, 2005). For instance, it provides new opportunities for teaching and learning including offering opportunity for more student centered teaching, opportunity to reach more learners, greater opportunity for teacher-to-teacher and student-to-student communication and collaboration, greater opportunities for multiple technologies

delivered by teachers, creating motivation in learning amongst students and offering access to a wider range of courses.

Even though the recent increase in primary school enrollment has amplified the demand for and access to secondary schools such that there are currently 4000 public secondary schools in Kenya, the extent of use of computers in teaching and learning is not well documented. This is an inference of minimal and incoherent use of the technology in secondary schools in Kenya. Be that as it may, the Kenya Ministry of Education, Science and Technology (MOEST) is concerned with the quality of secondary education which is characterized by poor performance in core subjects such as Mathematics, Science and Geography. There are several benefits for integrating computers into secondary schools as students need to focus on subject-specific content, greater critical thinking skills as well as scientific inquiry. Students may benefit greatly with the analytical, creative, and collaborative power of computers to map out and analyze assumptions, present ideas, and collaborate in projects with peers from around the country and around the world (MOEST, 2005).

There are a number of challenges facing access and use of ICT in Kenya such as high levels of poverty that hinder access to ICT facilities, limited rural electrification and frequent power disruptions (Republic of Kenya, 2005). Where there is electricity, there is high cost of Internet provision, high costs associated with ICT equipment, infrastructure and support. As a result of such challenges, the use of computer technology in education in Kenya may not be widespread. The Kenya Government's Ministry of education's policy on ICT is to integrate ICT education and training into educational systems in order

to prepare the learners and staff for the country's future economy and thereby enhance the nation's ICT skills (Republic of Kenya, 2005).

Kinuthia (2009) and Farrell (2007) contend that very few secondary schools in Kenya have sufficient ICT tools for teachers and students. Even in schools that have computers, the student-computer ratio is 150:1. Most of the schools with ICT infrastructure have acquired it through initiatives supported by parents, the government, non-governmental organizations (NGOs), or other development agencies and the private sector, including the New Partnership for Africa's Development (NEPAD) electronic school programme. The basic problem is that Kenya lacks adequate connectivity and network infrastructure. Although a small number of schools have direct access to high-speed connectivity through Internet service providers, generally there is limited penetration of the national physical telecommunication infrastructure into rural and low-income areas. Consequently, there is limited access to dedicated phone lines and high-speed connectivity for electronic mail and the Internet. Even where access to high-speed connectivity is possible, high costs inhibit access. As a solution to these access problems, the ministry hopes to leverage the electronic government initiative of networking public institutions countrywide to facilitate connectivity for the educational sector (Farrell, 2007).

According to Underwood and Underwood (1992), certain assumptions underlie the assertion that computers can be used for educational benefits. The first is that educationists, parents and society in general want learning situations to embrace effective use of new technology in the classroom. Although many people are apprehensive about

computers, they are interested in the machine and acknowledge its immense powers. The second assumption is that many classroom applications of the technology is not beneficial; often because of the paucity of training for new and serving teachers in the more prolific uses of the machine. Thirdly, by using the computer as a tool, it becomes both amplifier of human capabilities and catalyst to intellectual development. These views about the computer may lead to more productive outcomes in the classroom than do those uses which turn the machine into a surrogate teacher. These uses may however require new social organizations in the classroom relating to the teacher and learner roles (Underwood & Underwood, 1990).

The computer is an important resource not only because of its unique control capabilities, but because these attributes are also isomorphic with the representations and processes involved in human learning. With this parallelism and the capability of either learner or instructional control, the computer can be employed for a range of methods that accommodate learner aptitudes. The computer, for instance, can 'short-circuit' learner cognition by taking on a large amount of information processing burden of the learner. It can dynamically model a process, activate or amplify the learners' own processes as well as accommodate a range of tasks (Kozma, 1987). Likewise, the computer can tutor verbal knowledge, model intellectual skills, activate, or amplify cognitive strategies. This last possibility may be more promising, for learners may internalize the processes in which the computer excels and thus become better learners (Saye, 1997; Kozma, 1987).

In order to engage students actively by making learning interesting, constructivism is advocated for in the inclusion of technology in educational settings. A basic constructivist assumption is that empowerment should be intrinsically motivating because in such circumstances, learners become inclined to seek information and solve problems. Applying this assumption to technological innovation, acceptance and integration of technology is viewed as an evolutionary process, rather than a radical paradigm shift. If technology is presented properly, individuals become more contented, proficient and innovative in applying it to self-paced learning, guided by the expert, teacher or facilitator (Saye, 1997; Hannifin, 1992; Collins, 1990).

One of the most deplorable features of the move toward having computers in the classroom has been the lack of understanding on the part of many professional educators as to what this technology could mean to the improvement of learning process (Harper 1987). Majority of teachers do not know how to use computers to promote educational efficiency and are not being adequately trained to use the technology. Harper (1987) attributed this to the facts that training teachers to use computers is complicated, and that many people have a distorted view of what computers can do for education.

Over the last few years, however, there has been a notable growth in the range, sophistication, penetration rate and potential implications of computers in Geography teaching and learning within the developing economies. This is partly due to the rapid rise in computing power, substantial fall in micro-computer costs and the rapid emergence and use of the Internet. The World Wide Web became readily accessible only

from 1993 after the appearance of Mosaic, the first big browser, followed by the transmission of pictures and the founding of Netscape (Castleford, 1998).

There are already a wide range of computer uses in educational endeavours especially in the developed economies such as the UK and the USA, and more uses are being explored. The internet can be used by staff to support efficient course administration and to assist students to manage their learning. It can assist in achieving many features of flexible delivery, including student choice in the time, place and pace of study. The internet, particularly, can be used to support a variety of teaching and learning tasks, including distributing information that could be conveyed in other ways; e.g., a course syllabus is available electronically instead of on paper, or photos appear on a website instead of being shown around in class; giving access to information storehouses; e.g., the internet can be used as an online library giving access to information sources and databases; providing alternative means of communication (e.g., e-mail, electronic bulletin boards, chat rooms, desktop videoconferencing) for both administrative and instructional purposes. Other uses of the internet include delivering formative and summative assessment tasks. In the United Kingdom, for instance, the commercial product *QuestionMark* has wide usage, being the chosen package in about two-thirds of all the Higher Education Institutions that use Computer Aided Assessment. Developed primarily as a Windows-based version, their relatively new product is Web based; supporting online course and staff evaluation exercises; delivering materials in multiple media that would be difficult to transmit by other means, e.g., a text explanation can be supplemented with pictures, sounds, video clips, links to other sites, simulations. CD-ROMs are used for storing and distributing large data sets of numerical, graphical or

cartographic information. It can also be used for giving students active, hands-on, interactive experience in analyzing information or solving problems. For instance, a student can acquire data, processes it, make a map, and develop a presentation. An example of such software available on CD-ROM, is *Exploring the Nardoo* (University of Wollongong, 1996), a virtual inland river environment where research questions can be explored and environmental management strategies simulated; allowing students to work collaboratively (e.g., students at different institutions working on a common problem). An example is the 'Middle East Politics Simulation' developed at Macquarie University, Sydney, Australia, where students participate in role-playing exercises conducted using the Internet or by videoconferencing. Groups of Political Science students in Australia, New Zealand and the United States play the role of prominent leaders in the Middle East, USA or Europe, attempting to resolve a specific political, social, economic or environmental issue, after carrying out research to identify the background, interests and agenda of their particular character. In other cases, the simulation has been modified to involve scenario building between groups of Political and Environmental Science students, for example in exploring conflicts over water allocation in the Middle East (Alexander, McKenzie & Geissinger, 1998; Alexander & Blight, 1996).

Even though the internet has been used for such tasks, the challenge is to make more innovative uses of the technology in order for the real potential of the technology to be realized. These uses are more prevalent in the developed countries as opposed to the developing ones. The situation as regards computer use in Geography in Kenya is yet to be established.

Potential benefits of computer technology in Geography education can be identified as follows: resource savings are possible in some circumstances: automating repetitive, labour-intensive activities such as skills training can save staff time; use of e-mail for staff-student contact can save time and allow broadcasts of urgent messages or new information; virtual field trips can offer improved preparation before real field visits, or can provide a partial substitute for them; access to an enhanced range of information resources: compared with a conventional library, an online virtual library offers timeliness (constant updating of information), multiplicity (many users can access a resource simultaneously) and variety or balance (multiple web sites can be used to represent contrasting views e.g. on an environmental issue). Use of ICT can facilitate enhanced student learning, by supporting and encouraging the adoption of contemporary effective practices, e.g. a constructivist model of education (Duffy & Cunningham, 1996), resource-based learning (Brown & Smith, 1996), flexible learning (Wade, Hodgkinson, Smith & Arfield, 1994), asynchronous virtual or online tutorials can produce educational benefits quite different from conventional tutorials for different groups. There is evidence that they benefit less assertive or more reflective students, facilitate deeper interaction and generate active participation by student groups marginalized by other methods (Harasim, Hiltz, Teles & Turof, 1995). Also, electronic communications can support enhanced collaborative learning (Johnson & Johnson, 1996; Bednarz, 2004).

Johnson and Johnson (1996) and Bednarz (2004) portend that increased use of ICT in teaching and learning raises a wide variety of issues which are technical, pedagogic, industrial, financial and strategic, for example: effective use of ICT on any significant

scale requires new teaching methods, and awareness of effective practices. It requires a further breakdown of the traditional 'private' nature of teaching, and, there is a need for active staff-development programs, greater teaching support (and/or a wider range of non-teaching skills from the staff), e.g. technical support, web developers, and substantial investment may be required in hardware and software. Substantial reworking of capital and recurrent budgets is also likely to be necessary. There may also be a need for student training programs and help-desk facilities. There are access and equity issues for students: e.g. marginalization by certain groups as a result of the reliance on expensive technology. Rewards and incentives to encourage staff to invest substantial time and effort to initial developments, copyright rules, intellectual property and moral rights, equitably managing teaching loads, especially when there is unequal involvement in ICT-based teaching, or the greater capital investment and time often required are other crucial issues (Johnson & Johnson, 1996; Bednarz, 2004).

Teachers, therefore, are encouraged to develop a personal approach to computer technology to become familiar with a variety of forms of electronic communication, web-authoring, hypercard programs, presentation software and databases and to periodically update themselves on the upgraded versions of these software package to demonstrate awareness of such issues.

Even though the term Computer Assisted Learning has been used since the 1960s, the widespread use of the personal computer market in the 1980s brought the subject into more focus. Maguire (1989) described the uses of CAL in Geography as enhancing presentation, aid in lecture preparation, tutorials, field work, and problem solving. While

computers are common in Geography instruction in higher education, their use at the pre-collegiate level is not very common, though increasing. CAL indicates use of computers as an aid in learning rather than only as a tool for research. Unwin (1992) suggested a typology for CAL in Geography that include computers as sources of data and information, computers as analytical tools, computers as laboratories for investigating the world and computers as instructors. In CAL, the computer is used to interact with the student in form of programmed, self-paced course of instruction. An example of CAL in Geography is the HyperCard program GISTutor which allows students to explore basic GIS concepts in a self-directed environment (Unwin, 1992).

Examples of computers as sources of data and information include interactive video, Compact Disk Read-Only Memory (CD-ROM). Electronic atlases also serve as a source of data and can also be used as an instructional tool. A Geographic Information System can also serve as a repository for information and various types of data. A GIS is also used to manipulate data, create new information or present better visualization for existing data. GIS is an example of the computer as an *analytical tool* in geography given the fact that analysis of spatial data is one of the main purposes for which GIS packages are designed. In addition to GIS, Unwin (1992) mentions digital cartography, image processing, statistical, and even word processing software as other computer-based analytical tools.

A range of computer uses both in the collegiate and pre-collegiate environments include (Taylor, 2003; Fitzpatrick, 1992 & Maguire, 1989): Word Processing, Database, Spreadsheets, Tutorials, Statistics, display, communications, simulation, modeling,

experiments, computer cartography, remote sensing, Geographic Information Systems. All of these functions can be part of CAL at the university level and also at the pre-collegiate level. One type of use not mentioned in this list which is common in the schools is the use of computers for drill and practice. Some of these drill and practice programs emphasize map work where student "basic knowledge" about maps is reinforced. The concepts emphasized include directions, grid references, projection types, distance estimation, and various map reading skills. These map work exercises were often created in the period when personal computers began to be used in the schools and were used more in the primary rather than the secondary schools (Tapsfield, 1984).

Various software packages are used in the university setting to accomplish one or more of the functions listed above. In some cases the software that is used in the universities may be used in the schools, even though educational software have normally been developed independently of these packages. Fitzpatrick (1990) provided a list of educational software for geography teaching in the schools. He identified three categories for these software packages as database, exploratory, and simulation.

Within the local context, computers were introduced in Kenya in the 1970s and the Internet became available in 1993 (Kinuthia, 2009). As of March 2008, 7.9% of the population was accessing the Internet, with the majority being government and private sector employees. Beyond these users, cybercafés are the major providers of Internet service for the majority of the population. While there are over 30 Internet Service Providers in Kenya and the number continues to grow, access is still limited, especially in rural areas.

