EFFECTS OF PHYSICAL AND VIRTUAL LABORATORIES ON LEARNING OUTCOMES IN GEOGRAPHY AMONG SENIOR SECONDARY SCHOOL STUDENTS IN NORTH CENTRAL NIGERIA

BY

USMAN, Hussaini
PhD/SSTE/2017/991

DEPARTMENT OF EDUCATIONAL TECHNOLOGY
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

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ABSTRACT

This study investigates the Effects of Physical and Virtual Laboratories on Learning outcomes in Geography among Senior Secondary School Students in North Central Nigeria. The study adopts a quasi-experimental research design. Nine research questions were answered, and nine hypotheses were tested in this study. The population of the study was made up of eight hundred and nineteen thousand nine hundred and eight (819,908) students in the Senior Secondary schools in North Central. Cluster sampling, purposive sampling and random sampling were used to select 768 students from twelve co-educational secondary schools in the North Central States of Nigeria that participated in the study. The schools were assigned to experimental groups; I, (Physical Laboratory), experimental group II (Virtual Laboratory) and Control Group (Lecture Method). A Geography Achievement Test (GAT) containing 30 – items covering topics in cross section, contour representation of land form and relief features in physical geography was used to collect data for both pre-tests, post-test and retention test, while Questionnaire on Attitude of students Towards Geography (QASG) was used for collecting data on attitude of students towards geography, experts validated the instruments. A Pearson product moment correlation and Crombach alpha formula were used to determine the reliability coefficient of GAT and QASG which yielded 0.76 and 0.70 respectively. The data were analyzed using descriptive statistics (mean and standard deviation), inferential statistics, analysis of variance (ANOVA), Analysis of Covariance (ANCOVA) and Sidak post hoc test was used. The hypotheses were tested at 0.05 level of significance. The results of the study revealed that there was significant difference in the achievement of the three groups ($F_{(2, 764)} = 1654.14$, $p < 0.05$). Also, there was significant difference in the mean retention scores of the three groups ($F_{(1, 264)} = 47.85$, $p < 0.05$). Therefore, it was recommended that Physical and virtual laboratories be embraced as teaching strategies for teaching geography concepts in our senior secondary schools because it has been proven to improve students' achievement in geography.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The revolution in technology has brought innovations into classroom teaching and learning. Technology usage in schools today has influenced the way educators plan, design instruction, and assess their students. Similarly, innovations in educational technology have changed systems of communication, learning resources, lesson ideas, professional development, learning productivity and creativity (Garrett, 2015; Falode *et al.*, 2016; Mohammed, 2017). In addition, Mahya (2017) revealed that with the increasing usage of modern technologies, students are becoming better and faster at using innovations.

The current trend among educational technologies has been on increase in their focus towards establishing the effects that technological tools may have on students' performance, both academically and behaviourally (Garrett, 2015). Even though specialised devices such as educational games, online simulations, and virtual learning environments have increased in education over the years, academic researchers need to understand better how these technological tools like virtual laboratories can affect learning (Mahya, 2017).

In specific terms, the applications of technologies such as interactive multimedia tools, virtual learning environments, animations, simulations, audio and their applications to delivery of instruction have grown tremendously over the past two decades. Interestingly, these tools are now proposed and used as instructional delivery models in various disciplines in our secondary schools (Sundara, 2013). Furthermore, Sundara (2013) opined that applying current technologies to deliver courses in the science disciplines requires a laboratory component to provide activity-based practices to the learner, ranging from Learning Management Systems (LMSs) to virtual avatars in digital games and virtual laboratories.

Significantly, physical and virtual laboratories allow learners to visualize, interact, and experiment with specific visual effects, such features they may not see in their traditional face-to-face environment in a science classroom (Trindale & Almeida 2002; Kotsilieris & Dimopoulou, 2013). Categorically, the physical laboratory has a central and distinctive role in science and technology education (Hofstein, 2015). According to Ratamun and Osman (2018), a physical laboratory is a setting using actual experimental equipment and materials and undergoing 'hands-on' activities where students hold and experience practical experiences like scientists. This type of laboratory makes it easy for students to change concepts from concrete to abstract and help them to connect the idea with the real world. It implies that a physical laboratory is a place of practical work activities where science students manipulate and observe objects and materials in science and technology.

Science and technology educators believe that physical laboratories are the most important instruction in science since the 19th century. For science to be taught effectively and adequately, physical laboratories must be an integral part of the science curriculum (National Science Teachers Association, 2009).

In addition, a physical laboratory is a workplace for scientific research; it is where a student develops scientific thinking, conducts scientific investigations, and obtain knowledge of physical principles and experimental techniques through the usage of equipment. At different levels of education, starting from senior secondary school to the university level, science laboratories are designed with specific goals, including enhancing the understanding of scientific concepts, interests and motivations, practical skills, and problem-solving abilities (Russell & Weaver, 2011). The role of the laboratory is central in secondary school Geography courses; students construct and develop a personal understanding of Geographic ideas. This type of knowledge is designed by students in interactions using experiments and practical skills. Meaningful learning will occur when laboratory activities become a well-integrated part of a learning sequence. In traditional laboratory experiments, students have direct physical involvement with laboratory materials to study the observable facts of the real world. Research and experience suggest that these laboratory activities promote optimal learning for students (Tracy, 2009; Garrett, 2015).

Physical laboratories have a long tradition within science classrooms, both within secondary and higher education settings. They have been used to assist students with any combination of the three major goals of science classrooms: learning science (developing conceptual knowledge), learning about science (building an understanding of the nature and methods of science), and doing science (engaging in the scientific inquiry) (Garrett, 2015).

Likewise, Hofstein (2015) defined physical laboratory activities as learning experiences in which students interact with materials or models to observe and understand the natural world. This assertion implies that to understand the nature of science, students ought to experience learning in laboratory settings where they can use tools as evidence to conclude the phenomena they observe. The practice of going through a well-designed laboratory enables students to appreciate the process of gaining knowledge by navigating through a series of steps and using the available tools to complete the given tasks. The process through which every researcher thrives in modern society is fundamentally based on making decisions. It is also important for every student to recognize the cause and effect relationship in communicating opinions that make science education a crucial part of any individual's educational experience (Marincola, 2006). For future generations to become independent thinkers, they need to think like scientists and understand how science functions as part of their daily lives. Using available science laboratory equipment to conduct an experiment and make sense of what the results mean allows students to view science and technology education as a process of learning and reflecting. Using laboratory equipment to conduct experiments allows students to gain the 21st-century skills necessary to become future problem solvers and active participants in society (National Science Teachers Association, 2009).

Science laboratories play a vital role in promoting positive attitudes toward science and enhancing students' interest in science as well (Luketic & Dolan, 2013). Although making science laboratories part of the everyday curriculum may sound appealing, many educators and practitioners face challenges when educational resources such as laboratory equipment become limited (Quigley, 2014).

Similarly, Garrett (2015), on the other hand, sees Physical laboratory environments, which consist of real-world materials and equipment, and computer simulations – digital, dynamic, interactive representations of phenomena or processes. Over the past few decades, several research studies have attempted to investigate the value of using physical laboratory environments and virtual laboratory environments within science classrooms to support students' conceptual understanding (Olympiou & Zacharia, 2012). Though much of the researches on physical and virtual science investigations have treated physical experimentations and computer simulations as competing methods in science classrooms (Jaakkola & Nurmi, 2008), recent research also showed that virtual and physical laboratories each has unique but somewhat overlapping affordances for learning, and several authors are beginning to suggest that a combination of physical and virtual laboratories should be considered in science classrooms (Olympiou & Zacharia, 2012)

A virtual laboratory is perceived by Falode (2014), Chaurura and Chuma (2015) as an interactive environment without real laboratory apparatuses meant for creating and conducting simulated experiments. Similarly, a Virtual laboratory is viewed by Ratamun and Osman (2018) as computer-assisted teaching through the integration of identified simulations with laboratory activities. The virtual laboratory can change abstract teaching into concrete, linking the concepts learned with everyday life, and students can learn at their own pace and needs. It is a tool that students can use to run their experiments using the mouse to control physical actions such as pushing objects, turning objects, lifting objects, changing tools or materials, measuring fabrics, and mixing two materials. Animation and simulation in a virtual laboratory allow students to interact with materials and apparatus to see the results of the reactions in an experiment. Given these, Virtual Laboratory enhances the interaction of teachers and students during an investigation and could also save the cost of doing experiments compared to physical Laboratory (Ismail, 2011). Hence, it provides students with tools and materials on a computer to perform experiments saved on CDs or websites (Nurmi, 2008; Babateen, 2011). An example of a virtual laboratory is a collection of digital simulations supported by discussion forums, video demonstrations, hyperlinked glossaries, and e-mail lists organized in a World Wide Web format or on a CD in a shell produced by an authoring language.

Falode (2014) categorized virtual laboratory into five enclaves based on different sorts of simulations. They are; classical simulations which have some aspects of laboratory experiments and are available locally (Simulations); classical simulations which have some aspects of laboratory experiments and are accessible on the web and are known as JAVA-Applets (Cyber Labs); simulations that attempt to represent laboratory experiments as closely as possible (Virtual Labs); simulations of lab experiments using virtual reality techniques (VR Labs); and real experiments which are controlled via the internet (Remote Labs).

The roles of virtual laboratory in the teaching and learning process cannot be over-emphasized. Therefore, Ay and Yilmaz (2015) opined that virtual experiments could be used in different contexts and steps to increase the accessibility of laboratory activities and to assist students who previously had no access to the physical laboratory. Such limits may emanate from a student’s reduced dexterity, physical disability, or geographic distance (Chaurura & Chuma 2015). The virtual laboratory makes students active in their learning, provides opportunities for students to construct and understand complex concepts more easily (Gambari *et al.*, 2012).

Furthermore, Physical and Virtual technologies combine physical objects, actions, and environments with digital representations, either through augmenting the physical world with virtual attributes or by augmenting a virtual environment with aspects of the physical world (Garrett, 2015). By integrating physical actions and objects with virtual representations of cotour, gradients, and cross-section in physical Geography, learning environments can expand upon the range of possible actions and sensory-motor experiences within the learning environment. Zufferey *et al.* (2009) and Lindgren and Johnson-Glenberg (2013) suggested that these innovative technologies can bridge the “abstraction gap” between everyday experience and abstract understanding by creating a controlled context for physical interaction with content from which abstract concepts can be built.

The use of both physical and virtual environments is helpful in Geography contexts, where the virtual representations can shape how students interpret the physical world. The virtual laboratory approach has assisted in the development of a particular type of interactive animation and computer simulations, especially in the field of Geography in secondary schools.

Geography is viewed by Iwena, (2017) as the study of people, their activities, place, and physical things within the earth. Analysts in Geography still concentrate on people, culture, and planet earth. The earth elements are the area physical geographers, and their work incorporates research about atmospheres, arrangement of area structures, plant and animal dispersion.