A study by Wabuyele (2006) revealed that while ICTs had penetrated many sectors including banking, transportation, communications, and medical services, the Kenyan educational system seemed to lag behind. The study found out that computer use in Kenyan classrooms was still in its early phases, and concluded that the perceptions and experiences of teachers and administrators played an important role in the use of computers in Kenyan classrooms. This highlighted the need to provide pre-service and in-service training programs to enable them to successfully teach using computers in the classrooms as pertinent. Wabuyele's study also indicated that the government and the MOEST needed to review both teacher preparation and staff development programs, as well as develop a revised national plan to implement ICT into the curriculum (Kinuthia, 2009; Wabuyele, 2006).

A survey of 56 schools in seven out of eight provinces in Kenya by Oloo (2009) indicated that use of computers for teaching and learning in Kenya was dismal with a 7.14% performance as shown in Table 2. Respondents in schools surveyed by Oloo felt that they did not have adequate funding to purchase ICT equipment and would consider buying them for administrative purposes such as letter typing and examination processing. The priority of most schools surveyed was to acquire computers for administrative purposes before anything else (Oloo, 2009).

The empirical data collected in Oloo's survey showed that the range of number of computers owned by schools varied widely from one school to another. In his survey 17.9% of schools had less than 5 computers. 46.4% of schools had 20 or less schools while 62.5% had 130 or fewer computers.

Table 2. Computer usage in schools in Kenya in 2009

Activity	Frequency (No. of schools)	Percentage
School Administration	40	71.43
Teach Basic Skills	38	67.86
Examination Processing	29	51.79
Teach KNEC Syllabus	22	39.29
Internet Research	13	23.21
E-Learning Services	4	7.14

Given an average secondary school population of 500 students, this gave a very low student to computer ratio. During this survey it was clear that majority of teachers where ill equipped to effectively integrate ICT in classroom. The main challenge for teachers interviewed was lack of adequate number of computers, educational applications, training, policy and strategy on how integration should be done (Oloo, 2009). This baseline survey report of ICTs in secondary schools in selected parts of Kenya established that administrative use and examination processing was the most frequent followed by teaching of basic computer skills. This was because most schools felt financially constrained and the little money they had would rather be spent on administrative support services. It was also found that a few schools had purchased management software which were used with varying success. Most schools felt unsupported with lack of training on use of management software. The most common modules bought by schools were examination, timetabling and accounting modules

(Oloo, 2009). Even though Oloo's survey indicated some increase in computer use in schools for general purposes, it is observable that integration of computers in teaching and learning specific subjects like Geography was non existent, occasioning an in-depth study to establish availability and extent of utilization of computers in geography education in Kisumu District.

As has been observed, in Kenya and subsequently Kisumu, there has been erratic use of computers for educational purposes. The cultural context of ICT adoption, language barriers, and attitudes toward ICT affect the rate at which it is adopted. Perceived difficulty in the integration of ICT in education is based on the belief that technology use is challenging, its implementation requires extra time, technology skills are difficult to learn, and the cost of attaining and maintain resources is prohibitive. Few schools own or have access to computers for teaching and learning. According to Odera (2002), the introduction of Computer Studies as an examinable subject in Kenya could be traced to private commercial colleges that introduced the course for income generation in the early 1990s. Even though there was plummeting popularity of computer courses among students, parents and teachers, there was lack of reciprocal action on the side of the government to increase enrollment and related infrastructure. ICT operators in the Kenyan education field included organizations such as Computer for schools Kenya (CfSK), Kenya ICT Trust Fund, Kenya Computer Initiative (KCI), Kenya Education Network (KENET) and others. Such agencies and non governmental organizations made attempts to provide ICT hardware and software as well as technical services to schools in Kenya in liaison with the government (Krige & Okono, 2007). Be that as it may, the efforts are disjointed and have had little impact in education. This necessitated the study

to establish innovative computer uses that would help raise educational standards in the country.

2.2. Attitudes of teachers and students towards the use of computers in Geography

Computer simulation is becoming increasingly popular in teaching in higher education. Dissatisfaction with traditional teaching techniques such as the lecture, the need to understand processes and to teach problem-solving skills are some of the reasons for this. The roots of simulation are in war-gaming, management and business studies, and in psychologists' approaches to 'experiential learning'. Simulation in geography developed in the late 1960s. The example of the Caribbean Fishing Game can be used to demonstrate flexibility of gaming (Walford, 1997).

Using games and simulations in school geography have been found to encourage fun and interactive teaching and learning by interspersing geography games and activities within curriculum teaching. Simulations encourage enthusiastic participation in the geography classroom, improve performance using games, which have been proven to be effective teaching and learning tools, contribute to students' social and emotional aspects of learning, developing skills of empathy, decision-making and critical thinking that they can use across the curriculum and throughout their lives, add to the teacher's range of teaching strategies, particularly those which encourage interaction with students (Wong, 2005; Walford, 1997).

Even though the majority of teachers and students may not be using or even aware of the unique potential capabilities of computer technology in teaching and learning, they tend

to have a positive attitude towards computer use in education (Sang, Valcke, van Braak, & Tondeur, 2010; Teyfur, 2009). According to Wagner and associates (2005), use of ICT in education could have a positive impact on students beyond their knowledge in traditional school subjects. A number of studies carried out established that computers could positively influence student motivation, their attitudes towards technology, instruction or in the subject (Wagner, 2005). For instance, Wagner (2005) found out that students using computer tutorials had significantly positive attitudes towards instruction and the subject matter than students who received instruction without computers.

Another study aimed at understanding the extent to which GIS technology had been diffused throughout secondary school Geography lessons in Turkey by focusing on Geography teachers' attitude towards GIS was carried out (Demirci, 2009). In the study, a survey form was sent to Geography teachers in 200 private secondary schools in Turkey. As the study revealed, knowledge of GIS and its use in Geography lessons by teachers was minimal. More than half of the teachers (66%) had no precise understanding of what GIS was and 82% of the teachers did not know how it could be used in Geography lessons. The use of GIS among teachers in Geography lessons was found to be very low. Only seven of these teachers indicated that they had used GIS software in their Geography lessons. The teachers' attitudes, however, were positive towards GIS. Most of the teachers (76%) thought that GIS was an effective teaching tool for Geography lessons. Although some external barriers such as lack of hardware, software, and data existed, the positive attitude of teachers towards GIS was a significant factor which would contribute to the integration of GIS into Geography.

In the same context, six computer assisted learning modules in Geography were developed by researchers and evaluated in the unique milieu of Singapore schools in terms of impact on achievement, attitudes and classroom psychosocial environment. A sample of 671 students from the second year of high school were assigned randomly to either a CAL or control group. Compared with control students, CAL students had higher achievement and attitude scores and perceived their classes as having greater gender equity, investigation, innovation and resource adequacy (Teh, 1994).

A study by Wong (1996) also attested to the fact that students and teachers had a positive attitude towards use of computer technology in education. The main aim of the study was to examine the relationship between the nature of the classroom learning environment and the students' attitudes towards computer-assisted Mathematics classes. In addition, the students' actual and preferred perceptions of the computer laboratory learning environment and gender differences in students' perceptions of computer-assisted Mathematics classroom environment were also explored. The sample used in this study comprised 177 Primary 5 pupils from a government primary school located in a densely populated housing estate in Singapore. The instruments used were the actual and preferred versions of the My Computer Class Inventory (MCCI) and the Computer Lesson Attitude Questionnaire (CLAQ). A series of data analyses were conducted to establish the MCCI's internal consistency reliability, discriminant validity and ability to differentiate between perceptions of students in different classes. The investigation of attitude-environment association involved using simple and multiple correlational analyses using the student as the unit of analysis. The findings from the study revealed the existence of positive associations between the nature of the computer-assisted

Mathematics classroom environment and the students' attitudinal outcomes (Wong, 1996).

Similarly, a comparative study of Physics classes in Kenya revealed that students who had computer based instruction learned the subject matter better and exhibited positive attitudes about the subject compared to their counterparts who did not use computers (Batchelor & Nocrish, 2005). In their study, two randomly assigned classes used computer based instruction while a third group did not. The results were ascertained by interviewing the students at the end of the lesson.

To corroborate the research findings above, another study carried out to investigate teachers' and administrators' perceptions and experiences towards computer use in Kenyan classrooms revealed that both teachers and administrators viewed the use of computers in Kenyan classrooms as worthwhile. Teachers who used computers were enthusiastic and spoke positively about computer use, whereas non-computer users felt left behind technologically. Teachers reported feeling unprepared by teacher training colleges to use computers in the classrooms, and expressed the need to provide both practicing and pre-service teachers with professional development opportunities in technology. This resulted from in-depth interviews, participant observations and document analysis The study suggested that teachers' and administrators' perceptions and experiences play a significant role in the use of computers in Kenyan classrooms and hence the need to provide pre-service and in-service training programs to enable them to successfully teach using computers in the classrooms (Wabuyele, 2006).

A number of researchers have also been involved in the investigation of associations between students' cognitive and affective learning outcomes and their perceptions of their classroom environment (Allesi & Trollip, 2001; Azita, 1999; Fraser, 1994). One notable tradition in past classroom environment research involved investigation of association between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser & Fisher, 1982; Haertel, Walberg & Haertel, 1981). Research has shown that student perceptions are associated with appreciable amounts of variance in learning outcomes, often beyond that attributable to student background characteristics (Wong, 1996a). One of the practical implications from such research is that student outcomes might be improved by creating classroom environments found empirically to be conducive to learning. For example, Fraser's (1994) tabulation of 40 past studies in science education showed that associations between outcome measures and classroom environment perceptions were replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples (ranging across numerous countries and grade level). Using the Science Laboratory Environment Inventory (SLEI), associations of classroom environment perceptions with students' cognitive and affective outcomes had been established for a sample of approximately 80 senior high school chemistry classes in Australia (Fraser & McRobbie, 1995), 489 senior high school biology students in Australia (Fisher, Henderson & Fraser, 1997) and 1592 grade 10 Chemistry students in Singapore (Wong & Fraser, 1996). Using an instrument suited for computer-assisted instruction classroom, Teh and Fraser (1995) established associations between classroom environment and achievement and attitudes among a sample of 671

high school Geography students in 24 classes in Singapore. Association between student outcomes and perceived patterns of teacher-student interaction were reported for samples of 489 senior high school Biology students in Australia (Fisher, Henderson & Fraser, 1997), 3994 high school Science and Mathematics students in Australia (Fisher, Fraser & Rickards, 1997) and 1512 primary school Mathematics students in Singapore (Goh, Young & Fraser, 1995).

Even though research findings indicated that attitudes of teachers and students towards computer use was positive, regardless of having used the technology or not, there was need to find out whether or not the perceived favourable attitude would be corroborated in specific difficult Geography topics by teachers and students in Kisumu District. It was necessary to find out if at all both teachers and students in Kisumu district would have a positive attitude towards the application of computer technology in teaching and learning for improved performance in Geography.

2.3. Cognitively difficult topics in secondary school Geography that may be taught through computer simulations

Teaching and learning Geography involves mental operations that relate to the acquisition of certain concepts, principles, theories and skills contained in the subject. Like in any learning situation, perceptual problems abound, for instance, in the observation of phenomena either directly in the field or indirectly through the media of maps, diagrams, pictures and written evidence (Graves, 1980). What learners and teachers see may not be an objective reality but an interpretation of individual sense perceptions in terms of the kind of conceptual framework they have acquired over time.

Whatever is perceived helps individuals in concept formation. But, equally, the existing concepts to some extent guide what is perceived (Graves, 1980). Learning involves assimilation of experiences in an individual's existing conceptual framework to new experiences. If the new experiences do not disturb the conceptual framework, there is an equilibrium in the mental system. If new experiences become difficult to assimilate in to the existing conceptual framework, then there is disequilibrium manifested by making certain typical errors. The process can only change if the conceptual framework is altered to accommodate new experiences (Gagne, 1966). Therefore, teachers attempting to stimulate the mental faculties of learners need to be aware of learning problems which students may have.

In Geography, it is worth noting that perceptual difficulties are likely to arise in the direct observation of the environment or in the study of secondary evidence such as photographs, maps, weather, climate, the earth and the solar system (Graves, 1980). Concepts taught in Geography vary considerably in order of difficulty. The simplest are those that describe features or processes which can be observed at first hand and are within the learner's experience of the environment. The most difficult are concepts by definition or principles which express relationships of an abstract nature (Gagne, 1966). Part of the process of mental development relevant to the learning of Geography is that which relates to the development of spatial conceptualization. Since space is a relative and subjective concept, it follows that not all categories of learners from different cultural backgrounds may conceive it the same way. Since the process of conceptual development and growth of logical thinking is related to the development of language, geographical

education needs also to be developed with the use of all possible forms of communication.

Geography influences human life directly in several ways. Geographic knowledge makes life easier and develops social and environmental perspectives. The progress of geographic thought develops a person's feeling of knowing and taking responsibility in the development of the country. On the other hand, exploiting the environment increases the happiness and welfare of nations. Geographic thought provides social responsibility, harmony with nature, tolerance to different views and understanding. Geographic thought is a significant way of thinking that should be applied in terms of finding solutions to increasing technological developments and financial problems. Cognitive educational phases in a person's development process go through concrete procedures following abstract phases (Ünlü, 2008). More logical responses are taken as the students grow up. Students' responses develop through different levels from illogical to more logical, proving their proportions and thinking all possibilities. Thought improvement in reasoning develops with the increase of knowledge. Consequently, the learning habits ought to be appropriate to the child's cognitive improvement level (Ünlü, 2008). The improvement of geographic thought of students has a close relation with the cognitive areas in Geography lessons. Geographic events are from concrete to abstract, parallel to the progress phases in education (Gagne, 1966; Graves, 1980; Ünlü, 2008). As such, in line with the study objectives, it was necessary to investigate concepts or topics that students found difficult in Geography whose teaching and learning would be enhanced by computer simulations.

According to Ünlü (2008) learning in geography lessons depends on the adoption of concrete phenomena that a student perceives from the environment. Geographic knowledge needs to be given to the students at the first phase of primary school concretely. At the second phase and secondary education, abstract knowledge and skills should be given. Comprehension in Geography lessons develops when the students improve their thought levels to analysis and evaluation. Geographic concepts get developed as a part of students' perception and thinking process. It is not an easy task to pass geographic knowledge and facts to the students. It is difficult to teach abstract concepts possibly used in geographic terminology as ecliptic, world axis and equator (Ünlü, 2008). Building new knowledge items over half-learned abstract concepts may make students have incorrect information. The fact that some concepts related to Geography really exist does not necessarily mean that students learn them. The teaching of concepts to the students should start from the best example describing it and hence a generalization would be possible. It is also important that students have the opportunity to discuss about geographic aims including definition, explanation, description, connection, perception, proportion, forcing and arguments of concepts in geographic thought development (Ünlü, 2008). From Ünlü's (2008) discourse, it may be observed that the processes of cognition and perception of concepts have a strong relationship. As such, it was necessary for this study to indulge into investigations regarding the difficult topics in Geography and how they could be addressed. Since it is necessary to authenticate what learners traditionally learn in classrooms in order for them to apply facts and knowledge to real life problem solving situations, it was fundamental that the effect of computer

simulations in increasing performance in Geography be investigated for incorporation in to the curriculum.

2.4. Effect of computer simulations on students' performance in Geography

Several studies have been carried out in the developed countries attesting to the efficacy of computer simulations in various disciplines, including Geography (Lunce, 2006). All of such studies indicated that computer simulations were effective in enhancing comprehension of concepts thereby ameliorating students' performance. For instance, a study by Kathy Cabe Trundle, lead author of the study and associate professor of science education at Ohio State University (Ohio State University, 2010) found that people who used computer simulations to learn about moon phases understood the concepts just as well and in some cases better than did those who learned from collecting data from viewing the moon. The results suggested the use of computer simulations in science classes may be an effective and often less expensive and time-consuming way to teach some science concepts (Ohio State University, 2010). Participants in the study were 157 pre-service teachers. Studies had shown that majority of people including pre-service students and the students they teach do not understand the cause of moon phases. This study (by Trundle) examined how well pre-service teachers understood moon phases before and after taking a 10-week science methods course that included a unit on moon phases. In contrast to traditional instruction, the class was inquiry-based, which meant that students learned from gathering data themselves either directly from viewing the moon or from the computer simulation. The participants then analyzed the data they gathered to identify patterns. One class learned about moon phases using only a computer

simulation, one group from nature alone, and a third group from both a computer simulation and nature. The computer simulations were provided through a commercially available software program that allows users to visualize the movement of the sun and the moon through time from any point on Earth. The researchers tested the participants' understanding before and after the class in three areas: knowledge of sequences of moon phases, the causes of moon phases, and the shapes of moon phases. Before the class, none of the pre-service teachers had a complete scientific knowledge of the moon phases. After the class, teachers in all three groups (computer simulation only, nature only and simulation and nature) dramatically improved their scores. Up to 98 percent of the teachers showed they understood moon phases after the class was completed. Those who used only computer simulations did just as well as others in learning causes of moon phases and shapes of moon phases. Those who used the simulations were slightly more likely than the others to understand the sequences of moon phases. Trundle concluded that the computer simulation was more effective at teaching moon sequences because the students who used it had a complete set of data (Ohio State University, 2010). This study was indicant of the fact that computer simulations, if used ingeniously, had a positive impact on comprehension of concepts otherwise considered abstract. It was therefore necessary to establish if computer simulations could also have a positive impact when used to teach difficult topics in secondary school Geography in Kisumu District.

It is worth noting that there is a wide range of simulation and modeling activities that can be carried out by computers. Many of these are in physical Geography such as modeling storm water discharge in a hydrologic network. Brusilovsky and Gorskaya-Belova (1992) in Moscow documented a computer-based model of landforms used by students in a

physical Geography of oceans and continents course. The use of the landform modeling program nearly doubled the success rate of students in a test conducted by the researchers. Various human Geography topics can also be simulated. Maguire (1989) documented examples such as a site selection process for a new factory, a fractal based simulation of urban land use, and a modeling environment for future relationships on a global scale between population, agriculture, resource use, industry, and pollution. These simulations also had a positive effect on learners when used to teach such abstract topics.

There have also been simulation applications to GIS. A GIS is a system for capturing, storing, checking, manipulating, analyzing and displaying data which is spatially referenced (Hearnshaw & Unwin, 1994). Thompson (1991) reviewed the potential for GIS to serve as a medium for communicating various geographic concepts and suggested that it provides students with a rich resource of information (nodes), associations between discrete pieces of data (links or webs), different learning oriented activities (browsing , tutors, simulations), via a compatible interface (map based metaphor), within a networked social system. There are a variety of GIS software packages currently on the market many of which are used in colleges and universities to teach students about GIS and geographic information analysis techniques. Universities are beginning to use GIS for CAL. White and Simms (1993) documented an activity in an environmental studies course that used GIS software to help students determine a hypothetical location for a new solid waste landfill site. They concluded that this type of exercise using GIS as a teaching tool could present data more powerfully and spark creativity and imagination as well as accomplish the curricular objectives of the course (White & Simms, 1993).

At the pre-collegiate level, various GIS activities that make use of various GIS software packages, notably ARCVIEW and IDRISI are in use (Palladino, 1993). Walsh (1998) in an early article geared to introducing teachers to GIS provided an argument for the use of GIS by earth science educators in the schools. He pointed out the ability of GIS-based investigations to demonstrate the integration of data elements necessary to understand and analyze the complex nature of surface, subsurface, and atmospheric problems and systems. He also noted that the creation and manipulation of GIS layers can facilitate a clear understanding of the interactions of earth science elements and the spatial significance of their distribution. From the research done on the efficacy of computer simulations in education, it is discernable that simulations indeed have a positive effect in enhancing learners' comprehension. It is however evident that most of the research were done at the college level. It was therefore necessary to find out the effects of computer simulations in teaching and learning difficult topics at the pre-collegiate level, that is, in secondary schools in Kisumu District.

These reflections on some of the uses of geographic software demonstrate the wide range of possible computer uses in geographic education. As schools improve their computing infrastructure, as teachers become more comfortable with the use of computers as a teaching tool, and as software for geographic instruction continues to be developed, it is reasonable to assume that computers may be more effectively used in geographic education in the not so distant future.

Cole and Mather (1979) also considered the effects of wide availability of microcomputers on Geography teaching and on the content of geography syllabuses in

higher education and suggested that the most likely features to affect teaching methods are simulation, visual display and computer aided instruction, and that there would be greater emphasis on skills training. The design and use of a simple computer model which simulates aspects of hill-slope hydrology was described in a teaching context by Burt and Butcher (1986). The model allows students to simulate the hydrological response of real hill slopes. It may be used in several ways, and at different levels, and can be used in conjunction with other teaching methods.

Similarly, Churchill and Frankland (1980) reported the experience of running an undergraduate course which uses interactive mapping software to teach students spatial concepts and the problems involved in creating maps, arguing that the main benefit of the computer is that it enables students to discover problems relating to map construction through a process of interactive experimentation.

Joffe and Wright (1989) too described the development and educational potential of a gaming simulation targeted at the recreational market. The computer program permits users to build up a city map on screen, consisting of various land uses and transport systems, and then project its development into the future. The user can view summary maps as the city develops and the program provides an assessment of the effectiveness of the resulting development. Students are able to experiment with alternative planning scenarios, although they are unable to control or modify the operation of the program's growth model.

A study was also carried out in Kenya among the NEPAD and non NEPAD schools on the efficacy of computer technology in education (Ayere, 2009). The NEPAD schools on

average had a wider variety and a higher quantity of ICT equipment compared to the non NEPAD schools. The NEPAD schools made use of the Internet and online materials in research, electronic mail and ICT integration in teaching and learning as opposed to the non NEPAD schools. The study identified number of computers in schools, rules and regulations from the ICT department and the number of computer literate teachers as important factors that determine a student's use of an ICT laboratory. The study concluded that the NEPAD schools that had a wide variety and high quality ICT equipment posted significantly better performance in national examinations compared to non NEPAD schools.

Given the pre-eminence of the computer and the current inconsistent trends in its application in education, it is evident that educationists are yet to fully exploit the understanding of computers or explore their untapped potential. Although the computer has been useful in tutorial and simulation applications, perhaps the most significant applications of the technology are yet to be explored (Reiber, 1996). From the illustrations above, it is apparent that there is need for research on uses of the technology for situations other than computer science, as well as use of software that integrate simulations, more so in the developing economies. It is also factual that there is no emphasis on the importance of the use of the computer simulations under the principles of constructivism, alongside traditional modes of teaching, at the pre-collegiate level. The main objective of this study was to address this gap.

2.5. Design considerations for educational simulations

Simulations in educational endeavours may be traced to the use of war games in the 1600s with the purpose of improving the strategic planning of armies and navies. Since then, they have served as a component in the military planning. Each simulation began with a scenario, and the exercise unfolded as teams representing different governments acted and reacted to the situation. Since the late 1950s, the use of simulations has become common in both business and medical education, especially in language and science education and corporate training (Aldrich, 2005; Gredler, 2001; 1992; 1990; Jones, 1982; 1987; McGuire, Solomon & Bashook, 1975). Simulations entered the broad educational scene in the late 1950s. Until the early 1970s, they were not part of the instructional design movement. They were exercises primarily developed by business and medical education faculty and sociologists who adapted instructional developments pioneered by the military services.

Currently, the robust nature of computer technology is contributing to renewed interest in games and simulations. This development coincides with the current perception of effective instruction in which meaningful learning depends on the construction of knowledge by the learner, that is, constructivism. Simulations can provide an environment for the learner's construction of new knowledge, which is major component of this focus (Habgood, Ainsworth & Benford, 2005; Akpan & Andre, 2000).

This technology, as it is applied in educational realms, experiences certain hiccups reminiscent in similar innovations in their nascent stages. One of the problems is that

comprehensive design paradigms derived from learning principles have not been well comprehended and executed. This has resulted in a variety of truncated exercises erroneously labeled as simulations. For instance, a study referred to a static computer graphic of a pegboard as a simulation as another study that purported to be a simulation of decision making was a series of test questions about different situations in which the student was to assume that he or she was an administrator of special education (Ke, 2008; Foreman & Aldrich, 2005; Jonassen, 1988). These mislabeled exercises underscored the need for effective design models for simulations in this study.

Another major problem for developers and users of simulations is the lack of well-designed research studies. Much of the published literature consists of anecdotal reports and testimonials. These discussions typically provide a sketchy description of the game or simulation and report only perceived student reactions (Gredler, 1990). Most of the research is flawed by basic weaknesses in both design and measurement. As such, it therefore called for a more focused research in the design and effects of simulation in education that could address the intervening factors in the models as well as appropriate educational paradigms.

Gedler (1990) referred to simulations as experiential exercises because they provide unique opportunities for students to interact with a knowledge domain. Two important concepts in the analysis of the nature of simulations are surface structure and deep structure. Surface structure is the paraphernalia and observable mechanics of an exercise. An essential surface structure component in a simulation is a scenario or set of data to be

addressed by the participant. Deep structure on the other hand is the psychological mechanisms operating in the exercise (Gredler, 1990; 1992).

Table 3. Essential Design Criteria for Educational Games and Simulations adapted from Gredler (1990)

Criterion	Rationale
1. Winning should be based on knowledge or skills, not random factors.	When chance factors contribute to winning, the knowledge and, effort of other players are devalued.
2. The game should address important content not trivia.	The game sends messages about what is important in the class.
3. The dynamics of the game should be easy to understand and interesting for the players but not obstruct or distort learning.	The goal is to provide a practical, yet challenging exercise; added "bells and whistles" should be minimal and fulfill an important purpose.
4. Students should not lose points for wrong answers	Punishing players for errors also punishes their effort and generates frustration.
5. Games should not be zero-sum exercises	In zero-sum games, players periodically receive rewards for game-sanctioned actions, but only one player achieves an ultimate win. The educational problem is that several students may demonstrate substantial learning but are not recognized as winners.

Deep structure refers to the nature of the interactions between the learner and the major tasks in the exercise, and between the students in the exercise. Examples include the extent of student control in the exercise, the learner actions that are rewarded in the exercise or which receive positive feedback, and the complexity of the decision sequence in the exercise (e.g., linear or branching). Table 3 summarizes major design considerations as suggested by Gredler (1990).