Geography has application in different endeavours; geographers organize new groups, choose where new high ways should be, set up migration plans. New nation-states formed, disasters strike populated territories, environmental change, and the internet bring many persons closer together. There is continually something new to research in Geography. On this note, Rosenberg (2014) further asserted that investigating geographical features allows students to comprehend the world in which they live.

Geography has continued to play a significant role in national development. It is taught in schools to offer learners a sound knowledge of their immediate environment and develop the ability to comprehend and give details of natural occurrences. Obondo *et al.* (2013) opined that Geography is a subject that develops learners' critical thinking ability and understands spatial relationships among various features on the earth's surface, most notably in problem-solving and further prediction of the environmental phenomenon.

Today, more than ever, various fields of knowledge are dependent on Geography for solving problems and predicting the outcome of our environment. Cochran *et al.* (2015) opined that it is the science of place and space; as such, it emphasizes where things are situated on the surface of the earth, why they are located where they are, how locations vary from one another, and how people relate with the environment. Also, Geography is exclusive in linking the social sciences (Human Geography) with the natural sciences (Physical Geography).

Rosenberg (2014) noted that hardly any aspect of our lives is not affected, often in an ultimate and far-reaching way, by the product of Geography. When one thinks of the environment, the climate, the land forms, plant and animal distribution, and the impact of the environment on our lives, one realizes that we are, in fact, in a "Geographical universe. The National Policy on Education (FRN, 2009) described Geography as one of the elective subjects in the school curriculum.

The Nigerian Educational System has reliably under-gone sweeping changes. The old educational program was enhanced in nature, emphasis was put on Science, Pre-Vocational and Performance based learning, these progressions manifest in the introduction of the 6-3-3-4 organisation of education. Sofowora and Agbedokun (2010), revealed that the recent reorganization and the improvement of the Geography educational module and recent appropriation of the new 6-3-9 system of education at the Senior Secondary levels are extremely remarkable parts of these changes, resulting from these, educators are not more concerned simply with turning out students who are stacked with certainties and wordings in Geography (Sofowora & Agbedokun, 2010).

Today, the educational program had changed, it has turned into a matter of examination, enquiry and experiential. Emphasis was not laid on the importance of Geography to life and that is why unlike other core science subject like physics, chemistry and biology, geography is not taught at the junior secondary school. Also, emphasis was not placed to the use of geography laboratories in our secondary schools as it was the case in natural science subjects. The aspect the school proprietors and government consider important in the teaching of geography in the past was emphasis on geographical garden where instrument such as the wind vane, rain gauge, Thermometer were usually found.

The modern trend in the teaching of the natural science with the emphasis on the use of the ICT-based tools and strategies such as physical and virtual laboratories has actually proved that other allied science disciplines such as Geography could also be better taught by adopting or and adapting same strategies. The introduction of such discipline as Geophysics has moved Geography from ambivalent field of study to science.

It is observed that in our secondary schools there is almost non-existence of Geography Laboratory, even if it exists in some schools they are not adequately maintained and equipped. All these call for seeking an alternative means through which Geography should be taught. At senior secondary schools, students are given choice to study Geography as a core subject (FRN, 2009). Geography is one of the science subjects taught at the senior secondary school level of education in Nigeria. The importance of Geography and geographic studies cannot be over emphasised (Aderogba, 2005; Fellmnan *et al.*, 2005; Aderogba & Ogunnowo, 2010). Aside from it being offered at the SSS for Senior Secondary School Certificate Examination, it is a subject taught at the tertiary level and it links with a few other school subjects to make individual an expert. The West African School Certificate Examination Council (WAEC) has been assessing its syllabi over the course of the years to reflect contemporary issues, react to open issues and adjust to realities of time (Aderogba & Ogunnowo, 2010). The National Examination Council (NECO, 2004) likewise prepared its syllabus nearly to the

WAEC's which shows areas of interest of Geography syllabus as provided by the two national examination bodies and actualized by schools and universities.

The breakdown of the content of Geography syllabus is grouped into four areas specifically: Elements of Practical Geography (Map Work); Physical Geography; Human Geography; Regional Geography (Sofowora & Agbedokun, 2010). Geography is the study of man-environment relationship; (Hansen, *et al.,* 2007). The primary objectives of Geography education to provide insights into the relationship between common conditions and social activities in distinctive parts of the world and to show a related spatially-arranged ability that can be applied (Hemmer & Hemmer 2017). In accordance with these aims, students of Geography have the ability to perceive collaborations in relationship between the nature and society (economy, governmental issues, and social perspectives) taking into account various regional examples, they can likewise figure out how to comprehend the subsequent structures, procedures and issues included with these associations and to consider answers for these issues. To this end, a comprehension of the Earth as a framework is essential which is the different characteristic frameworks and subsystems of the geosphere.

Hemmer and Hemmer (2017) further found that Geography is centralizing a subject for all parts of geosciences relevant to schools which can improve comprehension of social frameworks in their fundamental spatially applicable essential structures. With this general geographical approach, Geography lessons make an exceptional commitment to the consolation of multi-viewpoint, systematic and critical thinking consideration. Students along these lines secure spatial orientation skills, and additionally examine areas of the Earth at distinctive scales for example, their country and different spots from alternate points of view and as to different issues (Hemmer & Hemmer 2017). Hence, students have the opportunity to be acquainted with various traditional and computerized media subsequently securing a methodological skill that is crucial for self-decided learning, field outings, and projects makes conceivable the consideration of reality outside of school and students own dynamic encounters. Furthermore, it was included that Geography as a school subject makes a significant contribution to interdisciplinary and co-operative assignments in education. Besides, Students gain from examples of numerous ecological subjects, both at home and far away. Hemmer and Hemmer (2017), observed education in development policy and intercultural learning as relevant aspects of Geography teaching in schools. By considering nature, economics, political and social interaction, students acquire important competences in these areas. Because of its contents and importance, Geography is mainly committed to education for sustainable improvement as well as to Global Learning. The aims, methods and contents of map reading which is an aspect of physical Geography creates the foundations for connectible vocational education in many professional areas for example, in planning, environmental protection, tourism and public and private economic development. Iwena (2017), revealed that the idea was intended to contextualize learning, connect regular encounters to the classroom, and raise the familiarity with traditional African sensibilities among students.

Even though, geography play a vital role in contemporary society; more emphasis is placed on Science, Vocational and trade subjects, these progressions manifest in the introduction of the 6-3-9 system of education for instance, in the present Nigeria educational system, Geography is one of the subjects required for admission in environmental-related courses in our institutions of higher learning yet it is not offered at the junior classes in our secondary schools. It is in the realization of its essential role that many countries now resorted to making special comprehensive and well-programmed efforts toward the effective teaching and learning of Geography at various levels of the educational system through the development and implementation of innovative programs and projects (Tasiu, 2012). As geography laboratories allow learners to visualize, interact, and experiment with specific visual effects in Geography, both physical and virtual laboratories will significantly enhance learning outcomes.

Learning outcomes in this study entails students' academic achievement, attitude and retention. Achievement is, thus, the outcome of students' results in subjects taken in a particular situation. Despite efforts put by teachers to effectively teach Geography in secondary schools, the result from the performance in senior secondary examination is not satisfactory. Obondo *et al.* (2013) revealed that prevailing poor achievement by students in Geography is as a result of misinterpretations they hold about a few topics in Geography and instructional mode. Obondo *et al.* (2013) concluded that general utilization of lecture method and integration of recent technological inventions in teaching alleviated the circumstance of low enrolment and adjusted to expect national quality and standard in Geography.

Also, secondary school students complained about Geography, especially; its physical aspect as complex. Therefore, some components such as physical geography remain challenging to instructors as students do not score well in such components (Obondo *et al*., 2013). It means that the basic foundation of Geography is very weak, which is carried forward to the final class, which has led to poor academic performance in Senior Secondary School Certificate Examination (SSCE), West African Examinations Council (WAEC), and National Examinations Council (NECO).

The table in (Appendix B, page 206) illustrates the chief examiners' report for both WAEC and NECO. The record is specifically the chief examiner report released by both the National Examinations Council and West African Examination Council (NECO 2005-2010, WAEC 2008-2018) depicting candidates' areas of weaknesses in Geography. Also, the analysis of results in (Appendix C; Page 207) released by WAEC between 2003-2013 revealed fluctuation in the number of passes in the Geography Examinations within these periods.

Many researchers have come up with practical reasons on the causes of students' poor achievement in secondary school Geography. For instance, Sofowora and Agbedokun (2010), Obondo *et al.* (2013), NECO 2009-2010 observed that the study of Geography from its inception was through oral explanation of geographic features, which made the lesson very theoretical and quite tedious. Also, the undue emphasis on the theoretical aspect of Geography to the detriment of scientific and experiential approach had made the subject very unclear and boring such that the subject is somewhat abstract, particularly among students at secondary school level in Nigeria. Geography seems to be the most challenging subject to teach. As put forward by Sofowora and Agbedokun (2010), some of the reasons are the nature of the subject and how the subject is taught. It is believed that Geography is taught in a way that discourages open questions, inquiry, and active participation.

The resultant effect of all the above is that the subject no longer attracts young students due to the dull, uninspiring, and stereotyped approaches adopted (Sofowora & Agbedokun, 2010). Similarly, the immediate effect of utilizing the lecture method on learners regularly prompts the absence of comprehension, which may bring about poor achievement and low enrollment of students in Geography (Onasanya *et al.*,2003). Also the chief examiners' report of National Examination Council (NECO) observed that the problems affecting achievement in Geography can be attributed to lack of qualified teachers to handle the subject. This has resulted to poor teaching delivery method of presenting the content of the curriculum to students and, non-availability of facilities (NECO Chief Examiners' Report, 2010).

Consequently, Sofowora and Egbedokun (2013) advocated for a change in instructional delivery modes. Physical and virtual laboratories as modes of instruction may be of paramount importance in teaching Geography in Nigerian schools. Because of these, a lot of studies have been carried out with respect to the use of laboratory approach; the approach is regarded as an indispensable element of education, students subjected to laboratory instruction exhibit higher achievement scores, deeper attention, and more frequent participation in science courses (Gunes *et al.*, 2011).

Ho (2009); Falode (2014) suggested that one way to bring about more practical change in the attitude of learners to science subject is by using student-centered approach through the integration of computer technology approach to teaching and learning process. These approaches can bring about positive attitudinal change and retention of Geography concepts.