As identified by Gedler (1990), the two broad categories of instructional simulations are *experiential* and *symbolic* simulations. Experiential simulations are dynamic case studies with the participants on the inside. They establish a particular psychological reality and place the participants in defined roles within that reality. The participants, in the context of their roles, execute their responsibilities in an evolving situation. Essential components of an experiential simulation are outlined as:

(1) a scenario of a complex task or problem that unfolds in part in response to learner actions,

(2) a serious role taken by the learner in which he or she executes the responsibilities of the position,

(3) multiple plausible paths through the experience, and

(4) learner control of decision making.

Experiential simulations were originally developed to provide learner interactions in situations that are too costly or hazardous to provide in a real-world setting. Progressively, they are able to fulfill the function of permitting students to execute

multidimensional problem solving strategies as part of a defined role. Experiential simulations are designed to immerse the learner in a complex, evolving situations in which the learner becomes one of the functional components. Conversely, a symbolic simulation is a dynamic representation of the functioning or behavior of some universe, system, set of processes, or phenomena by another system (in this case a computer). The behavior that is being simulated involves the interaction of two or more variables over time. A key characteristic of symbolic simulations (like experiential simulations) is that they involve the dynamic interactions of two or more variables. An example of a symbolic simulation is dynamic computer representation of a complex equipment system. The student, interacting with a symbolic simulation, may be executing any of several tasks, such as troubleshooting equipment or predicting future trends. The student remains external to the evolving events.

In experiential simulations category, exercises may differ in a number of ways: the nature of the participants' roles, the types of decisions and interactions in the exercise, and the nature of the relationships among the variables. That is to say, experiential simulations may be individual or group exercises, the focus may vary from executing professional expertise to experiencing a different cultural reality, and the relationships among the variables may be quantitative or qualitative. Four major types of experiential simulations are data management, diagnostic, crisis management, and social process simulations, each of which is summarized in Table 4 (Gredler, 1992).

Table 4. Summary of experimental simulations for learner interaction.

SUMMARY OF EXPERIMENTAL SIMULATIONS			
Type	**Structure**	**Underlying Model**	**Task**
Data management	Successive rounds of decision making; typically team based	Quantitative	Allocate economic resources to any of several
Diagnostic	An evolving complex problem that requires sequential interrelated decisions; typically an individual exercise	Qualitative	Select and interpret data and implement strategies in order to manage a complex, evolving problem
Crisis management	An escalating situation that threatens the welfare of a group or individual; may be individual or team based	Qualitative	Resolve the escalating situation under increasing time and other pressures
Social-process Simulations	The interaction of a precipitating social task or event, well-defined participant roles, complicating factors, and context; team based exercise	Qualitative	Resolve a social problem or issue that is accompanied by different priorities or goals of the associated roles

A symbolic simulation is a dynamic representation of the functioning or behavior of some universe, system, set of processes, or phenomena by another system (in this case, a computer). That is, symbolic simulations are populations of events or sets of interacting processes.

Table 5. Summary of symbolic simulations

SUMMARY OF SYMBOLIC SIMULATIONS			
Type	**Structure**	**Underlying model**	**Task**
Data universe	Represents a large population of events; may be individual or team based	Quantitative	To develop mental models about the interrelationships of variables and test the models
System	Demonstrates the functional relationships between the components of a physical or biological system or a constructed system (such as complex equipment systems)	Quantitative or Qualitative	To explain or predict events in the system
Process	Represents specific interactive processes in the physical world	Quantitative or Qualitative	To discover relationships among the variables and/or to confront misconceptions
Laboratory research	A series of student directed discrete experiments in Simulated environments	Quantitative or Qualitative	To become proficient in conducting specific experiments, documenting results, and conclusions

The role of the learner in relation to a symbolic simulation is typically that of a researcher or investigator. The learner manipulates different variables in order to discover scientific relationships, explain or predict events, or confront misconceptions. Symbolic simulations may be classified according to the nature of the variables and the nature of the interactions among them.

Four types of symbolic simulations can be identified as data universe simulations, system simulations, process simulations, and laboratory-research simulations. These are summarized in Table 5.

It can therefore be concluded that the process of designing a simulations software is a daunting task. As observed, a number of authors and researchers have erroneously referred to models as simulations which on close scrutiny fail the design test of simulations. This could lead to mystification of the concept thereby dispiriting its acceptance and adoption in educational realms. As such, in tandem of the study objectives, several design considerations ought to be calibrated so as to cater for the needs and interests of students, ease of operation and navigational aspects, specific lesson objectives, as well as age developmental factors. The instructional systems design approach where there is division of labour and consideration of all stake holders was also referenced. This study therefore endeavoured to specify design considerations for computer simulations that would consequently be used to enhance comprehension of difficult concepts in Geography.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Research design

The research design adopted in this study was the Completely Randomized Block design and descriptive surveys. This study consisted of two groups: an experimental and control group, where individuals were assigned randomly either to the experimental or control group and exposed to different treatments then post-tested after the introduction of the independent variable. Random grouping using the Completely Randomized Block design is shown in Table 6.

Table 6. The completely randomized block design table

Respondents (designated as R_1 and R_2)	**Treatment**	**Posttest**
R_1	Teaching by simulations	O_1
R_2	Teaching without simulations	O_1

The completely randomized block design (Table 6) was used since it necessitated the subdivision of the respondents into subgroups (blocks), such that the variability within blocks was less than the variability between blocks (Wikipedia, 2009). Participants within each block were then randomly assigned to different treatment conditions. This design reduces variability and potential confounding, therefore, it produces a good

estimate of treatment effects (Wikipedia, 2009). This method made it possible to control nuisance factors, that is, those that could affect the measured result, but were not of prime interest. The technique of 'blocking' was used to eliminate experimental error contributed by nuisance factors. The main advantage of using this design was to create homogeneous blocks in which the nuisance factors could be held constant and the factor of interest allowed to vary (Wikipedia, 2009). Within the blocks, it was therefore possible to assess the effect of different levels of the factor of interest, that is, the effect of computer simulations on the performance of students in the most difficult topic, without concern to variations due to changes of the block factors, which were accounted for in the analysis.

The use of descriptive surveys were underscored by Suter (1998) and Nachmias and Nachmias (1996) as the most predominant method of data collection in the social sciences. Here, a random sample of individuals were asked to respond to sets of questions about their backgrounds, experiences and attitudes, in line with research objectives. Data collected would be used to examine relationships between properties and dispositions of respondents in line with the objectives of the study. Both quantitative and qualitative methods were used. In order to collect and manage data in line with the research objectives, the hybrid approach which uses a number of different data collection methods was used. This method is justified because no single method of data collection would be sufficient in any study. A combination of methods compensates for the inadequacies that would abound in each individual method in the attempt to give the study results a holistic picture (Newby, 1997; Gay, 1996; Frackel & Wallen, 1993). The dependent variable was performance of learners in cognitively difficult topics in Geography whereas the independent variable was computer simulations.

3.2. Area of study

The research was conducted in Kisumu district of Nyanza province, Kenya. Kenya lies across the equator on the east of the African continent. Neighbouring countries include Ethiopia to the north, Somalia to east, Tanzania to south, Uganda to west and Sudan to north-west. Kisumu City is the third largest city in Kenya (after Nairobi and Mombasa), the principal city of western Kenya, the capital of Nyanza Province and the headquarters of Kisumu district. It is a port city in western Kenya at 1,131 metres (3,710 ft). It lies 0°6′ south of the equator and 34°45′ east of the meridian. It is the largest city in Nyanza Province and second most important city after Kampala in the greater Lake Victoria basin. It has a population of about 355,024 (1999 census) that is made up of people of diverse cultures and backgrounds, most of whom are of the Luo community. Kisumu is approximately 350 kilometers (k.m.) from Nairobi City.

Kisumu District is one of the twelve districts in Nyanza Province and has a total area of 918.5 sq. km. It has four (4) administrative divisions, namely, Winam, Maseno, Kombewa and Kadibo divisions. Winam division has the highest population density. The 1999 census showed that Kisumu district had a population of 504,359 which was projected to reach 576,256 by 2010, with a growth rate of 2.0% per annum. The population is mainly youthful with 67% of the population aged below 25 years. The youthful population has put pressure on the available educational, health and other social facilities. This has contributed to a high dependency ration of 1:1.18. 25% of the population (53,028) attend secondary school (14-17 years). There is high drop out rate attributable to high levels of poverty. The main causes of poverty could be identified as

environmental, lack of exploitation of natural resources, socio-cultural factors and HIV and AIDS menace. The population is economically active and stood at 53% (266,129) in 1999. It is estimated that about 53% or 267,310 people live below the poverty line (Government of Kenya, 2005). The administrative units, their size, population size and densities are shown in Table 7.

Table 7. Kisumu district administrative units

Division	Population (2002)	Area in Sq. Km	Population Density
Winam	350,365	395	887
Maseno	69,336	168.7	411
Kombewa	*63,969*	*192.1*	*332.9*
Kadibo	*51,901*	*162.7*	*318.9*
TOTAL	**535,571**	**918.5**	**583**

The main type of vegetation is Savannah woodland (Acacia, Albizzia and Butyrospermum). The main species of herbaceous vegetation is Cymbopogon, Hyparrhenia, Londetia and Cyperus papyrus. The major economic activities include crop and animal husbandry as well as fishing. The main kinds of crops are maize, cotton, sisal, tobacco, beans, sugar cane, sorghum, millet, wheat and root crops. The crops are mainly for subsistence even though to a minimal extent, some of the crops are sold for cash.

The geographical boundary of the area of study included the current administrative districts of Kisumu Town East, Kisumu Town West as well as parts of Nyando district. These administrative districts were subdivided in 2007 from the greater Kisumu district here referred to as 'Kisumu district'. The study covered various secondary schools in the district, including schools within the central business district as well as schools in the rural areas of the district. The location of the district is indicated by the map attached as Appendix 2.

3.3. Population

In this study, the general population was all secondary school geography teachers (N=240) and students (N=3,500) in Kisumu District. The target population was form three secondary school students who take Geography as an examinable subject (n=1,165) and form three secondary school geography teachers (n=80). Form three geography students were targeted because, in the Kenya secondary school system of education, Geography is an elective subject and students in forms one and two had not selected the subject, by the time of the study. Also, form four students were left out in the study because they were engaged in preparation for the national examinations hence would neither be available nor committed to the study. There are a total of five groups of subjects offered to students for examination at the end of the secondary school four year course by the Kenya National Examinations Council (KNEC). Geography has been categorized by the examinations council as an optional subject, falling under group thereof the five categories. Students are required to take all the three subjects in Group 1 and at least two subjects from Group 2. They are also required to select subjects in the

other three remaining groups, where geography falls. The selection of subjects is normally done in form three and is dependent upon what each of the individual schools offer, students' personal preferences as well as the resources and teachers available in the individual schools. At the end of the fourth year in secondary school, the Kenya Certificate of Secondary Education (K.C.S.E.) examination is administered to the students, based on their subject choices.

3.4. Sample and Sampling Techniques

Simple random sampling technique was used to select a sample of 80 teachers. According to Fraenkel and Wallen (2000); Suter (1998); Nkpa (1997) and Nachmias and Nachmias (1996), a critical attribute of the simple random sampling is that each member of the target population has an equal and independent chance of being included in the sample. Independence in this sense means that the selection of a member does not in any way affect the selection of any other member of the population. If, for instance there are 3500 members in the population, the probability of any member being included in the sample is 1 out of 3500 irrespective of whoever else is selected. The requirements of independence and equal probability are met by using tables of random numbers for selection (Appendix 10). Accordingly, simple random sampling technique was used to select a sample of 1165 form three Geography students and 80 Geography teachers who taught form three students. Ten percent of the population of teachers and students were involved in the pilot study. Table 8 indicates the total number of subjects and percentages sampled.

Table 8. Sample Frame

Subjects	Total Number (Population)	Number selected (Sample)	Percentage (%)
Geography teachers	240	80	30
Form 3 Geography students	3500	1165	30

Simple random sampling, as observed, gives each of the total sampling units of the population an equal and known nonzero probability of being selected (Panneerselvam, 2008; Nachmias & Nachmias, 1996). Each sampling unit of the population was numbered and listed. The table of random digits was then read starting at a random point and each digit that appeared in the table read and recorded to generate the random list of students. From the starting point, the table was read systematically in the downward direction (vertically) and the corresponding members of the population for all the selected numbers used as the random sample. This consequently eliminated bias in the selection procedure as it was possible to estimate parameters with confidence to be representative of the real values that would be found in the total population. The table of random digits used is attached as Appendix 10.

3.5. Research Instruments

The instruments that were used to collect data in line with the study objectives included interviews, questionnaires and experiment.

3.5.1. Interview schedule

According to Grinnell (2001), Nkpa (1997) and Kothari (1990), face to face verbal contact is the most basic and common form of communication among human beings. Survey respondents are usually more willing to participate when questions are posed directly by someone in their presence, therefore, response rates are relatively high. Respondents are also less likely to give distracted or ill-considered answers to questions in the presence of a person who directly asks for their views. An interviewer can explain the meaning each question is intended to convey in a way that is not attainable with self-administered written survey instruments. In harmony with Grinnell's (2001) sentiments, interviews were conducted with teachers and students to determine their attitudes towards use of computer technology in education (Appendices 3 and 4). The semi-structured interview schedule included prompts, reminders and explanatory sessions as need arose.