According to Obi *et al.* (2014), retention is the ability to recall things. In confirmation of this, Akor (2017) stressed that among the features of retention closely associated with achievement are the power to remember (memorize) and identify. Memory, in this case, is the ability to recollect an impression of past experiences. Akor (2017) further categorizes memory based on how learning took place and retrieval of learned items. In continuation of this, Iji (2010) emphasizes the fact that man is gifted with restricted ability for memorizing and to efficiently and adequately apply all that he has learned for which retention must have come to play an important role, Furthermore, Gana (2013) and Ismail (2015) describe retention as a preservative factor of the mind and a repeat of performance of a task of learned behaviour earlier acquired. Modern studies on the effects of an instructional package on students' retention indicated that instructional package enhances the retention of students as compared to the lecture method of instruction (Ismail, 2015). Given these, Hussaini and Ali (2012) revealed that students' long-term retention of concepts reported that 67 % observed after 12 months of using recent technologies. Similarly, Akengin (2011) noted a mean difference in retention scores between the group of students taught with modern technologies and those instructed with conventional methods.

Consequent to the above assertion much needs to be done because knowledge retention is an essential ingredient of learning. Several factors are responsible for adequate retention of learned materials, according to Ismail (2015). These include manipulation of the learning tool and the instructional method adopted. Research evidence continues to accumulate in support of the idea that students' visual learning and active involvement in the lesson could be more powerful than verbal communication alone (Yisa, 2014). Despite the above statements, much need to be done by making learning more interactive to the students using various interactive packages; this could, in turn, enhance the attitude of secondary school students towards geography.

Attitudes in the teaching and learning process are enduring positive or negative assessments, sincere feelings, and tendencies regarding social objects. The attitude was also a settled behaviour or acting, representing feeling or opinion. It refers to a certain predisposition to act or react positively or negatively towards certain situations and ideas (Issa *et al.,* 2013).

Attitude likewise represents an individual level of preferences or aversions for something. That is why attitude towards a subject will enormously influence a person's engagement; due to the rapid changes in science and technology in today’s world, new methods, and techniques needed for science teaching. An essential teaching technique is experimental techniques. This technique involves all the senses and enables learning to be more meaningful. This technique will be more effective if students’ attitude towards science is more positive. The use of laboratories in experimental techniques have led to more outstanding achievement and sincerely improve students’ attitudes toward science subject, as lab experiments have a big role in education by providing a genuine interactive model for students. (Ratamun & Osman (2018).

Information on whether students' attitude towards science improves students’ academic achievement is less clear based on the controversial findings from the literature. Nicolaidou and Philippou (2003) observed that a learner developed a positive attitude towards science subjects during the first time in school, yet, as they advance, their attitudes assume less positive and frequently become negative at high school. Negative attitudes are the outcome of regular and recurrent challenges when addressing tasks, and these might become somewhat steady if measures are not taken (Petty, 2018). Many circumstances explain why learners’ attitude to science turns out to be negative with the school grade. The reasons include; the tension to perform excellently, over-demanding tasks, uninteresting lessons, and less positive attitudes on the part of teachers (Nicolaidou & Philippou, 2003).

Bowen and Richman (2007) conceptualized an attitude as a mix of an individual's surveyed decision around a given element. The relationship between attitude and achievement as viewed by Bowen and Richman (2007) found in the theory of reasoned action. According to the theory, when individuals are positively disposed to an object or conduct referred to, they can take up the item or behaviour. Similarly buttressed by

Nwagbo (2018), the advancement of the right mentality to learning by both male and female students is pivotal to achieving good academic achievement in science subjects at senior secondary school.

One of the most recurring issues among educators, especially science educators and society, is gender equity or gender friendliness in teaching and learning (Ismail 2015). Gender is an attribute that affects students' achievement in science subjects at senior secondary school (Gambari, 2010). The issue of students' achievement as a cause of the discrepancy in learning outcome has drawn the attention of educational researchers. It is a common attribute in most educational settings to find students of mixed academic aptitude given the same treatment. Gender issues always had link with students' performance in an academic task in several studies, some of which are those conducted by Ismail (2015) but without any definite conclusion. This trend of gender imbalances in academic achievement and retention necessitates more work.

In view of the above, the sole interest of researchers is the usual gender differences and -their impact on several phases of human activities (Dangpe, 2015). The findings of Yusuf and Onasanya (2004); Ajai and Imoko (2015) show significant differences in academic achievement based on gender, while other results indicated that gender factors did not affect students' academic achievements. Ifamuyiwa (2004), Preckel *et al.* (2008), Kovas *et al.* (2015), and Musa *et al.* (2016) in their separate researches show that male students outperform their female counterparts in science-related subjects at secondary school level. In contrast, Olson (2002), Gimba (2003), Anagboju and Ezehiora (2007), and Contini *et al*. (2016) noted that female students outperformed their male partners. Other researches such as Orabi (2007), Iwendi and Oyedum (2014), Egorova (2016) revealed no gender differences in achievement of males and females in mathematics and science subjects. However, on a larger scale, research such as Trends in International Mathematics and Science Study (TIMSS) has found that "there were no gender differences in 22 of the 42 countries that tested at Year 8, including Australia" (Thomson *et al.* 2012). For these reasons, there is a need to investigate gender differences in the Nigerian school context. Based on the present trend in the world and attention given to gender matters in the millennium statement of September 2000 (United Nations, 2000), which has it as its aims, the advancement of gender equity, women empowerment, and the eradication of gender disparity in elementary and secondary education and at entire levels by 2015 with a view of suggesting possible intervention strategies.

All together call for seeking a substitute through which Geography should be taught, in light of these, this study investigated the effects of physical and virtual laboratories on learning outcomes in Geography among senior secondary school students in North Central Nigeria.

1.2 Statement of the Research Problem

Geography as one of the central subjects for all components of geosciences and a requirement for admission into environmental-related courses in our institutions of higher learning, students' achievement is unsatisfactory. Previous researches by Falode *et al*. (2015); Falode *et al*. (2016); Amosun (2016); Eze (2020) pertaining students' outcomes in Geography have indicated the undeserving, poor, and discouraging performance of Nigerian secondary school students.

Following this assertion, the researcher projected that among other factors responsible for the trend of students' unsatisfactory performance in West Africa Examination Council (WAEC) to be the teaching methodology, as substantiated by Odili (2006); Idoko (2009). West Africa Examination Council Chief Examiner's report in (2008), (2010), (2013), and (2018) had linked students' failure in geography to an inadequate explanation of points, inadequate preparation, poor presentation of geographic features. As presented by the report, other factors leading to failure in geography include an ineffective description of concepts required to be taught practically, making its concepts highly theoretical and difficult for the students to comprehend. Similarly, Sofowora and Agbedokun (2010) observed that the study of Geography from its inception was through a verbal description of geographical features, which made the lesson very abstract and relatively uninteresting.

unlike other core science subject like physics, chemistry and biology, geography is not taught at the junior secondary school level and that is why students found it difficult to comprehend making it an abstract subject at senior secondary classes. Again, emphasis was not placed to the use of geography laboratories in our secondary schools as it was the case in natural science subjects. The aspect the school proprietors and government consider important in the teaching of geography in the past was emphasis on geographical garden where instrument such as the wind vane, rain gauge, thermometer were usually found. The modern trend in the teaching of the natural science with the emphasis on the use of the ICT-based tools and strategies such as computer simulation, animation and virtual laboratories has actually proved that other allied science disciplines such as Geography could also be better taught by adopting or and adapting same strategies. The introduction of such discipline as Geophysics has moved Geography from ambivalent field of study to science.

It is also observed that in our secondary schools there is almost non-existence of Geography Laboratory, even if it exists in some schools they are not adequately maintained and equipped. All these call for seeking an alternative means through which Geography should be taught.

This has become a source of concern to all stakeholders in Nigerian education system, as most teachers in Nigeria that teach Geography particularly, Physical aspect of Geography across secondary school stages, (SS I to S,S III) have decried less emphasis and the effectiveness of methods used in the teaching and learning of the subject (Sofowora & Agbedokun, 2010). Those who teach topics like urban and regional planning and environmental studies that require the application of Geography also complained of the challenges they face. As stated in the NECO Chief Examiners Report of 2009, one of such challenges was the method and little knowledge of the content of the Geography syllabus and general phobia for questions that require diagrams, sketches, and charts in the physical aspect of Geography.

Also, the undue emphasis on the theoretical aspect of Geography to the detriment of the scientific and experiential approach had made the subject unclear and uninteresting. Of all the subjects in the school curriculum at the secondary level in Nigeria, Geography seems to be a complex subject to teach. Some of the reasons for these are the nature of the subject and how it is taught. The common method of teaching Geography is the lecture method. The approach contradicts the provision of the new education policy because students cannot discover facts for themselves, and they are not motivated to be creative and active.

Despite the widespread application of various effective interactive strategies like simulation and animation packages to improve classroom instruction in Nigeria, the trend persisted. Following these, Literature appeared to prove that there has been insufficient research that specifically examines the effects of Physical and Virtual Laboratories on learning outcomes in Geography among senior secondary school students in North Central Nigeria. Consequently, to the researcher’s knowledge, from the reviewed work, none of the studies seek to address the issue of contour representation of landforms, cross-section, and relief features in Physical Geography in North Central Nigeria. Therefore, to address these problems, a more interactive strategy that will actively involve the students in the Geography lesson becomes imperative.

Hence, the strategy that might salvage the situation may be the use of physical and virtual laboratories. Therefore, the study investigates the effects of Physical and Virtual Laboratories on learning outcomes in Geography among senior secondary school students in North Central, Nigeria.

1.3 Aim and Objectives of the Study

This study aims to determine the effects of Physical and Virtual Laboratories on learning outcomes in Geography among senior secondary school students in North-Central, Nigeria. Specifically, the study intends to achieve the following objectives;

1. Determine the effects of physical laboratory (PL), virtual laboratory (VL) and lecture method (LM) on the achievement of secondary school students in geography.
2. Examine the influence of gender on the academic achievement of students in geography when taught using physical laboratory.
3. Investigate the influence of gender on the academic achievement of students in geography when taught using virtual laboratory.
4. Determine the effects of physical laboratory, virtual laboratory and lecture method on students' retention in Geography.
5. Find out the influence of gender on the retention scores of students taught Geography when exposed to physical laboratory.
6. Find out the influence of gender on the retention scores of students taught Geography when exposed to virtual laboratory.

7. Determine the attitude of secondary school Geography students taught using physical laboratory, virtual laboratory and those taught with lecture method.
8. Find out whether gender influences the attitude of Geography students towards geography after being exposed to physical laboratory.
9. Find out whether gender influences the attitude of Geography students towards geography after being exposed to virtual laboratory

1.4 Research Questions

The following research questions were raised for the study.

1. Is there any difference in the mean achievement scores of Geography students taught using physical laboratory, virtual laboratory, and those taught with lecture method?
2. Is there any difference in the mean achievement scores of male and female Geography students taught Geography using a physical laboratory?
3. Is there any difference in the mean achievement scores of male and female Geography students taught Geography using virtual laboratory?
4. What is the difference in the mean retention scores of students taught Geography using physical laboratory, virtual laboratory, and lecture method?
5. Could there be any difference in the mean retention scores of male and female students taught Geography using physical laboratory?
6. Could there be any difference in the mean retention scores of male and female students taught Geography using virtual laboratory?
7. What is the difference in the mean attitude score of Geography students taught using physical laboratory, virtual laboratory and those taught with lecture method?