Face to face interviews were carried out with secondary school Geography teachers (n=80) and the form three secondary school Geography students (n=1165) in order to ascertain how they perceived use of computer simulations in teaching and learning, regardless of having used or experienced them. This information was crucial since it would inform the inclusion of the technology in Geography education. Annexed to the semi-structured interview questions were brief explanations to computer simulation

concepts for the respondents' perusal if they deemed it necessary. The teachers were expected to provide information regarding the name of their schools, classes they taught, contact details, whether or not they had computers for teaching Geography and in case computers were used at all or effectively in order to enhance comprehension of concepts. The teachers were also to indicate whether or not computer simulations were necessary in aiding instruction in topics they taught. Information was also sought from the teachers if computer simulations were likely to improve performance in the difficult topics. Likewise, the students were expected to provide information regarding the name of their schools, their forms and contact details, whether or not they had computers for learning Geography and in case computers were used at all or effectively in order to enhance comprehension of concepts. The students were also to indicate whether or not computer simulations were necessary in aiding comprehension of difficult topics they learned. Information was also sought from the students if computer simulations were likely to improve performance in the difficult topics. The interviewer would then take note appropriately, or audio record comments by the respondents for transcription. The responses were based on a two to five tier Likert type scale where 'Yes'=2, 'No'=1, 'Strongly Agree'=5, 'Agree'=4, 'Undecided'=3, 'Disagree'=2, 'Strongly Disagree'=1. Each of the interviews was to take a minimum of twenty minutes since the interviewer had to give time for the respondent to be comfortable and not feel rushed in order to elicit meaningful responses. Consent of the respondents was sought by notifying them of the general purposes of the study, the uses to be made of the data and the means by which confidentiality would be maintained. Informed consent was attained when the

respondents agreed to participate in the study after the preliminary consent seeking, as recommended by Grinnell (2001).

3.5.2. Questionnaire

A questionnaire gathers large amounts of data from many subjects inexpensively (Krathwohl, 1993; Kothari, 1990). It elicits responses to ascertain facts, opinions, beliefs, attitudes and practices (Nkpa, 1997). In line with this assertion, to further investigate the attitudes of teachers and students towards computer use in Geography education, an adaptation of the Loyd Gressard Computer Attitude Scale (Loyd & Gressard, 1984; 1985) (CAS) on five measurement points on the Likert type scale was used. CAS is an instrument used to measure different aspects of computer attitude. The teachers were supposed to indicate whether or not they had computers for teaching Geography and in case computers were used at all or effectively in order to enhance comprehension of concepts. They were also to indicate whether or not computer simulations were necessary in aiding instruction in topics they taught, and, if computer simulations were likely to improve performance in the difficult topics. Likewise, the students were expected to state whether or not they had computers for learning Geography and in case computers were used at all or effectively in order to enhance comprehension of concepts. The students were also to indicate whether or not computer simulations were necessary in aiding comprehension of difficult topics they learned. Information was also sought from the students if computer simulations were likely to improve performance in the difficult topics.

Questionnaires were also administered to teachers and students to identify cognitively difficult topics and misconceptions in secondary school Geography. The questionnaires presented to teachers and students included a substantive list of 16 topics from the secondary school Geography syllabus that was currently approved by the government to be used to teach students in forms 1, 2 and 3. The questionnaire was semi-structured and the respondents were supposed to select and tick from the range of topics provided, indicating the level of perceived difficulty. At the same time, space was provided for the respondents to give comments and suggest any other areas of difficulty that might have emerged. There were two types of questionnaires, that is, the teacher questionnaire and student questionnaire. The purpose of each of the questionnaires was to elicit information from both the teachers and students regarding the cognitively difficult topics in Geography. The teachers were to indicate the topics from the form one to three Geography currently approved syllabus that they found difficult to teach, or that they felt learners had a problem comprehending. Likewise, learners were to indicate the topics that they found difficult to comprehend and consequently performed poorly in. This information would make it possible to design a plan of remedial action that would address the problems herein identified with the aim if improving performance in the subject.

3.5.3. Experiment

The strong chain of reasoning in experiments is important in the linkage of cause and effect. They aid in seeking the laws of nature, the rules and principles that guide individual and group behaviour (Krathwohl, 1993). An experiment, based on the

Completely Randomized Block design was conducted using the adapted computer simulations software to determine its effectiveness in addressing learners' conceptual problems.

After identifying cognitively difficult topics in Geography as 'The earth and the solar system', 'Field-work', 'Soils', 'Agriculture', 'External land-forming processes', experiments were carried out to determine the efficacy of the computer simulations in addressing the difficult topics. The study ascertained that the most difficult one was 'The earth and the solar system'. Form three Geography students from each school that had been sampled (n=1165) were randomly subdivided into two. Random numbers were used to divide form three Geography students in each of the schools in half. One half formed the control group as the other half formed the experimental group. The randomization and blocking was replicated in all schools to culminate in a total number of 582 students in the experimental group and an equal number (583) as the control group. After randomly subdividing the classes in to two groups, the experimental and control groups of students were initially subjected to different treatment conditions. One group (control group) was taught the most difficult topic ('The earth and the solar system') using the predominant traditional method of teaching (verbal expositions only) whereas the other group (experimental group) was taught the same topic using computer simulations software illustrating the topic 'The earth and the solar system'. The lessons took 40 minutes for each of the groups. The two groups were consequently given the same test based on the topic taught. The test administered, which had been adapted from the standard Kenya National Examinations Council lasted 40 minutes. The students were expected to provide

written answers to the questions set in the spaces that had been provided. The test was marked out of a possible maximum of one hundred percent. The sample test used as adapted from the K.N.E.C is attached as Appendix 7. The results of both the control and experimental groups were compared to establish the effectiveness of computer simulations in remedying the cognitively difficult topics, thereby enhancing comprehension and raising educational standards.

The 1165 students and 80 teachers involved in the experiment were sampled from 80 schools. After getting authorization from the school administration, the researcher presented the experimental group in each school with the simulations software incorporating the topic 'The earth and the solar system'. The geography teacher used the software to teach the topic, simultaneously with the traditional teaching method of verbal expositions for a duration of 40 minutes. The same teacher then taught the same topic to the control group using the traditional method (lecture) only for the same duration. The same test was then presented to the two groups for 40 minutes in order to determine the efficacy of the simulations software on the performance of the learners.

3.6. Validity and Reliability of the instruments

3.6.1. Validity

A highly reliable instrument is of no practical value if it is not valid. Validity is the degree to which an instrument measures exactly what it purports to measure (Nkpa, 1997). To ascertain validity of the instruments, items were discussed with three

authorities in the content area and their expert opinions used to determine and ascertain validity of the instruments.

Triangulation was also used. Once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced by triangulation as a form of cross-checking (Nkpa, 1997). It is one of several rationales for such multi-method research and involved the gathering of data through several sampling strategies from different populations, at different times and in different places, the use of more than one theoretical stance when interpreting data and the use of more than one data gathering-method.

3.6.2. Reliability

Reliability is related to the difference between an individual's true score on a construct and the measurement value arising from any administration of the measuring instrument (Nkpa, 1997). The degree of reliability is measured by coefficients which indicate the degree to which a measuring instrument is free from error variance. In order to ascertain accuracy and consistency of the instruments with regard to reliability, the *test-retest* reliability procedure was performed. Suter (1998) and Nkpa (1997) contended that by administering the same instrument again to the same subjects after a time period has elapsed and statistically comparing the results, evidence of reliability would be observed.

In this study, subgroups were randomly selected from the normative groups to examine the test-retest reliability of the revised questionnaires. The teachers and the learners were

then asked to complete check-lists twice over a four week period. The Pearson Product Moment correlation co-efficient on total check-list scores was then determined. The exact agreement method for specific check-list items (agreements on both occurrence and non-occurrence cases divided by the total number of items) was then used to determine the test-retest reliability. The formula used for calculating the reliability coefficient was:

$$r = \frac{\sum(X - \ddot{X})(Y - \bar{Y})}{\sqrt{[\sum(X - \ddot{X})^2 \sum(Y - \bar{Y})^2]}}$$

where r is the *linear correlation coefficient* which measures the strength and the direction of a linear relationship between two variables, X and Y being the two subgroups randomly selected for the test-retest reliability of the instruments. The table used to derive the critical value of r is attached as Appendix 9.

Another way of ascertaining reliability was to carry out a pilot study. A limited research project with a few subjects (24 teachers and 350 students randomly sampled) that followed the research plan in every respect was carried out as a pilot study. The purpose of this was to be able to consider information about necessary modifications to instruments, materials, procedures and treatments that would result from analyses of the pilot study results. Piloting was done purposively, that is, the schools having been known to have computers were identified. 24 teachers from 24 secondary schools in Kisumu district formed the piloting sample.

replication done for all students in all schools. Each of the groups was taught the difficult topic by the same teacher but using different methods. One group was taught using the predominant lecture method only (control group) while the other group was taught using the simulations software (experimental group), after which the same examination was administered to both the groups and performance compared in order to determine the efficacy of computer simulations in teaching the most difficult topic.

3.8. Methods of data analysis

Quantitative data was analyzed using the Mann-Whitney U – Wilcoxon Test in the Statistical Package for the Social Sciences (SPSS). Data from the questionnaire were numbered, ordered, categorized then coded according to the responses. 'Yes' responses were coded as '1' and 'No' coded as '0'. The total sum of scores were converted in to percentages then sorted in ascending order and ranked. Responses to items on the attitude scales were coded using score values on the five point Likert type scale as follows: strongly agree=5, agree=4, undecided=3, disagree=2, strongly disagree=1. A mid point (3) was taken to represent a neutral attitude, points above 3 positive and points below 3 reflected a negative attitude. Likewise, for teachers and students' attitudes, frequency counts were computed for the data collected by use of the questionnaire on a five point Likert scale, based on the Loyd Gressard Computer Attitude Scale. Mean scores of the respondents on each item of Likert scale were then calculated. The statements on the Likert scale were scored as follows: 'Strongly Agree'=5 points, 'Agree'=4 points, 'Undecided'=3 points, 'Disagree'=2 points, 'Strongly Disagree'=1 point. A mean score

of above 3 was interpreted to denote a positive perception, a mean score of 3 denoted a neutral perception and a mean score of below 3 denoted a negative perception.

The results were compared, in relation to the learners' and teachers' responses regarding their attitudes on the use of computer simulations as well as learners performance in the examination using cross-tabulations and the Mann-Whitney U – Wilcoxon Test. These statistical procedures were best suited for management and analysis of such non-continuous data. The non-parametric Mann-Whitney U – Wilcoxon Test was used to determine statistical differences between learners' and teachers' responses regarding their attitudes on the use of computer simulations as well as learners performance in the examination at a confidence level of 0.05.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Availability and utilization of computer based resources

The first part of the research involved an investigation of the percentage of secondary schools within Kisumu district that had computers. Out of a total number of 80 schools, a paltry 8% had computers whereas 92% did not have computers (Figure 2) that could be used for geography teaching and learning. A close scrutiny disclosed that even though computers existed in such schools, they were not integrated in teaching and learning specific subjects such as Geography but used for office management.

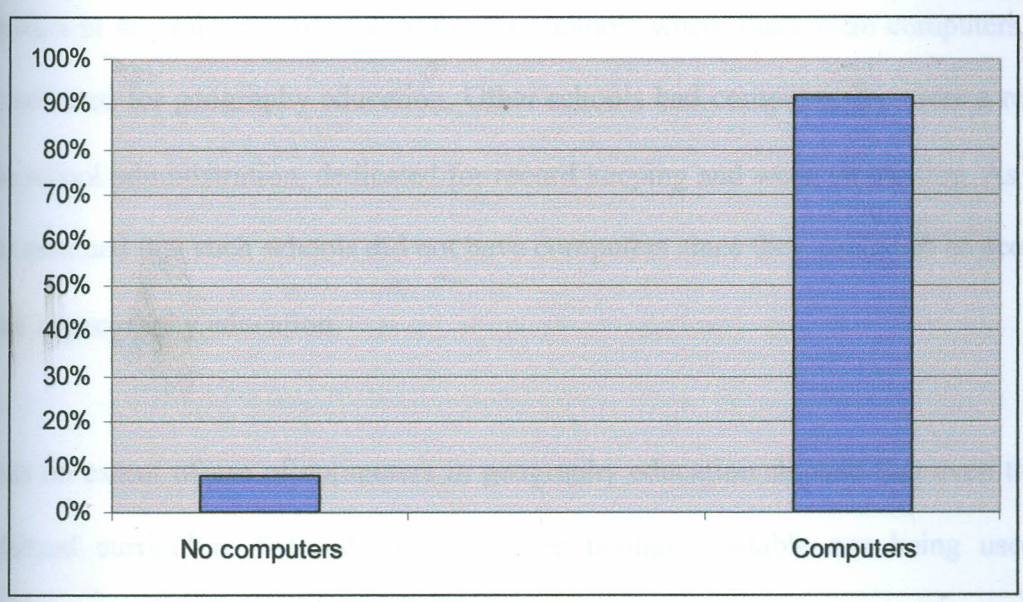

Figure 2. Percentage of schools in Kisumu District that have computers

Figure 2 shows that a total of 92% of the schools in Kisumu District did not have computers that could be used for teaching and learning Geography. From this information, it is apparent that computers were not available in Kisumu District for teaching and learning geography, and, the use of computers in education is non-existent as corroborated by Oloo (2009), Demirci (2009), Kinuthia (2009) and Odera (2002). For example, Odera (2002) found out that computers dedicated for geography education were not available in secondary schools in Kisumu District and the use of computer technology in teaching and learning Geography was therefore non existent.