8. Would there be any difference in the mean attitude scores of male and female students to Geography after being taught using physical laboratory?
9. Would there be any difference in the mean attitude scores of male and female students to Geography after being taught using virtual laboratory?

1.5 Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 alpha level of significance.

HO_1: There is no significant difference in the mean achievement scores of Geography Students taught using physical laboratory, virtual laboratory and those taught with lecture method.

HO_2: There is no significant difference in the mean achievement scores of male and female students taught Geography using physical laboratory.

HO_3: There is no significant difference in the mean achievement scores of male and female students taught Geography using virtual laboratory.

HO_4: There is no significant difference in the mean retention score of Geography student after being taught using physical laboratory, virtual laboratory and lecture method.

HO_5: There is no significant difference in the mean retention score of male and female Geography student taught using physical laboratory.

HO_6: There is no significant difference in the mean retention score of male and female Geography student taught using virtual laboratory.

HO_7: There is no significant difference in the mean attitude scores of students towards Geography after being taught using physical laboratory, virtual laboratory and those taught with lecture method.

HO_8: There is no significant difference in the mean attitude scores of male and female students towards Geography after being taught using physical laboratory.

HO_9: There is no significant difference in the mean attitude scores of male and female students towards Geography after being taught using virtual laboratory.

1.6 Significance of the Study

The findings of this research will be of immense benefit to the following group of people; Students, Teachers, Educational Administrators, Parents, Researchers, Curriculum planers, Educational Technologists, Non-Governmental Organizations (NGO's), amongst others,

The study will enable students to learn and build their knowledge structures by investigating and discovering since learning through virtual laboratories (VL) and Physical Laboratories (PL) are student-centred and participatory. The use of the above strategies will also make learning authentic, concrete and develop the students in practising the basic needed skills in learning geography and learning at their own pace and time. The development and construction of VL and PL can make students develop a positive attitude towards Geography and creative skills in manipulating computers and inculcate the behavioural intention to study Geography and Geography related courses in tertiary institutions of learning.

Also, the result will be beneficial to students by exposing them to better learning strategies that will improve understanding of difficult concepts in Geography. This shall improve their academic achievement in the subject and also enhance students' interest in Geography. The VL will readily be available and affordable to the learners, thus enabling them to learn individually or collectively.

Geography teachers in all Secondary Schools will see the need for and appreciate favourable teaching strategies like physical and virtual laboratory and use them for the classroom instructions to promote and enhance active involvement of students and provide opportunities for learners to understand difficult and abstract concepts in Geography. This would assist in reducing the misconceptions already formed by students that Geography is a difficult subject as stated in the waec chief examiner report. The training of the teachers by the researchers may impact positively on the capacity building of teachers and therefore encourage them as depicted by physical and virtual laboratories. Geography teachers will be more resourceful in making use of innovative media instructional delivery which may lead to students' achievement, attitude, and intention to pursue Geography and Geography related courses in higher institutions of learning.

The findings of this research will assist the education administrators to provide in-service training for their teachers to make them more effective and efficient in knowledge transmission to the learners which may enhance students' performance in Geography. Non-governmental organizations (NGOs) will see the relevance of this research and be able to provide assistance to the schools by retraining teachers on development of VL packages and the need for other instructional materials to promote learning in schools and thus, the problem of poor performance will be reduced.

To the researchers, the findings of this research would be expected to serve as a reference to science and technology educators and Geography education researchers. This study could provide useful information upon which future research studies in PL and VL and other teaching strategies can be based. It may provide practical evidence in their search for further research studies in other interactive teaching and learning strategies.

The results of this research may also serve as a guide to policy makers such as Joint Consultative Council on Education (JCCE), National Council on Education (NCE), and National Commission for Colleges of Education (2009) and National Universities Commission (NUC) including stakeholders on the implementation of proper multimedia instruction policy particularly at the secondary school level. It is hoped that the results will also enable the government and educational authorities to be conscious of the need to sponsor Geography teachers for training in the application of multimedia for teaching and learning in order to enhance their skills in the use of instructional equipment and materials. This therefore, will enable the government to appreciate the need to provide instructional materials, such as simulation instructional packages for teaching and learning Geography in schools. The research results will among others enable the curriculum planners to be guided during reviews of Geography curriculum in order to make provision for multimedia based curriculum.

Parents, through Parent Teachers Association (PTA) and non-governmental organization will be able to buy relevant books and multimedia packages that illustrate important concepts in Geography and also assist the government in providing good study environment for students through self-help efforts.

To the government, the research may be of enormous help because the result that will be obtained from this study will assist both the Federal and State Ministry of Education to plan policies that will make the study of computer science compulsory right from primary school level through secondary to tertiary levels in order to achieve scientific and technological advancement through science and technology.

Again, the study will keep the developers of curriculum abreast with the current pedagogical instructional needs of the learners which include knowledge acquisition through scientific and technological tools, thereby introducing computer innovative programs in schools so that the application of ICT becomes the media for instruction in the classrooms.

To the nation, the findings of the study will be of great importance in the equipping students and teachers with current technology in the aspect physical geography in order for them to meet up with the challenges of teaching difficult concept in physical geography in Nigerian schools in the current dispensation. This study may also serve as the hallmark for future educators, scientists and technologists who will be interested in conducting similar studies in other spheres of knowledge.

The package will be uploaded CD and be distributed among the schools in the zone to enable teachers have access to it and further create awareness on the need to inculcate the physical and virtual laboratory strategies into the teaching and learning of physical geography. Also, the instructional technology designers, and evaluators, educational media centres, educational resource centres will be in a better position to purchase and keep VL and PL as exhibition materials in the educational media centres.

Finally, the findings will add to the already existing literature on the effects of physical and virtual laboratories on learning outcomes in geography among senior secondary school students in North Central Nigeria thereby assisting upcoming researchers.

1.7 Scope of the Study

The study was carried out to investigate the effects of Physical and Virtual Laboratories on learning outcomes in Geography among Senior Secondary School Students in North Central Nigeria.

The zone is made up of Niger, Kwara, Kogi, Benue, Plateau, Nasarawa states and the Federal Capital territory (FCT). Twelve co-educational public Senior Secondary Schools were used (four from each state). Senior secondary school (SSII) students were used for the study; the aspect of Geography concepts focused were regarded as difficult and falls under the SSII syllabus and scheme of work (WAEC Chief Examiner Report, 2011-2014).

The Geography topics treated include contour representation of land forms, cross section and relief features. The variable scope of the study is achievement, retention and attitude while gender is the moderating variable. The study lasted for twelve weeks.

1.8 Basic Assumptions of the Study

The fundamental assumptions underlying this study are:

1. The teaching strategies mostly used by Geography teachers in secondary schools in North-central zone of Nigeria may be the conventional methods characterised by the teacher- centred approach and the students' little or no contributions.
2. Instructional materials may be rarely used in the teaching and learning of Geography in secondary schools in the North-central zone of Nigeria.
3. Physical and virtual laboratories may not have been used in teaching and learning process in the selected schools.

Therefore, it becomes important to carry out a study investigating effects of physical and virtual laboratories on learning outcomes in geography among senior secondary school students in North- central Nigeria.

1.9 Operational Definition of Terms

The following terms were operationally defined as used in the study:

Achievement: Notable change in geography students' performance resulting from their exposure to the teaching strategies.

Attitude: Settled behaviour or manner of acting, as representation of opinion or feelings in Geography lesson.

Contour: These are lines drawn to join places of equal height to create and conduct simulated and real geography experiment in the physical and virtual laboratories.

Cross section: it is a practice whereby relief shown by contours on the map are drawn to bring out the real appearance of such relief as it is on the ground when conducting geography experiment in the physical and virtual laboratories.

Gradient: Is the slope of the ground expressed as a ratio between height and the length of the ground in the process of carrying out an experiment to the groups.

Lecture Method: the control group classes where traditional instruction was administered during the study.

Physical laboratory: Is known as a place of practical work activities where geography students manipulate and observe objects and materials in geography laboratory.

Relief: Refer to the position and the character of the highlands and lowlands in geography lesson

Slope: A Non-flat area of ground that tends upward or downward during physical geography lesson

Valley: refers to low land between two highlands in geography experiment

Virtual laboratory: An collaborative geography setting or a platform without real laboratory apparatuses meant for creating and conducting simulated practical geography experiments.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The concepts of virtual laboratory and simulation

Virtual laboratory is an interactive environment without real laboratory apparatus meant for creating and conducting simulated experiments (Falode 2014). It provides students with tools, materials and lab sets on computer in order to perform experiments saved on CDs or on web site (Babateen, 2011). Virtual laboratory is a computer-based learning environment where individuals are able to simulate experiments completed in a traditional laboratory. In other words, virtual laboratory is simulated versions of the hands-on laboratory. In science and engineering education, virtual laboratories have emerged as alternative or complementary tools of the hands-on laboratory education (Mahmoud & Zoltan, 2009).

Virtual laboratory uses the power of computerized models and simulations as well as varieties of other instructional technologies to replace face-to- face laboratory activities.

An example of a virtual laboratory is a collection of digital simulations supported by discussion forums, video demonstrations, hyperlinked glossaries, and e-mail lists organized in a World Wide Web format or on a CD in a shell produced by an authoring language such as Authorware or Director (Scheckler, 2009).

Virtual Reality (VR), on the other hand, is a technology that allows students to explore and manipulate computer-generated, 3-dimensional multimedia environments in real time. One form of VR is Desktop Virtual Reality (DVR), which uses an interactive computer-based, multimedia environment in which the user becomes a participant with the computer in a “virtually real” world. Students are not only motivated by simulation, but learn by interacting with them in a manner similar to the way they would react in real situations (Falode, 2014). It has the potential to enhance and improve learning by enabling the user to interact with the environment. DVR environments are presented on an ordinary computer screen and are usually explored by keyboard, mouse, wand, joystick or touch-screen. Web-based "virtual tours" is an example of a commonly available DVR format. One of the major methodologies used in DVR is that of simulation and modelling. Educational computer simulation is based on dynamic interaction between a learner and a computer program and may be defined as that part of the modelling process involving the learner’s execution of a model.

Simulation is a replica of an item or event which can be created in all fields through computer games, virtual laboratory, role-plays, or building models; it is a program that empowers learners to connect with a computer representation of a genuine experience (Falode, 2014). The specific aim of simulation is to copy, or simulates a genuine framework with the aim that we can investigate it, perform practical on it, and comprehend it before executing it in this present reality. Simulation makes imitated circumstances accessible to the learner to rehearse and enhance vital aptitudes. Indeed, simulation gives an immersive learning background, where aptitudes, procedures, and information can all be improved in a manner reality cannot. The capacity to investigate, experiment, over and over and apply the information to boundless model circumstances is the thing that makes simulation the most flexible type of learning accessible.

Falode (2014) further observed that computer simulation offers learners several advantages, it can for instance, give the students the chance to take part in exercises that may not be conceivable, upgrade academic achievement and the learning accomplishment levels of students, and be just as effective as genuine hands-on research centre encounters. Computer simulation gives students the chance to take activity when finding out around a given subject like map reading. Consequently, the accomplishment of computer simulation relies upon similarity with the curricula and in addition educators' adequacy in its usage (Sahin, 2006; Yilmaz, 2015). In a related study as reported by Garcia- Lugue, *et al* (2004), suggested that very much planned computer simulations has beneficial outcomes on learning, imagination, decision making, correspondence, thinking power and activities. Nsofor (2010) explained that conventional instructional materials, for example, textbooks bring in two-dimensional representations, simulation can on the other hand, offer three-dimensional representations that bring subject matter to life.

In continuation, Nsofor (2010) added that through simulated representation, it results in the advancement of mental constructs that permit one to consider, depict, and clarify questions, phenomena, and procedures in a true to life form. Trundle and Bell (2005), describing students’ abstract understanding about concepts especially in Geography indicated that students learned more by using the computer simulation than by making real appraisal and studying nature alone.

The rapid increase in educational computer use resulted to increase in students' motivation, immeasurable achievement gains and creating better learning environment for effective teaching and learning process through the use of physical and laboratory approach. This approach has assisted in the development of a special type of interactive animation and computer simulations especially in the field of Geography (Gorsky & Finegold, 2005).

In addition, Falode, (2014) described computer simulation in an educational context as a powerful technique that teaches and replaces some aspects of the world. In addition to these, a computer-generated edition of real-world objects or processes, it has the potential to enhance and improve learning by enabling the user to interact with the environment. It can take many different forms, ranging from computer renderings of 3-dimensional geometric shapes to highly interactive computerized laboratory experiments. The learner experiments with the simulated phenomenon by observing and analyzing the interactions between him/herself and the modelled phenomenon. In simulation systems, the learner enters a powerful learning environment and engages in a cycle of expression, evaluation and reflection. With design changing, simulation-based programs can become VR-based programs.

Usman, (2016) classified simulations into four categories; experiencing, informing, reinforcing and integrating. Experiencing simulations enhance future learning and are used before the formal presentation of the material to be learned. Informing simulations are used to transmit information to the student and to supplement or replace the lecture or textbook as a means of initial formal exposure to a topic. Reinforcing simulations apply knowledge in the same context in which it was learned and are used to strengthen specific learning objectives. Integrating simulations help students to integrate separate facts, concepts, and principles into functional units and assimilate them with other units; they are used in situations in which several knowledge elements have been learned independently and must be applied collectively.

Simulations in science education can vary according to use. Usman, (2016) identified five types of simulation in science instruction. The first type involves repeating existing laboratory activities, such as titrations. The second type involves simulations of industrial processes, such as the manufacturing of sulphuric acid. The third type involves simulations of processes that are too dangerous, slow, fast or small for experimenting within a school environment. Examples of these processes are evolution, population growth, collisions and sub-atomic changes. The fourth type of simulation involves non- existent entities such as ideal gases or frictionless surfaces. The fifth type can be used to teach models of theories, such as kinetic theory or the wave model of light.

In addition, Usman, (2016) categorized simulation into four different types as enumerated thus;

(a) Physical simulation, in which a physical object such as electric cell is displayed on computer on the computer screen, giving the students an opportunity to manipulate it and learn about it;

(b) Procedural simulation, in which a simulated machine operates so that the students learn the skills and sections needed to operate it;

(c) Situational simulation, which normally gives the students the chance to explore the effects of different methods to a situation; and

(d) Process simulation, which is different from other simulations in that the student neither act as a participant (as in situational simulation) nor constantly manipulates the simulation (as in physical or procedural simulation) instead select values of various parameters and then watch the process occur without intervention.

Incorporating simulations in science instruction increases students' learning (Aydogdu, 2006; Saka & Akdeniz, 2006; Sambur & Can, 2007). The primary contribution of simulations in science education is their usefulness in the process of teaching. In addition, simulations can help reduce the costs associated with the chemicals and equipment necessary for laboratory experiments. They can also save time in situations in which there are few variables being examined. Simulations make it easy to control variables and may even prevent traditional classroom management problems.

2.1.2 Simulation-based virtual learning

With advancement in educational technology and research in learning science, simulations have found their way into educational institutes. Simulation is described as a technique to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion. This technique has incorporated various kinds of technological tools to create experiences that are impossible to achieve in real environments. The history of simulations goes back to more than a century ago. The military, aviation, and medicine have all incorporated the use of simulation to train and prepare their novice members. Simulations in the field of business have also become a central mode of instruction. Business simulation games are designed with inclusion of virtual characters that create scenarios in a community. Participants are able to meet objective in topics such as decision-making and teamwork (Faria, *et al.*, 2009). In addition to the business industry, the field of medicine has also benefited from the use of simulations, which started in the second half of the 20th century (Bradley, 2006). The emphasis on preparing students to become competent led to a major movement of including simulation training during the course of preparation. As Bradley (2006) mentioned, the major drive behind adapting simulations in the science was due to the lack of time to train students in a real environment. Moreover, students were able to cover more materials and gain necessary communication skills while practicing the skills involved in their professional endeavour.

Another study concluded that using simulation in training environments has led to self-efficacy, finding that participants who used simulation learning demonstrated a higher satisfaction and confidence (Gegenfurtner, *et al.*, 2014). As they have gained popularity in the field of training and education, simulators are organized in four categories: part-task trainers, computer-based systems, simulated patients and environments, and integrated simulators (Bradley, 2006). Part-task trainer simulators allow the participants to focus only on an area or task. For instance, students training to examine a human ear are going to use the model of an ear rather than the entire model of a human body. Computer based systems are simulators that include audio and video.

Computer-based system simulators are categorized into two systems: interactive system or VR system. Interactive systems provide the user with feedback where VR systems create more sophisticated, computer generated images that are similar to real objects or environments. Simulated patient and environment simulators allow the participants to become part of a scenario involving role-play. This type of simulator is more commonly used as an assessment tool by creating situations that involve students making decisions by taking necessary steps. Integrated simulators usually used in the medical training field “combine a manikin with computer controls that can be manipulated to provide various physiological parameter outputs that can be physical or electrical” (Bradley, 2006).

The role of education in today's society has shifted from transferring knowledge to learners to developing skills and practices. Educational researchers aim to help students understand and implement strategies to solve problem they may come across in the real world (Sawyer, 2006). Simulations provide opportunities for students to propose solutions to a problem and take necessary steps to try out their solutions or explanations. Moreover, Bradley (2006) offered an additional rationale about why implementing simulation in educational settings could provide participants with a supportive environment where they can move toward their learning objectives at their own pace. "Students using a simulator are able to 'stop the world, and 'step outside' of the simulated process to review and understand it better" (Mahya, 2017). In regard to secondary education, simulations have opened new doors to instruction strategies.

A study by Kukkonen, *et al.* (2014) concluded that simulation used in a science class to study the greenhouse effect allowed students to acquire a better understanding of the topic. Accepted by educational researchers and practitioners, Simulation-Based Learning (SBL) has become the touchstone for primary, secondary, and higher education. The theories that could be applied as an infrastructure for environments that promote SBL are: Social and cognitive constructivist theory, pioneered by Piaget and Vygotsky, and experiential learning, introduced by Dewey and Kolb. The connection between constructivist theory and experiential learning in simulation is through a learner's "psychomotor, affective, and cognitive learning domains, which tend to result in a deeper and more memorable experience" (Shapira-Lishchinsky, 2015). The components involved in SBL support the constructivist theory of learning where knowledge is not provided, but rather constructed by the participants while interacting with the environment (Shapira-Lishchinsky, 2015).

The constructivist theory of learning is considered to be an important component of simulation exercises or tasks. By becoming engaged in the task, the learners are able to use information and tools in the simulated environment to generate their own understanding about the phenomena they observe. In simulations, learners explore different approaches, test diverse strategies, experience various outcomes, and build a better overall understanding of key aspects of the real world (Shapira-Lishchinsky, 2015). The advantage that SBL provides to its participants is the ability to experience outcomes that may be surprising to the learners. The surprising outcomes prepare learners for unknown situations and results. One reason why simulations are being included in formal educational settings is how learner-centered simulation environments are. The shift to empower learners is a unique feature in learner-centered teaching.

Mahya (2017) noted, students in such an environment are engaged, motivated, and asked to reflect on their learning more often. Students are able take responsibility and make decisions based on available tools and information. The effectiveness of SBL has been utilized and explored in science education for the past 4 decades. SBL supports and promotes students' problem-solving skills and higher order thinking while encouraging students to take ownership of their learning process (Smetana & Bell, 2012). Since SBL is practiced in an environment that recreates real world experiences, students are able to go through the process of decision making by collecting and organizing qualitative and quantitative data. This may not be achievable in real environments where factors involved are not being controlled or the environment is simply too dangerous or inadequate to conduct observation and data collection. Instructors' roles in SBL environments change as students are encouraged to make independent decisions about how and where they should start in order to complete their given tasks or activities. Since SBL promotes learner-centered instruction as opposed to traditional environments that practice direct instruction, students may not be receptive to instructional strategies.

For instance, a study by Foti and Ring (2008) found that when instructors switched instructional modalities while implementing SBL, some students were not able to adjust easily and continuously requested their teacher to tell them where to find answers. Rutten, *et al.* (2015) analyzed the role of teachers in simulation learning environments and stated that practicing an inquiry teaching approach led to positive attitudes among students and teachers, but teachers were not able to incorporate both inquiry teaching strategies and have their students participate actively in class activities. Additional findings about the effectiveness of SBL concluded that students' abilities to successfully perform tasks stayed at the same level in both simulated and real environments, but more importantly, students who used computer simulation as the instructional medium were able to practice inquiry-based learning more than those who completed the same task in traditional instructional medium such as a classroom (Smetana & Bell, 2012).

2.1.3 Virtual learning environments as simulated learning

A computer simulation that enables essential functions of laboratory experiments to be carried out on a computer is called a Virtual Laboratory (VL). Availability of VL in current science curricula and resources for instance, McGraw-Hill's virtual laboratories at http://www.glencoe.com offer science educators opportunities to expose students to the process of experimentation and inquiry. The visual representation of tools and equipment in VSLs resemble the artefacts students observe and utilize while conducting science experiments. In order to make students' VSL experience authentic, designers provide the tools and equipment needed to complete the experiment. From saving time and lowering expenses to minimizing ethical and safety issues, VSLs present a milestone in providing students with unlimited opportunities to experience scientific phenomena through experimentation and simulation.