It was apparent from the results above that many schools in Kisumu district did not have computers that could be used in teaching and learning Geography. There was paucity of computers in several schools, and, in the few schools where there were computers, they were not used for geography education. Other schools had computers but were a reserve of the school administration, dedicated for record keeping and word processing. As such, it was assumed that such schools did not have computers since they could not be accessed for use in geography education.

Results on extent of use of computers in geography education showed that even though specialized curriculum focused software were neither available nor being used for teaching and learning Geography, 9% of the teachers (Figure 3) occasionally used general purpose software such as Microsoft Word and Excel to either type or analyze examinations but not for geography education. This was so as a result of deficient

knowledge in the use and unavailability of curriculum focused software to teach Geography.

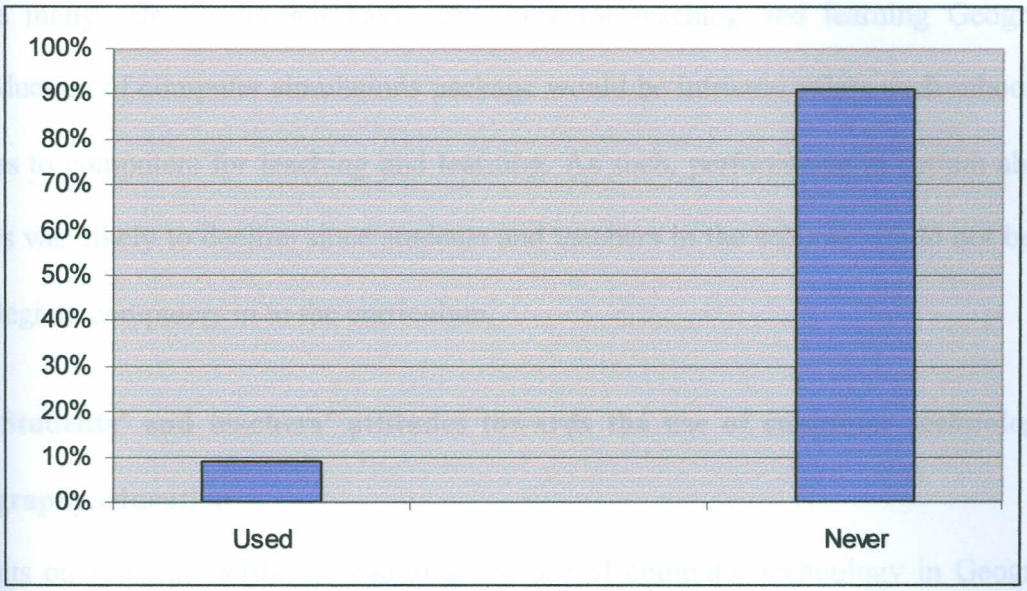

Figure 3. The extent to which computer applications are used in teaching and learning in secondary schools in Kisumu District

As is shown in Figure 3, the extent of usage of computer technology in geography education in Kisumu District was non-existent. Even though 9% of the teachers contended that they had used computers for teaching Geography, they disclosed that the use was administrative. As such, there was no integration of computers in to classroom teaching and learning. The percentage of teachers that had never used computers to teach Geography was 91%, indicating a very high level of no usage. This finding was in tandem with other research findings that computers were basically being used for

administrative purposes and had not been incorporated in to specific subject content teaching (Oloo, 2009; Wabuyele, 2006).

Since many schools did not have computers for teaching and learning Geography, introduction of computer simulations package would be intricate unless such schools got access to computers for teaching and learning. As such, performance in certain abstract topics was likely to decline since students and teachers in the schools would not be able to integrate computers in to the curriculum.

4.2. Students' and teachers' attitudes towards the use of computer technology in Geography education

Results on students' attitudes regarding the use of computer technology in Geography education revealed that a mean rate of 4.81 of them were convinced that computer technology in education would have a positive effect on their performance while a mean of 2.47 thought it would have a negative effect as indicated in Table 9.

Table 9. Attitudes of students towards use of computer technology in Geography education

Mean	Attitude
4.81	Positive
2.47	Negative

69.1% of the learners were convinced that computer technology in education would have a positive effect in their performance while 30.9% thought it would have a negative effect as shown in Figure 4.

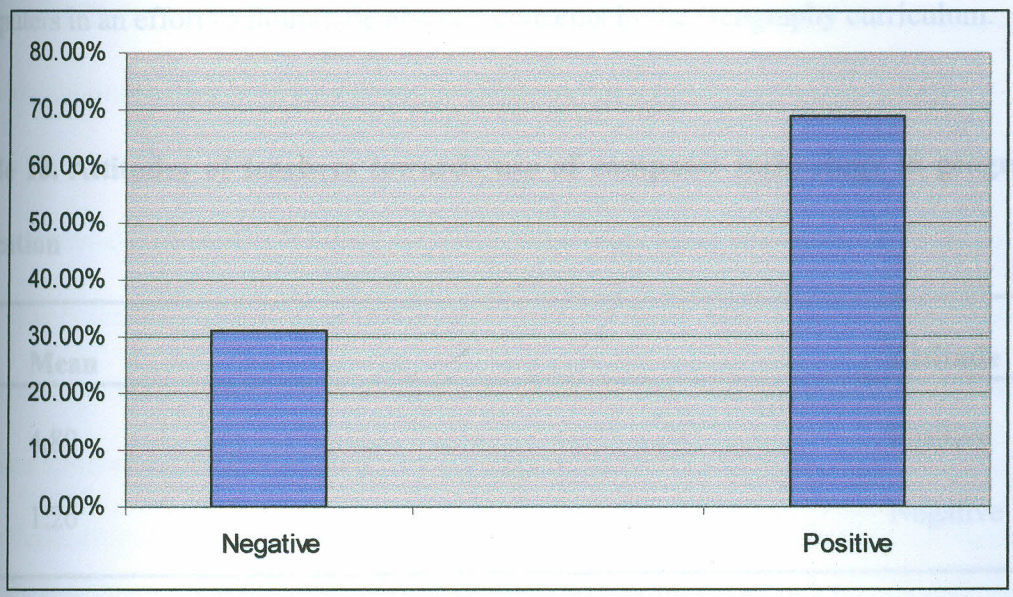

Figure 4. Learners' attitudes regarding use of computer technology in geography education

Attitudes of Geography teachers were also sought regarding the use of computers in teaching and learning. 18% of the respondents said computers were likely to have a negative effect whereas 82% said computers were likely to have a positive effect in geography education. It could be inferred from this that 18% of the teachers had a negative attitude towards the use of computers in geography education and would therefore not support their integration in to the geography curriculum. On the other hand, 82% of the teachers had a favourable attitude towards use of computers in geography education and would therefore support their inclusion in the geography curriculum.

As indicated in Table 10, the majority of teachers showed willingness to embrace computer technology, regardless of having used the technology or not. This positive perception implies that given the chance, the teachers would not hesitate to make use of computers in an effort to illuminate abstract concepts in the Geography curriculum.

Table 10. Attitudes of teachers towards use of computer technology in geography education

Mean	Attitude
4.89	Positive
1.26	Negative

The introduction of the computer simulations package would therefore have a positive effect in the performance of learners thereby raising educational standards. A student respondent said "…I suppose computers are very interesting to use for learning. I feel motivated and look forward to using them to learn Geography…" while a teacher, on a positive note, responded …"computers have become a way of life and their use in education and learning is unavoidable…". These positive responses indicated positive perceptions of both the teachers and students on use of computer technology in geography education.

As such, a super majority of students and teachers in Kisumu district had a positive attitude towards use of computer technology in Geography education. Therefore, it would

be expected that the teachers and students would recommend and support the inclusion of computer technology in teaching and learning. As such, integration of computer technology in to Geography curriculum would be realized, as long as such schools had access to computers. Consequently, the teachers and students would be able to make use of the simulations package in order to teach and learn difficult topics in Geography, consequently improving performance of students in the subject.

The non parametric Mann – Whitney U – Wilcoxon Test using the Statistical Package for the Social Sciences (SPSS) at a confidence level of 0.05 was used to determine the statistical differences between the attitudes of teachers and students regarding the use of computer simulations in Geography as indicated in Table 11. Analysis based on teachers and students attitudes regarding the use of computer simulations in teaching and learning Geography indicated that more teachers and learners had a favourable attitude (p=0.0029) towards use of simulations in education as opposed to the few whose attitude was negative.

Table 11. Table of Mann – Whitney U – Wilcoxon Test

Respondents	p Value	Attitude	Percentage
Teachers	0.0029	Positive	82.0
	0.6637	Negative	18.0
Students	0.0031	Positive	69.1
	0.6711	Negative	30.9

The findings imply that even though the majority of teachers and students in Kisumu district had never used computers in geography education, they had a positive attitude towards the use of computers in geography education (82%). This positive perception of use of computer simulations in geography education by the teachers and students is in accord with research findings by Sang, Valcke, van Braak, and Tondeur (2010) and Teyfur (2009), who established that even computer use in education tended to be perceived positively by students and teachers irrespective of having used them or not. The few students and teachers who had used computers had superficial knowledge on the technology and merely used it to manage text and manipulate figures. It may therefore be concluded that if the myriad of problems facing the teachers such as apprehension and fear of the technology and its unavailability in the district could be addressed, several teachers and students would make more meaningful use of computers in Geography education.

The study indicated that despite the fact that many schools did not have computers and consequently many students and teachers did not use computer technology for Geography education, both the teachers and students had a positive attitude towards the use of computer technology as shown in Table 12.

Table 12. Attitude of teachers and students towards use of computer technology in Geography education

Respondents	Mean scores	Attitude
Teachers	4.91	Positive
Students	4.87	Positive

This implied that the main impediment they had was access to computers, and given a chance, they would recommend and enthusiastically make effective use of the technology in Geography education. These findings were consistent with those of several researchers such as Demirci, 2009; Wabuyele, 2006; Batchelor and Nocrish, 2005; Wong, 2005; Allesi and Trollip, 2001; Azita, 1999 and Fraser, 1994 who found out that students and teachers who used computers in education perceived the technology positively.

4.3. Cognitively difficult topics in secondary school Geography curriculum that may be taught through computer simulations software

Table 13 shows cross tabulations indicating the topics and responses from teachers and students on the most difficult to the easiest topic. All the topics (16) of the current secondary school Geography syllabus from Form 1 to 3 were given to the Geography teachers and learners to determine which ones were cognitively difficult and the order of difficulty. It can be concluded from Table 14 that the topics found by students to be difficult were 'The earth and the solar system, 'Field work', 'Soils' and 'Agriculture'. The students found the topics External land forming processes, Introduction to Geography, Minerals and rocks, Vegetation, Climate, Forestry, Internal land forming processes, Mining, Photograph work and Weather as neither difficult nor easy. The students found the topics Statistical methods and Maps and map-work easy.

Table 13. Topics and responses from students on levels of difficulty

Topic	Responses					Mean Rate
	*VD	QD	NS	QE	VE	
1. The earth and the solar system	985	61	36	36	1	4.767
2. Fieldwork	883	122	45	69	2	4.611
3. Soils	642	338	70	68	1	4.374
4. Agriculture	530	502	9	9	0	4.191
5. External land forming processes	552	278	105	68	0	3.852
6. Introduction to Geography	394	281	348	27	68	3.797
7. Minerals and rocks	254	456	184	147	72	3.576
8. Vegetation	315	412	174	35	114	3.566
9. Climate	377	307	182	87	169	3.563
10. Forestry	378	282	162	178	122	3.543
11. Internal land forming processes	355	143	297	203	72	3.312
12. Mining	244	336	200	227	71	3.287
13. Photograph work	288	295	196	130	213	3.281
14. Weather	202	237	367	245	71	3.225
15. Statistical methods	165	174	78	633	72	2.757
16. Maps and map-work	218	305	527	72	0	2.509

*Key: VD = Very Difficult QD = Quite Difficult
NS = Not Sure QE = Quite Easy
VE = Very Easy

Similarly, the teachers were in concurrence with the students that the topic 'The earth and the solar system' was the most difficult followed by Soils, Internal land forming

processes, External land forming processes, Field work, , Agriculture, Minerals and rocks, Climate and Vegetation.