Simulated learning in virtual science laboratories refers to the learning that occurs in a simulated environment. In simulated environments, objects and tools are designed and represented visually to model and represent the real environment. Through their interactions with simulated environments, learners are given opportunities to make decisions, become part of an simulated environment that was created like a real laboratory, and receive immediate feedback on their decisions (Smetana & Bell, 2012). Simulations used in Virtual Learning Environments (VLEs) have subsequently found their way into the education system. Mikropoulos and Natsis (2011) defined Virtual Learning Environments as learning environments that are based on a certain pedagogical model, incorporates one or more educational objects, provide users with experiences they would otherwise not be able to experience in the physical world and contribute positively to specific learning outcomes.

The inspiration behind designing VLEs emerged from the popularity of commercial gaming software that incorporated virtual environments, Virtual Reality (VR), into their designs. VR not only captured students' interests but also promoted learning among participants (Kontogeorgiou, *et al.*, 2008), which has inspired educational researchers since 1990 to design and create VLEs that promote learning. A study by Kontogeorgiou *et al*. (2008) concluded that participants' sense of presence played an important role in students' learning due to their ability to visualize and manipulate information in the virtual environment.

With considerable attention given to the design of VLEs, educational researchers have examined different avenues by which students gain lifelong learning skills. For example, a study by Chen (2010) found that, although the presentation and interaction of materials are genuine and real in virtual laboratories, laboratory tasks are simplified for students in these environments. Concerns regarding overall learning outcomes of using VLEs have called for educational researchers' attention and clearly called into question whether or not VLEs can be as effective as real learning environments (Chou & Liu, 2005).

2.1.4 Advantages and disadvantages of virtual laboratory

It is important to understand how to use virtual laboratory in a proper and effective way in science class rooms. With the help of virtual laboratory, teachers are able to present demonstrations and conduct labs which may not be possible to afford in real labs, because of cost, space, and safety issues. With virtual settings, Sundara, (2013) opined that it is possible to deliver the visualization of abstract things and ideas. In case of learning about certain phenomenon in science subjects, it is difficult to visualize the process at the microscopic level. It was believed that with interactive simulations of virtual labs, it would be possible to view even microscopic interactions.

In view of these, Falode (2014) opined that virtual science laboratories are the best when they are used to supplement and or integrate hands-on science. Similarly, no research supports the fact that the virtual labs are effective as a standalone science program. These labs are inquiry-based explorations of topics, and not meant to replace more traditional experiments therefore, hands-on work remains critically important. Some researchers believed that it is impossible to replace hands-on labs with virtual labs, because the scientific skills and procedures may never be duplicated by virtual labs. Some researchers reported that in some cases, while manipulating the 3D structure of learning materials or dealing with virtual laboratories, the students are not clear about their expectations (Dalgarno *et al.,* 2009). Sometimes, the design of virtual labs is not well suited to a particular classroom. According to some of the researchers, the technology of 3D may not be understood by the students, thereby producing misconceptions and ambiguity rather than reducing them (Gervasio, 2004; Tasker & Dalton, 2006). The supervision and contact with experienced teachers is missing in virtual settings (Oloruntegbe & Alam, 2010).

In the case of life sciences such as biology, microbiology, and anatomy subjects, the experience gained from virtual labs does not have an immediate impact of dealing with specimens and live organisms (Oloruntegbe & Alam, 2010).). Even though there is better understanding in 3D virtual environments, some students preferred hands-on laboratory than virtual laboratory (Corter *et al*., 2007). According to Clark and Mayer (2008), the online delivery is already an abstraction of the actual application of knowledge, and simulating the lab environment may make abstraction inherently more difficult (Pyatt, 2012).

Laboratories have a long tradition within science classrooms, both within secondary and higher education settings. They have been used to help students with any combination of the three major goals of science classrooms: learning science (developing conceptual knowledge), learning about science (building an understanding of the nature and methods of science), and doing science (engaging in scientific inquiry). Physical laboratory environments, which consist of real-world materials and equipment, and computer simulations – digital, dynamic, interactive representations of a phenomena or process – each have a long history within classroom science laboratories. Over the past few decades, several research studies have attempted to investigate the value of using physical laboratory environments and virtual laboratory environments within science classrooms to support students' conceptual understanding (Olympiou & Zacharia, 2012). Though much of the research on physical and virtual science investigations has treated physical experimentation and computer simulations as competing methods in science classrooms (Jaakkola & Nurmi, 2008), recent research suggests that virtual and physical laboratories each have unique but somewhat overlapping affordances for learning and several authors are beginning to suggest that a combination of physical and virtual laboratories should be considered in science classrooms (Olympiou & Zacharia, 2012). Still, it is not yet clear in this long line of research exactly when to provide what form of laboratory environment, as empirical results of studies comparing physical and virtual experiments, as well as to sequential combinations of the two, have been somewhat mixed (Olympiou & Zacharia, 2012)

In this dissertation, it is suggested that there have been two important pieces missing from the discussion on physical and virtual science laboratories in classrooms: one theoretical, the other technological. First, very little of the research on physical and virtual science laboratories has paid much attention to the specific perceptual-motor features of these learning environments, which may significantly affect students' learning. Second, with emerging technologies that allow new links between physical and virtual elements, there may be new ways to combine physical and virtual laboratories that go beyond offering a sequence of separate physical laboratories and computer simulations.

There is mounting evident that our sensorimotor system affects cognition and learning in complex ways. According to theories of embodied cognition, our body's interaction in the world shapes how we think and learn, and even abstract conceptual understanding is grounded in perception and action (Barsalou, 2009). As such, the particular perceptual-motor aspects of science laboratory environments may shape how students think and learn about the underlying science in important ways, and analyzing physical and virtual laboratory environments in terms of their perceptual-motor features may offer insights into how best to design laboratory environments to support student learning. In terms of their perceptual-motor features, computer simulations can “make the invisible visible”, offering students multiple, dynamic, linked representations of the underlying science variables, including variables that cannot be measured directly in the physical world (Hofstein 2015). Physical laboratory environments, on the other hand, are unique in that they can incorporate haptic, as well as (limited) visual, feedback within the learning environment.

There may also be added profits of directly connecting the haptic response offered by actions on physical materials with the rich, active visual feedback provided in simulation environments. Our experience in the world is inherently multimodal-combining visual, auditory and haptic information. As such, the specific perceptual combinations of modalities utilized in interacting within a learning environment can also play an important role in conceptual understanding.

A class of “mixed reality” technologies is emerging that combines physical objects, actions and environments with digital representations, either through augmenting the physical world with digital attributes or by augmenting a digital environment with aspects of the physical world. By integrating physical actions and objects with digital representations, mixed reality learning environments can expand upon the range of possible actions and sensory-motor experiences within the learning environment. Some authors suggest that these technologies can bridge the “abstraction gap” between everyday experience and abstract understanding (Zufferey *et al.*, 2009) by creating a controlled context for physical interaction with content from which abstract concepts can be built (Lindgren & Johnson-Glenberg, 2013).

The use of mixed reality laboratory environments may be especially useful in

Geography contexts, where the digital representations can be used to shape how students interpret the physical world. Despite a substantial body of empirical research, Geography remains difficult to teach and to learn, and many students perceive Geography as overly abstract and complex (Duit, *et al.*, 2007). In an inherently physical and spatial domain such as Geography, the specifics of students' perception and action may be an essential component of how they develop formal understanding of the domain. Being that mixed reality laboratory environments may be especially effective in Geography contexts, this study focused on learning from combinations of physical and virtual experiments within classical mechanics.

Building upon emerging research on how perceptual processes affect conceptual understanding, prior studies on physical and virtual science laboratory environments, and emerging technologies that combine physical and virtual elements in new ways, the study described in this dissertation attempted to explore how the perceptual-motor features of Geography laboratory environments – including physical, virtual, sequential combinations of physical and virtual, and mixed-reality laboratory environments – influence learners' conceptual understanding.

2.1.5 Physical laboratory environments in science classrooms

A laboratory is a facility that provides controlled conditions in which scientific or technological research, experiments, and measurement may be performed. It is also described as a building set upon for conducting practical investigations in natural science originally and especially and for the manufacture of chemical, medicinal and like products. Laboratories are also in a sense, cultural entities that possess a certain magic, secrecy, and particular symbolism for outsiders (Dominiczak, 2013).

Laboratories used for scientific research take many forms because of the differing requirements of specialists in the various fields of science and engineering. Geography laboratory contains maps, soil models rocks and devices, a metallurgy laboratory could have apparatus for casting or refining metals or for testing their strength.

A chemist or biologist might use a wet laboratory, while a psychologist's laboratory might be a room with one-way mirrors and hidden cameras in which to observe behaviour. In some laboratories, such as those commonly used by computer scientists, computers (sometimes super computers) are used for either simulations or the analysis of data. Scientists in other fields will use still other types of laboratories. Engineers use laboratories as well to design, build, and test technological devices. Scientific laboratories can be found as research room and learning space in schools and universities, industry, government, or military facilities, and even aboard ships and spacecraft. Despite the underlying notion of the lab as a confined space for experts, the term laboratory is also increasingly applied to workshop spaces such as Living Labs, Fab Labs, or Hacker spaces, in which people meet to work on societal problems or make prototypes, working collaboratively or sharing resources.

Laboratories have played a prominent role in science classrooms for several decades. Evidently, laboratories have continually been used to help students in the main combination of the three major goals of science classrooms: learning science (developing conceptual knowledge), learning about science (building an understanding of the nature and methods of science), and doing science (engaging in scientific inquiry) (Garrett, 2015). Physical laboratory environments, which consist of real-world materials and equipment, and computer simulations – digital, dynamic, interactive representations of a phenomena or process – each has a long history within classroom science laboratories, both in Secondary and higher education settings (Garrett, 2015).

Over the past few decades, several research studies have attempted to investigate the value of using physical laboratory environments and virtual laboratory environments within science classrooms to support student learning (Olympiou & Zacharia, 2012). Though much of the research on physical and virtual science investigations has treated physical experimentation and computer simulations as competing methods in science classrooms (Jaakkola & Nurmi, 2008), recent research suggests that virtual and physical experimentation each have unique but somewhat overlapping affordances for learning (Olympiou & Zacharia, 2012). Several authors are beginning to suggest that a combination of physical and virtual laboratories should be considered in science classrooms.

2.1.6 21st Century physical laboratory goals

Science Laboratories in the beginning were viewed by Hofstein, (2015) as mainly focusing on older and higher achieving students. Over time, the idea of the Science Laboratories adapted into a broader movement to support science learning on a more general level by offering students of all schooling levels out-of-school experiences and practical lab work which has been challenging to implement in traditional schools due to a lack of equipment, time, finances, or overall quality in the school lab facilities. The rationale behind this educational innovation as emphasized by Hofstein (2015) was to promote science learning, discuss current goals for science laboratory instruction, and presents models on how science students learn and how teachers and students should engage in science laboratory activities. Furthermore, it was stressed that laboratory science experiences should be developed around a constructivist framework to promote opportunities for Meta cognition and student autonomy as well as development of scientific argumentation, and allow student-instructor and pair interactions.

The rationale behind this educational innovation such as the 21st century laboratory, according to Affeldt *et al.* (2015) was to promote science learning and to improve students' engagement in science and engineering studies and to further enhance mastery of subject matter, develop scientific reasoning, assist students in understanding the complexity and ambiguity of empirical work, develop practical skills, and understanding of the nature of science.

In general, the goals of the laboratories are summarized as follows:

i. The lab should engage each student in significant experiences with experimental processes, including investigation experience.
ii. The laboratory should help the student to develop a broad array of basic skills and tools, especially in Geography.
iii. The laboratory should provide conceptual learning, so that it helps the student in mastering the basic concepts in related subjects.
iv. The laboratory should help students to develop collaborative learning skills that are vital to success in lifelong endeavours.
v. Computer-based laboratory, called Micro-computer based labs (MBL), can increase the active engagement of students as well as improve conceptual understanding.

Following these, there is a change in the laboratory settings from 20th to 21st century, modern laboratories use computers in the laboratories to demonstrate experiments and to analyze the data. Researchers and educators in science education seek to include and improve computer simulations in the laboratory activities for also improving the conceptual understating of students. Ismail (2015), advocated for the increasing application of new technologies in the schools based on the fact that there is need for students to be innovatively educated for achievement in the twenty-first century. Technology thus, becomes the fundamental part of the environment as it is utilized as an apparatus for learning and taking care of genuine issues which may involve the use of computer simulation.

2.1.7 Types of laboratories

Traditional labs or hands on labs: The very first type of laboratory is the formal or academic laboratory. It is a traditional procedure for teaching a lab course. Other names for this type of instructional approach are structured, traditional, and convergent or cookbook laboratories. A lab manual is provided to students that describes the procedure, techniques, tools, and other materials needed to do the lab experiment in a space called lab and use the lab manual, and then produce the written report. This type of physical laboratory was initially designed to address the prescribed outcomes and the laboratory environments of 20th century.

In these labs, the instruction is teacher-centered, that is, students perform the lab activities in a structured fashion, following the guidance of their instructor. The students are allowed to do the experiment by means of the schedule and within the time period. If a student misses an experiment on any particular day, it may not be possible for that student to redo the experiment, especially in science courses where certain labs require preparations for the experiment. Also, time and safety are issues, because the students are allowed to use the experiment tools only in the prescribed manner in the manual. Moreover, the studies on traditional labs by Sundara, (2013) indicated that the instruction in traditional lab is ineffective; because the procedure does not provide either inquiry or discovery learning in students. It does not mean however, that the traditional labs have no instructional value.

Micro computer based lab (MBL): This is a science laboratory in addition to the traditional sources. MBL consists of a hardware system, including an interface, sensors, connecting probes, and software for data analysis. MBL works in such a way that it collects the data, such as the sound, temperature, and PH of a solution, using sensors and probes. The data is converted to digital input and displayed graphically by a software on the computer. The hardware and software used to convert physical properties into electrical signal. Research on MBL has shown that MBL can increase student learning of difficult concepts. High school students displayed improved conceptual understanding after using selected MBL tools in a constructed curriculum; MBLs has shown increase in the graphing skills of students and conceptual understanding and interpretation skills. MBL guides students to find the relationship between events and data. For example, after running or exercising, students can view their change in heart rate on the computers with sensors and an interface (Dixon, 2011). MBL provides real time data that are displayed quickly for the data analysis. Students can replicate the experimental process and observe the changes with the data analysis. In this way, MBLs offer an opportunity for inquiry learning and discovery learning in students. MBLs also can increase interest and enthusiasm for science learning, because they are designed in accordance with 21st century technology skills and goals.

Inquiry labs: seen as diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. The Inquiry labs are designed in such a way that students more or less independently develop, and produce an experimental plan, and collect relevant data.

Finally, the data are analyzed to find a law or a relationship between variables. The same information was reported by National Science Teachers Association (NSTA). According to NSTA, the lab instruction in the 21st century is to create an environment where students can observe specific science phenomena and investigate them by the process of scientific inquiry. The inquiry process is fundamental to the practice of science. Inquiry-based learning (IBL), when applied to a scientific context, is known as inquiry-based science instruction. It is grounded on the idea that science instruction should be authentic to the practice of science. Wenning (2005) suggested that the inquiry based labs can be classified into 3 types;

Guided Inquiry Lab: This is a type of lab in which the teacher poses a problem and multiple leading question that when answered, point the way to procedures. In these labs, clear and concise objectives are provided to students. Hence, a guided inquiry lab might be applicable as a pre-lab activity or discussion.

Bounded Inquiry Lab: In this type of lab, students are provided with a clear and concise performance objective connected with a concept, and they are required to design and conduct an experiment without the detailed pre-lab and response to leading questions. Students must make simple observations about the relationship between variables, and then formulate a logical basis for a conducting experiment.

Free Inquiry Lab: In this type of lab, students identify a problem to be solved and create the experimental design. Students work throughout the course; hence, it is a semester-long program.

Problem based labs: Problem-based learning is shifted from a teacher-centered approach to a student- centered approach that allows students to construct meaningful knowledge by relating new concepts and ideas added to previous knowledge (Kelly &

Finlayson, 2007). An instructional model, based on the constructivist theory (Edens, 2000), this type of instruction encourages the active involvement of the learner (Tan, 2004). The goals of PBL are in line with the goals of the 21^{st} century where the instruction is learner-centered and utilizes problem solving skills.

Discovery labs: Discovery labs are learner-centered and are consistent with the 21^{st}century goals. It is also a type of inquiry-based instruction, where the learners discover facts and relationships for themselves. The labs provide a place for students to experience hands-on learning and to build a lab for science. Discovery labs involve the learners in scientific investigations, permitting the learner to discover the scientific topics by himself

Remote labs: Faltin, *et al*. (2002) presented a remote laboratory concept providing access to real laboratories with the additional support of a tutorial assistant. The Internet assisted Laboratories (I-Labs) was a collaborative effort between the Stanford Centre for Innovations in Learning in California and the Learning Lab Lower Saxony in Germany. I- Labs learning strategies are based on collaborative learning skills and are self-directed in online laboratories with tutorial assistance (Faltin *et al*., 2002). By definition, remote lab is an experiment which is conducted and controlled remotely through the internet. The experiments use real components or instrumentation at a different location from where they are being controlled or conducted (Chen & Howard, 2010; Richter *et al.*, 2012). The concept of remote laboratory is based on the instructional Systems design process of cyclic needs analysis, design and development, and evaluation and revision (Alhalabi, *et al.* (2004)). Song *et al.* (2007) explained this with an example: The University of Houston offers access to its remote laboratory for the Smart Materials and Structures Laboratory. Conducting a real laboratory is a big problem for universities with a large number of students and limited space, experiment materials, and support personnel. Remote laboratories are suitable in the situations where there is a need to handle a large number of students, with a very few or limited availability of experiments like the nanotechnology experiments (Chang *et al.,* 2002). Yet the disadvantage of the remote labs is that they are a scarce resource; remote experiments must be booked and reserved by a single student or student groups to access them at a certain time (Richter *et al.,* 2012).

Virtual labs: A computer simulation which enables essential functions of laboratory experiments to be carried out on a computer is called a virtual laboratory (VL). With the help of simulations, virtual labs facilitate different ranges of learning processes, such as the discovery of new content and new assessment, or the solution for complex problems. The labs are self-explanatory and their use by instructors requires no training before being used in a student environment.

Most virtual labs use applets. These applets form the core of the computer-based laboratory experiences, thus enabling students to use standard Java and Shockwave as the programming medium. An Applet is essentially an application that runs within a regular browser window similar to Internet Explorer, Mozilla or Firebird. These mini-applications provide total interactivity when combined with full multi-media and graphics that allow students to easily visualize difficult concepts (Sethi, 2005).

Virtual labs are all about utilizing technology to achieve an edge in science education. With the online virtual lab pre-lab, students perform and analyze multifaceted hands-on simulations that are user-friendly and enjoyable to navigate. The student then enters the wet lab phase prepared and ready to work. All of the labs stress important safety guidelines, proper lab techniques, and important concepts that students must understand in order to achieve positive results. Teachers and faculty are able to save time and resources by means of the virtual lab. At present, there are different databases which provide various virtual lab experiments and activities. Many computational scientists still attempt to develop very complex systems in biological, environmental, atmospheric, and geological or Geography courses, and chemistry and biology courses.

2.1.8 Comparing physical and virtual science laboratories for efficient geography instruction

When directly comparing physical and virtual experimentation, several studies have found no significant and consistent difference between simulations and physical laboratories (Zacharia & Constantinou, 2008; Zacharia & Olympiou, 2011). However, there have also been instances where the use of virtual laboratories has better supported students' learning than physical laboratories (Zacharia, 2007; Zacharia *et al.*, 2008). Though this may suggest that physical laboratories have little to offer learners when compared with purely virtual environments, when considering combinations of physical and virtual experiments in comparison to each by itself, several studies have found that combined physical/virtual experiments can be more beneficial for learning than either form alone (Zacharia, 2007; Zacharia, *et al.*, 2008; Jaakkola & Nurmi, 2008). Though that is not always the case Zacharia (2007); Zacharia *et al.* (2008); Olympio and Zacharia (2012) argue that the reason that combinations of physical and virtual experiments often support learning than either of the two experiments used separately, is that physical and virtual materials offer different but overlapping affordances for learning.

Physical laboratory environments and virtual environment, for example, can introduce students to the important conceptual and procedural knowledge of science and frame students' activities around important concepts and can provide perceptual grounding for concepts that might otherwise be too abstract to be easily understood, this can expose students to scientific experimentation and its corresponding skills (Garrett, 2015). However, only physical laboratory environments offer students experiences that involve the manipulation of the actual items of a lab experiment, helping them to develop perceptual-motor skills (Olympio & Zacharia, 2012).

Additionally, conducting physical experiments naturally includes measurement errors, while computer simulations are often designed to avoid measurement error. Competency in the practices of science includes the knowledge of the types of measurement errors that exist in the domain and the ability to appropriately deal with them.

Virtual laboratories, on the other hand, provide opportunities for exploration that would be impractical or impossible with physical materials (Garrett, 2015). Setting up simulations is often less time consuming than preparing physical investigations, thereby allowing students more time for reflection (Hofstein, 2015). They can also combine multiple representations – verbal, numerical, pictorial, conceptual and graphical – and allow students to perceive variables and conceptual relationships that are not directly observable in the physical environment.

2.1.9 Combining physical and virtual science laboratories for effective geography instruction

Given unique affordances of physical and virtual materials, several researchers have promoted using a combination of physical and virtual experiments in science laboratories and have offered different reasons for this (Jaakkola & Nurmi, 2008; Jaakkola *et al.*, 2012; Zacharia & Constantinou, 2008; Zacharia & Olympiou, 2011; Zacharia, *et al.*, 2008) claims that both real and virtual experiments can be directed at facilitating students' conceptual change: simulations can assist students in the conceptual framework of science" and physical labs can reinforce student conceptions by demonstrating to what extent the representation matches real phenomenon. It was argued that the use of computer simulations provides a valuable conceptual tool, which should be augmented with actual experiments in the classroom.