Table 14. Topics and responses from teachers on levels of difficulty

Topic	Responses					Mean Rate
	*VD	QD	NS	QE	VE	
1. The earth and the solar system	70	4	2	2	2	4.725
2. Soils	68	2	3	7	1	4.650
2. Internal land forming processes	68	3	4	2	3	4.636
3. External land forming processes	67	2	5	3	3	4.588
6. Fieldwork	66	1	4	8	1	4.536
7. Agriculture	64	0	8	5	3	4.463
8. Minerals and rocks	63	5	4	1	7	4.450
9. Climate	61	3	4	7	5	4.350
7. Vegetation	57	1	2	15	5	4.125
8. 10. Forestry	48	2	6	16	8	3.825
11. Statistical methods	44	1	6	19	10	3.625
12. Mining	37	2	2	21	18	3.238
13. Maps and map-work	8	13	7	42	10	2.588
13. Introduction to Geography	3	8	4	27	38	1.888
14. Photograph work	0	2	6	14	58	1.400
16. Weather	1	1	2	12	64	1.289

*Key: VD = Very Difficult QD = Quite Difficult
NS = Not sure QE = Quite Easy VE = Very Easy

All of the topics from form one to three were presented to the teachers and students in order to have a clear picture of the levels of difficulty based on the syllabus topics. This was done because some teachers and students were likely to omit certain topics because of inability to remember all of them due to the vastness of the subject. As is observable from Tables 13 and 14, even though both the students and teachers were in agreement that the topic 'The earth and the solar system' was the most difficult one, the feelings of the teachers and students on the levels of difficulty of the other topics were not always in tandem. For instance, whereas the teachers felt that the topics Internal land forming processes (4.636 mean) and External land forming processes (4.588 mean) were difficult, the students felt they were not (mean rates of 3.312 and 3.852 respectively). This is indicative of the fact that the perspective of the teachers regarding levels of difficulty was not similar. Teachers' perceptions would have been influenced by prior training and experience in teaching the said topics, which the students lacked. Also, it is possible that the teachers regarded the difficult topics in view of the difficulties the students experienced or were likely to experience in comprehending the topics as they were taught by the teachers.

The most difficult topic, 'The earth and the solar system' was a topic from the syllabus normally categorized under physical Geography. As such, the study findings were in tandem with findings of other researchers which established that such physical aspects of Geography which were spatio-temporal in nature tended to be perceived differently by

different learners and teachers hence difficulty in their comprehension (Unlu, 2008; Graves, 1980; Gagne, 1966). Also, several aspects of the topic are removed from the experiential dimensions of both students and teachers and might not be experienced in real life. This implied that the students and teachers were bound to find it difficult since the topic also had several aspects that needed to be simulated and animated to enhance authenticity of the concepts. Also the difficulty could have arisen from the fact that various concepts from the topic were liable for idiosyncratic perception and interpretation, which would sometimes be inaccurate. The topic would therefore be best suited for mitigation by the use of computer software to enhance comprehension.

4.4. Effect of computer simulations on students performance in Geography

After ascertaining from both the students and teachers the most difficult topic from the syllabus, the topic ('The earth and the solar system') was taught to the form three students on which they were later examined. Each class was divided into two, using randomly generated numbers (Appendix 10). One group of the students (n=582) was taught by use of the traditional methods of teaching only whereas the other (n=583) was taught using simulations software incorporated in to a CD-ROM. In order to determine the method that would be more effective in teaching the difficult topic, the same examination was given to both the groups. The examination questions were adapted from the standard Kenya National Examinations Council (Appendix 8). The examination was administered for 40 minutes and the results analyzed.

The results indicated that the students who were taught using the traditional methods of teaching performed dismally (11%) compared to their counterparts who were taught using computer simulations (73%) as shown in Figure 5.

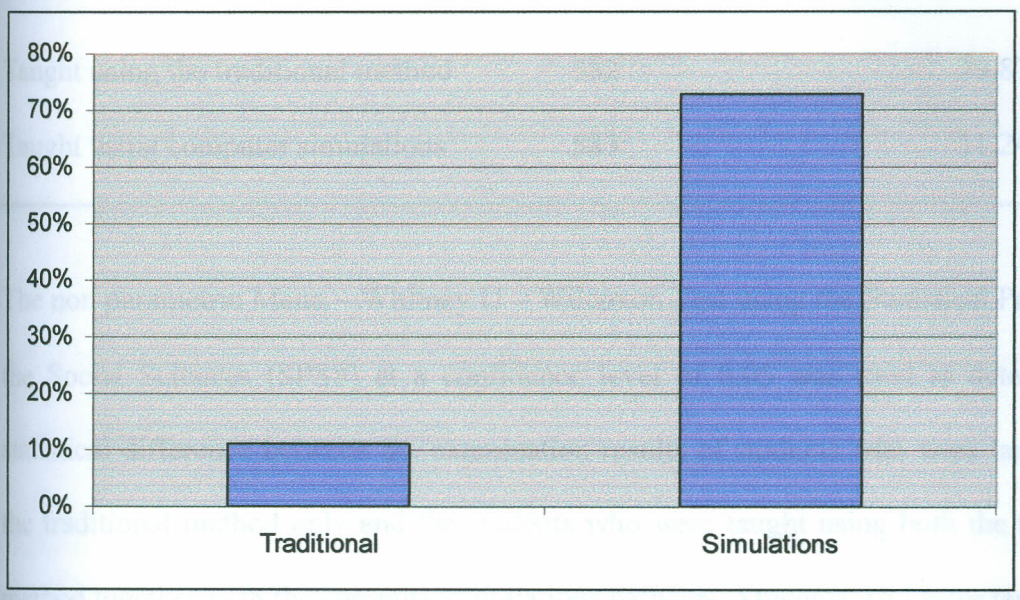

Figure 5. Performance of students after instruction by the traditional methods of teaching and computer simulations

The actual mean score out of a possible total of 100 for students who were taught using computer simulations was 79.876 whereas the mean for students taught by the traditional method (without computer simulations) was as 11.241 shown in Table 15.

As indicated in Figure 5 and Table 15, the performance of students on the most difficult topic after instruction by use of computer simulations was far much better than that of the students who were taught the most difficult topic using the traditional method of teaching.

Table 15. Mean score of students after instruction by traditional method of teaching and computer simulations

Respondents	Total number	Mean score
Taught using the traditional method	582	79.876
Taught using computer simulations	583	11.241

The non parametric Mann – Whitney U – Wilcoxon Test using the Statistical Package for the Social Sciences (SPSS) at a confidence level of 0.05 was used to determine the statistical difference between the examination results of students who were taught using the traditional method only and the students who were taught using both the traditional method together with the computer simulations software. Students who were taught using computer simulations performed much better ($p= 0.0001$) than their counterparts who were taught using only the traditional method. It can therefore be concluded that the use of computer simulations together with the traditional teaching method in addressing cognitively difficult topics in secondary school Geography is more effective than the use of the traditional methods alone. These findings were consistent with the research findings that established that computer simulations are useful in illuminating difficult concepts due to their richness and ability to incorporate movement, interactivity and authenticity (Ohio State University, 2010; Reiber, 1996; Joffe & Wright, 1989; Churchill & Frankland, 1980).

Geography is unique among disciplines in its focus on the spatial aspects of physical processes and human actions and many geographic processes are dynamic. Thus, it is problematic to demonstrate several concepts in a traditional classroom setting using static media. The manipulation of geographic information by computer simulations of dynamic geographic processes can supplement Geography education at all levels of the curriculum. In addition, the use of computer aided instruction allows for decision making and interactive learning by the students (Johnson, 2007).

4.5. Establishment of computer simulations design appropriate for teaching the most difficult topic in Geography

Since the study had already identified the most difficult topic (section 4.3. of the study) in secondary school Geography as 'The earth and the solar system' and use of computer simulations as a remedial strategy (section 4.4. of the study), certain design considerations had to be underscored for the simulations software to be effective. As observed earlier, simulations offer the opportunity to learn in a relatively realistic problem-solving context, practise task performance without stress or danger, systematically explore both realistic and hypothetical situations, change the time-scale of events, interact with simplified versions of the process or system being simulated. In designing the software, features that help better learning of concepts need to be based on real events and data as very simplified representations may confuse learners. There should also be use of multiple representations, graphs and an opportunity to observe any graphs forming while the experiment is running (in real time). Also, there should be facilities to tailor activities to student ability levels and a narrative for students to follow.

There should also be due consideration for the underpinning learning theory, that is, the constructivist approach (Jackson, 2006). In this approach, a strong emphasis is placed on the learner as an active agent in the process of knowledge acquisition. Here, students construct their knowledge from individual and/or interpersonal experiences and from reasoning about these experiences (Jones, 1985).

Instructional design features included sequencing of increasingly complex problems to be solved, the availability of a range of help information on request, the presence of an expert troubleshooting module which can step in to provide critique on learner performance, suggestions on how to proceed, the option of having the expert module demonstrate optimal performance afterwards as well as the use of different ways of depicting the simulated system.

Other considerations were multiple views of the same model, multiple perspectives, qualitative descriptions of numeric relations, information on the epistemological qualities of the model, a demonstration mode in which no learner activity is involved, showing relations in the model in different ways (diagrams, functions), progressive implementation of models in increasing complexity of models by adding elements and relations, starting with the recall of prerequisite knowledge, working with a sub-model in a complex model, and offering domain information in a more direct instructional way (Darabi, Nelson & Seel, 2009). It was necessary to create a simulation model, a learner interface to the simulation, an instructional design of the environment, instructional interventions, as well as integrate the parts of the environment to a complete system.

The simulations software adapted from Microsoft Encarta Encyclopedia Standard 2005 (Microsoft Corporation, 2004), http://www.1994SolarEclipseAnimation.htm and Google search engine (http://www.google.com) had the following general system requirements: Windows 7, Windows Vista, Windows 98, Windows 2000 Professional SP3, Windows Millennium Edition, Windows XP, or Windows Server 2003 operating system; Minimum of 64 MB of RAM for Windows 98 and Windows Millennium Edition; Minimum of 128 MB of RAM for Windows 2000 Professional SP3, Windows XP, Windows Server 2003 or Windows 2007; Super VGA, 16-bit or higher monitor supporting 800 x 600 screen resolution; 4 MB or more of video memory; Microsoft Mouse, IntelliMouse, or compatible pointing device; 16-bit sound card with speakers or headphones; Internet Explorer 6.0 software or later (other default browsers can be used after installation); Multimedia PC with a Pentium 300-MHz or higher processor; up to 200 MB of available hard-disk space; DVD drive or Quad-speed (or faster) CD drive.

Encarta Encyclopedia Standard 2005 and Google earth incorporated a wide array of subjects and topics. In order to make it suitable to teach and learn selected topics in Geography, only relevant sections were included into the simulations program to optimize its use in relation to the study objectives. The pertinent scenes were written on a CD-ROM and used to teach the form three Geography students.

The package adapted software incorporated simulated scenarios relevant to the topic that allowed students to view various environments in such a way that they appeared authentic. For instance, questions relating to the composition of the solar system could be

got from the software segment showing the sun and all the planets in their respective positions with apparent movements as they would in real life as shown in Figure 6.

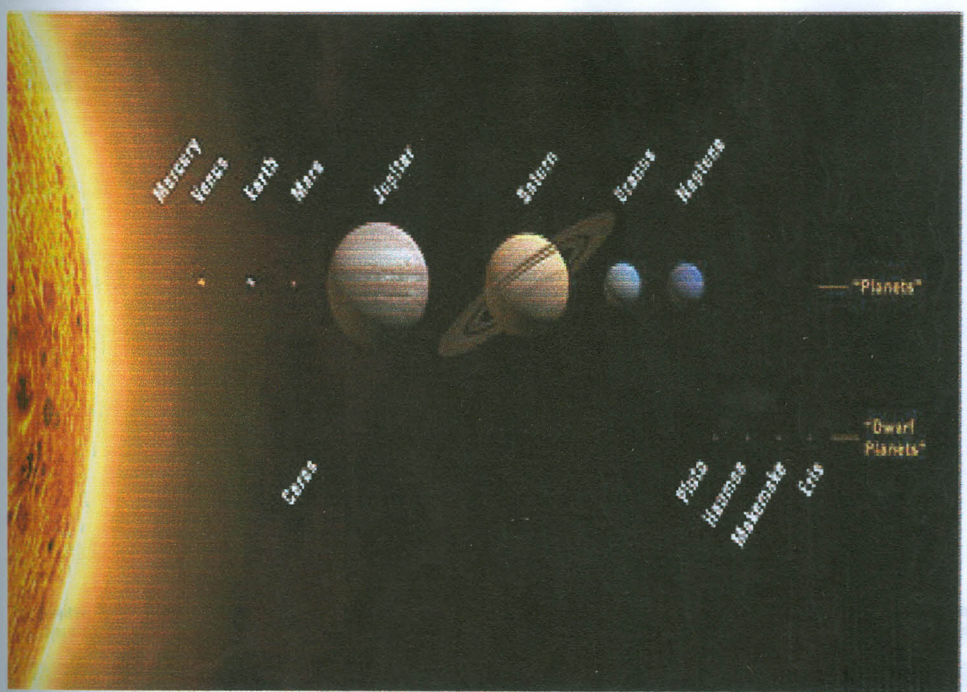

Figure 6. Screen shot illustrating composition of the solar system

The students were able to, by use a mouse, click each planet and be presented with corresponding textual information that would further explain the concept thereby making it easy to visualize and comprehend. This increased the level of interactivity.

In order to address the question on rotation of the earth as well as eclipses, the learners were presented with 3D scenes that depicted simulated environments of the earth, sun, moon and apparent movements reminiscent of authentic real life scenarios as shown in Figure 7.

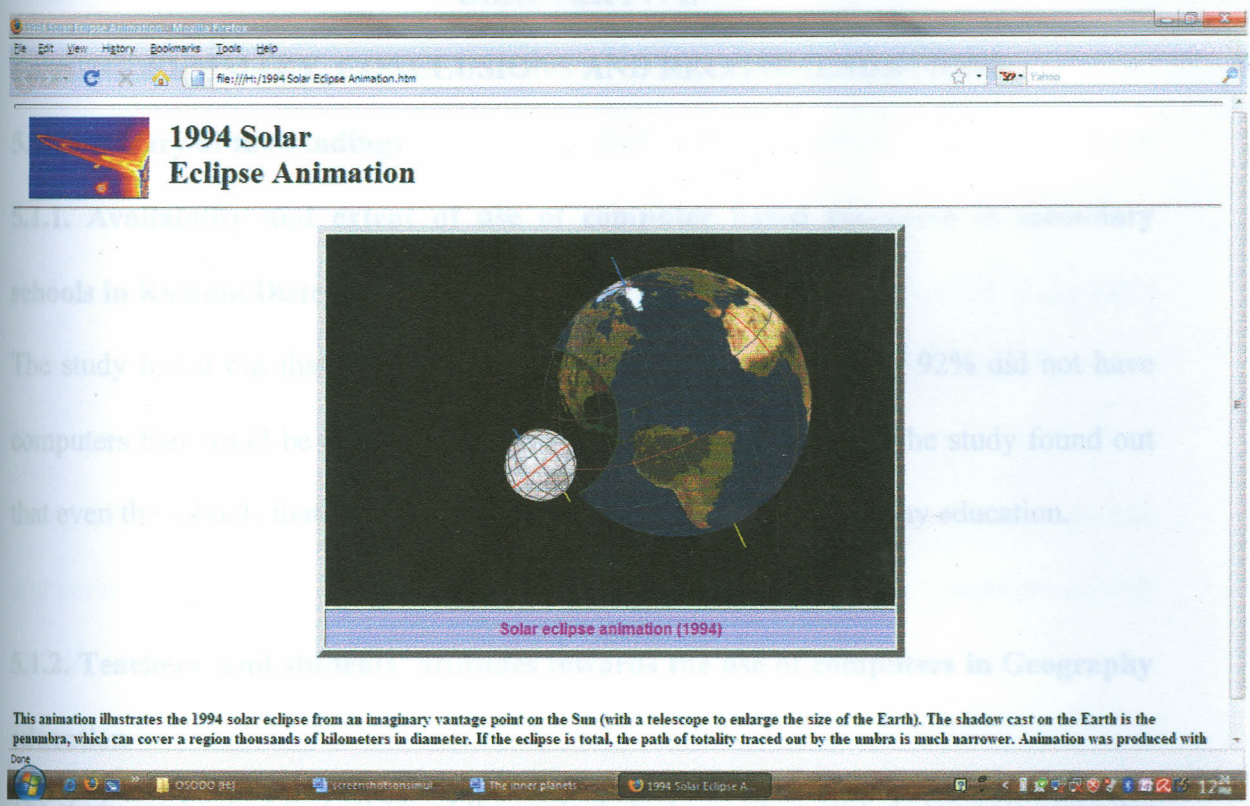

Figure 7. Screen shot illustrating animated solar eclipse

Consequently, the abstractness of the concept would be reduced or removed in such a way that the students would be able to perform better in the examination as opposed to their counterparts who did not learn using the simulations. Similar design considerations were given by Darabi, Nelson, & Seel, 2009; Jackson, 2006 and Gredler, 1992, 1990.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary of the Findings

5.1.1. Availability and extent of use of computer based resources in secondary schools in Kisumu District

The study found out that 8% of the schools had computers whereas 92% did not have computers that could be used for geography teaching and learning. The study found out that even the schools that had computers did not use them for geography education.

5.1.2. Teachers' and students' attitudes towards the use of computers in Geography education

The study established that 69.1% of the students had a positive attitude towards computer use in geography education and were convinced that computer technology in education would have a positive effect in their performance. 30.9% of the students had a negative attitude towards computer use and thought that it would not have a positive effect in their performance in Geography. Attitudes of geography teachers were also sought regarding the use of computers in teaching and learning. 18% of the 80 teachers said computers were not likely to have a positive effect whereas 82% said computers would have a positive effect in Geography education and would therefore recommend and support their integration in the Geography curriculum.

5.1.3. Cognitively difficult topics in Geography that may be taught through computer simulations

Relevant literature was reviewed to establish gaping misconceptions and inconsistencies the study sought to address. The literature review centered on various mediated and non-mediated practices revolving around media and methodologies used in geographic instruction and their effectiveness or lack of it. Specifically, review of related literature from the developed and developing countries on the use of computer simulations in Geography education was done. It also included basic tenets of constructivism and computer technology, general and exceptional educational benefits of computers as well as Computer Assisted Learning in Geography.

The objective of the third segment of this part of the study was to determine specific topics from the syllabus that learners found difficult to comprehend, and that teachers found difficult to teach or thought learners would have difficulties in comprehending. The difficult topics here identified would then be addressed by the design and use of a computer based simulations software. Out of all the 16 topics from the forms 1 to 3 Geography syllabus, the topic 'The earth and the solar system' was found to be the most difficult one with a mean rate of 4.767 of students and 4.725 of teachers saying it was very difficult. Both the students and teachers concurred that the topic 'The earth and the solar system' was the most difficult one out of the 16 possible topics in the form one to three Geography syllabus. These findings informed the design of the computer software that would consequently be used to teach the difficult topic.

5.1.4. The effect of computer simulations on students' performance in Geography

The fourth part of the study involved, after identification of the most difficult topic, testing the efficacy of the computer simulations software in assisting the students to comprehend the topics as well as aiding the teaching of the topics. It was established that the use of the simulations software concurrently with the traditional verbal expositions yielded positive results in the performance of learners in the hitherto difficult topic compared to the use of the traditional verbal expositions alone. After teaching the experimental group of students using both the traditional methods of teaching and computer simulations, 83% of them performed better in the topic 'The earth and the solar system' compared to 17% of the control group of students that was taught using the traditional methods only. The results therefore indicated that computer simulations were effective in teaching difficult topics in Geography and should be incorporated in to the secondary school Geography curriculum.

5.1.5. Design considerations for computer simulations appropriate to teach selected topics in Geography

The study found out that for a computer simulation to be effective in addressing difficult topics, due regard should be given to factors of design such as use of multiple representations, sequencing of increasingly complex problems to be solved, the availability of a range of help information on request as well as the underpinning learning theory, that is, the constructivist approach with emphasis on the learner as an active agent in the process of knowledge acquisition.

5.2. Conclusions

5.2.1. Availability and extent of use of computer based resources in secondary schools in Kisumu District

The study concluded that no school in Kisumu District had computers dedicated for teaching and learning Geography. The few schools that had computers did not use them for geography education. The extent of computer use in geography education in Kisumu District was therefore non existent.

5.2.2. The attitude of teachers and students' towards the use of computers in geography education

The study established that both geography teachers and students had a positive attitude towards the use of computer technology in teaching and learning. A super majority of teachers and students felt that the incorporation of computer simulations would be aid comprehension of difficult concepts in Geography. It could therefore be concluded that teachers and students of Kisumu district favoured the integration of computer simulations in to the Geography curriculum for the purpose of assisting teachers to teach difficult topics and learners to learn difficult topics.

5.2.3. Cognitively difficult topics in Geography that may be taught through computer simulations

The study established that there is geographic illiteracy among learners in secondary schools in Kisumu district, Kenya. Consequently, the performance of learners in Geography in secondary schools in Kisumu district was on the decline. The dwindling

performance in Geography was attributable to the fact that certain misconceptions and difficult topics abound and need to be addressed.

It was concluded that learners have problems in comprehending certain topics because of their abstract nature and that many teachers have a problem teaching certain abstract topics because of lack of knowledge on computer based resources or inconsistencies in their use. The study established that the most difficult topic for learners to comprehend and teachers to teach was 'The earth and the solar system'. Given that the study had observed that learners exhibited chronic deficiencies in comprehending certain topics in Geography, and, having identified the most difficult topic, it was obligatory to design a plan of remedial action.

5.2.4. The effect of computer simulations on students' performance in Geography

Computer simulations were established as vital in ameliorating the difficulties faced by learners in comprehension of difficult topics as well as the difficulties faced by teachers in teaching the difficult topics. The study concluded that computer simulations, used simultaneously with the traditional method of teaching (lectures) were very effective in teaching and learning difficult topics in Geography, as opposed to the use of traditional methods alone. Students who used simulations to learn difficult topics performed much better than their counterparts who did not use simulations. As such, the study concluded that computer simulations were very effective in teaching and learning difficult topics in Geography.

5.2.5. Design considerations of computer simulations appropriate to teach the most difficult topic in Geography

The study concluded that it was of necessity to consider sound educational practices and philosophies that underpin the use of interactive computer simulations, such as constructivism, and, relevant curriculum considerations. Design considerations for the simulations software to be considered ought to include friendliness in the user interface and ease of navigation, enhanced interaction and feedback mechanisms, multi-media approach, increasing levels of complexity, availability of a range of help information as well as multiple perspectives. The study concluded that a well designed computer simulations software would be effective in teaching and learning difficult topics in Gography.

5.3. Recommendations

5.3.1. Availability and extent of use of computer based resources in secondary schools in Kisumu District

Since it was established that hardly any schools owned and used computer technology for geography education, the study recommends computers and related accessories should be provided to schools that are not able to afford them. Sustainable computer projects should be initiated in schools.

The study also recommends that teachers should be trained on innovative uses of computers in teaching and learning so that they become competent in using them in teaching. Both pre and in-service teachers should be trained in computer literacy.

The government should also have clear guidelines regarding the design of standard curriculum focused educational software and make them available to schools for purposes of teaching and learning.

In line with the Government of Kenya (2005) Kisumu District Strategic Plan 2005, the government, in liaison with other stake-holders should implement policies relating to facilitation of universal access to ICT infrastructure, that is, power, equipment and improved connectivity, in all institutions of learning.

5.3.2. The attitude of teachers and students' towards the use of computers in Geography education

The study recommends that the government should give incentives to teachers and students who make significant efforts to learn and use computer technology in education. This would motivate the few teachers and students who were found to have a negative attitude towards the use of computers in teaching and learning.

5.3.3. Cognitively difficult topics in Geography that may be taught through computer simulations

The study recommends that geographic illiteracy among learners in secondary schools in Kisumu district need to be addressed by demystifying the subject. This would be done by the inclusion of computer simulations in to the curriculum to illustrate, demonstrate and

illuminate the abstract concepts. Both teachers and students should integrate the use of computer simulations in teaching and learning Geography.

There is need to train teachers on ingenious uses of computers such as use of educational simulations. This would consequently lead to improved standards of education. In-service computer courses and seminars or conferences should also be afforded to teachers already in the field so that teachers are enabled to make apt use of computer technology in education.

5.3.4. The effect of computer simulations on students' performance in Geography

The study recommends that computer simulations be integrated in to the Geography curriculum so that teachers and students can use if to teach and learn geography. Another implication of the study is that the application of computer based simulations software can be replicated to other subjects other than Geography. Even though the research was based on Geography, the technology and teaching modes can also be useful in the teaching and learning of other subjects and abstract topics which learners find difficult to learn and teachers find difficult to teach.

It is also recommended that the use of computer simulations to teach and learn difficult topics be supplemented by traditional teaching methodologies to exploit their maximum potential.

Computer literacy classes should also be introduced to students and teachers so that they may have adequate capacity for navigation, trouble-shooting and optimum machine-user interface.

5.3.5. Considerations for design of computer simulations appropriate to teach the most difficult topic in Geography

Endeavours towards design of computer simulations need to consider constructivism as the underpinning philosophy.

The study also recommends that the simulations software should consider interests of the learner, ease of navigation, incorporation of multimedia, graduation from simple to complex concepts.

It is recommended that suitable design considerations be calibrated in order to have an effective simulations software. Such considerations should include subject specificity, ease of operation, navigational and help concerns, interests and developmental stages of learners, feedback mechanisms as well as multi-media issues. The process of simulations design should involve the creation of a simulation model and learner interface, creation of an instructional design of the environment and instructional interventions as well as integration of the parts of the environment to a complete system. Other considerations include are goal, performance, target population analysis, task analysis, media selection, and cost analysis; interface design, sequencing, lesson design, and learner control; collaboration between programmers, graphic artists, writers and subject matter experts; and, implementation and evaluation goals such as delivering the final product to the learners and evaluating whether the goals were met. The resultant software should

provide motivation, reveal misconceptions that would inhibit learning, provide an organizing cognitive structure for receiving new material, serve as concrete examples of complex, abstract concepts, and have capabilities for scaffolding and meta-cognition.

5.4. Suggestions for Further Research

1. There is need to determine the influence of rural and urban environments on comprehension of abstract concepts mediated by simulations software.
2. A study should be carried out to determine the influence of the environment on the attitudes of teachers and students on use of computers in education.
3. A study should be carried out to determine the effect on gender on attitudes towards use of computer technology in Geography education.
4. It is also suggested that a computer simulations software be designed in line with the teachers' and learners' backgrounds and cultural orientations for teaching secondary school geography curriculum.