Building from the idea that physical and virtual offer rather unique affordances for learning and should be combined in classrooms, some researchers have begun to explore how best to combine them. In choosing a sequential combination of physical and virtual experiments, some authors suggest that using computer simulations first can serve as a cognitive framework that allow students to first understand theoretical principles and later apply them to real-world inquiry (Jaakkola & Nurmi, 2008). Meanwhile, Gire *et al.* (2010) suggested that conducting real-world experiments first provides important grounded, physical experience with the phenomena of interest, which can then be expanded upon and abstracted through a simulation environment. Still other researchers focus less on the sequence and suggest employing a thoughtfully interwoven combination of physical and virtual investigations. Olympiou and Zacharia (2012) found that such a "blended" combination of physical and virtual experiments on light and colour – taking advantage of the unique affordances of physical and virtual experimentation in conjunction with the learning objectives of each experiment is more effective than either purely physical or virtual experiments alone.

In addition, different science laboratory environments can have different affordances for learning, but in terms of building conceptual understanding, the results are not always consistent and there is no clear understanding of why and how these affordances exist. A focus on embodiment in science laboratory environments – how the specific perceptual-motor features of laboratory environments can serve to ground and otherwise influence conceptual understanding can provide insights into why different science laboratory environments have unique affordances for building conceptual understanding of science phenomena.

2.1.10 Virtual and physical types of laboratory environments

As mentioned earlier, there are several practical and theoretical advantages of using virtual experiments in science classrooms. In terms of their perceptual-motor features in relation to building conceptual understanding, computer simulations in virtual laboratories can "make the invisible visible", offering students multiple, dynamic, linked representations of the underlying science variables, including variables that cannot be measured directly in the physical world (Hofstein, 2015). The dynamic nature and flexibility of digital representations, as well as the ability to directly couple multiple representations, offers unique affordances not available in purely physical environments. In short, virtual experiments can offer rich, flexible, real-time visual feedback to learners in ways that physical experiments cannot (Trindle & Bell, 2005). This is a powerful advantage for computer simulations in the classroom, and this may be a primary reason that, in many cases, virtual experiments have been superior to purely physical experiments in supporting student learning.

In terms of their perceptual-motor features, physical laboratory environments are unique because they can incorporate haptic feedback in addition to visual feedback within the learning environment. Through interaction with physical materials, learners have access to tactile and kinesthetic information beyond what is available in purely virtual environments. There is emerging research that both the perception of force and the perception of bodily movement can affect learning and reasoning. The perception of force has been studied directly in science learning environments, often through supplementing computer simulations with force feedback devices. Indeed, there is some empirical evidence that adding force feedback to dynamic visualizations can affect students' learning, reasoning and motivation (Bivall *et al.*, 2011). Bivall *et al.* (2011), for example, added a force feedback interface to a 3-D visual model to allow students to feel, as well as see, the interactions between particles. Students who used the model augmented with force feedback learned more and incorporated more force-based explanations in their reasoning about particles than did students with the visual-only model. The addition of force feedback, they contend, may have also prevented students from drawing erroneous conclusions that were observed with students who used the visual-only model. Though this work was done in the domain of chemistry, it may easily apply to other domains as well.

For example, incorporating haptic feedback into Geography learning environments may similarly influence students' reasoning and may be particularly beneficial for helping students to build accurate conceptions of force. In addition to the perception of force, bodily movement and the resulting perception of one's own body movement may also influence learning and reasoning. There is growing evidence that action plays a central role in cognition and can have an effect on conceptual processing. Bodily movement can unconsciously influence problem solving and spatial reasoning (Thomas & Lleras, 2009). Additionally, actions on objects can affect children's categorization of those objects (Smith & Cardaciotto, 2011), and children's manipulation of objects during reading can enhance comprehension and memory of the material (Lindgren & Johnson-Glenberg 2013). Martin (2009) claims that for successfully learning how to solve mathematics problems with real objects, "actions coupled with interpretations serve as developmental precursors to general mathematical procedures, which can later be enacted mentally."

Though there is little research on how body movement may affect conceptual understanding within science laboratory environments specifically, emerging research on the influence of action on conceptual processes suggests that in some cases, physical action and perception of bodily movement may influence learners' conceptual processing somewhat similarly to the perception of force, particularly in grounding understanding of Geography concepts that relate to distance and movement.

2.1.11 Integrated physical and virtual laboratory environments into geography learning

As affirmed in a research conducted by Olympiou and Zacharia (2012) who made a case that by offering students access to both physical and virtual laboratory environments, they are provided the best of both worlds through combining their unique affordances. Indeed, combinations of physical and virtual experiments are often more beneficial for students than either form alone (Zacharia, 2007; Zacharia *et al.,* 2008; Jaakkola & Nurmi, 2008). Part of the reason for this may be perceptual in nature. When performing both physical and virtual investigations, learners are often exposed to both visual and haptic feedback about the phenomena of interest. However, in performing separate physical and virtual experiments, the haptic feedback provided in the physical experiments is largely divorced from the rich visual feedback provided by computer simulations.

There may also be additional benefits of directly coupling the haptic feedback offered by actions on physical materials with the rich, dynamic visual feedback provided in simulation environments. The experience in the world is essentially characterised by several different approach of activities that is, combining visual, auditory and haptic information. As such, the specific perceptual combination*s* of modalities utilized in interacting within a learning environment can also play an important role in conceptual understanding.

To understand how several modes of representations of scientific phenomena may influence learning, we can draw from Barsalou's theory of grounded cognition (Barsalou, 2009). According to Barsalou, concepts are built upon several modes of mental representations of events, which can be re-enacted through mental simulation, and a fully functional conceptual system can be built upon these re-enactment mechanisms. Indeed, current evidence from the neuroscience literature points to the existence of multimodal mental representations that may be flexibly accessed via either knowledge-driven or stimulus-driven processes (Lacey *et al.*, 2007) and that haptic and visual information, in particular, share overlapping neural networks (Lederman & Klatzky, 2009). If mental representation of concepts is indeed multimodal, offering, visual-haptic science learning environments may provide important benefits beyond separate physical and virtual environments.

For example, if in a Geography learning environment, an abstract representation such as contours is repeatedly paired with an object, this pairing may create a multimodal representation of several different modes of activities or occurrence. The ability to provide integrated, multimodal experiences may help build multimodal internal representations, which may lead to a more complete mental model of the intended phenomenon (Minogue, 2016). Directly coupling the rich, haptic information of physical objects and environments with the flexible, dynamic visual representations may help learners to actively interpret their multimodal experience of science phenomena and to build coherent, multimodal mental representations of science concepts.

2.1.12 Role of physical laboratory in science and technology education

Historically, it has been proven that the science laboratory is used to teach experimental techniques and theories that validate existing scientific principles as the application of computer technology in classroom environment has a significant role in enhancing teaching and learning. For instance, the use of artificial educational environment such as simulations and virtual reality in teaching and learning is increasingly becoming widespread and has proven to be effective in teaching difficult subjects in science for over two decades (Babateen, 2011; Kennepohl, 2011).

In teaching and learning Geography, various methods and techniques may be used in accordance with the subject matter. Laboratory methods are the best methods which provide interest, permanent learning, and understanding of concepts. In science subjects, theoretical ideas are important and they are verified by scientific observations or experiments. For these scientific investigations, the laboratory component plays a key role in Geography education. One cannot think about Geography teaching without Geography practical. The universally accepted fact is that the best way to communicate the Geography content, impart the knowledge, and keep the fascination of Geography alive as well is through a demonstration (Sofowora & Agbedokun, 2010). Laboratory methods encourage mental activities allowing students to work individually or in groups (Falode, 2014). Researchers and science and technology educators suggested that better laboratory activities yield rich benefits in science learning and in order to teach science effectively to students, the labs must be the part of science curriculum (National Science Teachers Association, 2009).

Laboratory activities in secondary school sciences provide the students an opportunity for systematic development of knowledge, ideas, and experience natural phenomena. The role of the laboratory is crucial in senior secondary school Geography courses, since students must construct their own understanding of geographic ideas. This knowledge is not transmitted by the teacher. Theory and research suggest that meaningful learning is possible in laboratory activities if all students are provided with opportunities to manipulate equipment and materials while working cooperatively with peers in an environment in which they are free to pursue solutions to problems that interest them (Sundara, 2013).

2.1.13 Role of computers in physical laboratories

Modern computers provide many opportunities to sciences consequently; the use of computer technology in science classrooms and science laboratories is widespread. In fact, computers play an integral role in laboratories for real or virtual investigations in science courses as computer aid each learner to depend on himself in learning and establishing the motor skill assignments provided through a paper with different and graded difficulty levels, which he/she has to carry out to achieve the desired goals (Mohammed, 2017). In order to provide better instruction to students, some science tutors used computers in their classrooms since computers have continued to make landmarks contributions on all spheres of cognition, education and training from primary through secondary to tertiary level (Ismail, 2015). Computer therefore offered efficiency in teaching scientific disciplines such as Geography, biology, and chemistry, seeing that computers allow the teachers to demonstrate complicated experiments and mechanisms to students.

When computers are used in a classroom or in a laboratory, it is believed that the practice leads to positive attitudes in students, since by means of computers; it is possible to do many new things rapidly, and with more safety. Computer technology according to Quinn (2011) has the potential to contribute at various stages of learning of skills and concepts in various fields of education. In continuation, Quinn (2011) highlighted the advantages of this technology to include improving learners' skills and techniques; assisting learners in the review and evaluation of their performance; developing learners' knowledge and understanding of the subject; shifting time through use of slow motion to highlight fine detail with a skill and developing pupils' understanding of the human body, physiology and health. The computer technology provides opportunities for investigations and inquiry-based learning, which are not possible in normal settings due to time, safety, and cost. Computer-based simulations and other multimedia tools can help in overcoming these constraints. With the computer technology, the interactive visualization provides student learners with real worlds to manipulate. It also increases teacher-learner interaction when properly used as computer-based technology is also used to design effective science lessons (Mohammed, 2017).

Computers and modern instruments should be part of the laboratory equipment. Although excellent Geography learning can take place using the simplest equipment, computers and measuring instruments incorporating modern technology can be powerful tools for learning Geography concepts and for developing skills with measurement, analysis, and processing information.

Each year, many schools and school districts allocate a substantial portion of their budget for computers and new multimedia tools. In distance education, online science courses, and web based science activities, it is impossible to conduct courses without computers; neither is it possible to deliver the online demos and science labs. With the advancements in computers, online science labs, simulated labs, and virtual labs continue to develop.

2.1.14 Concept and scope of geography as a discipline

Geography as an academic subject emphasizes on the evolution and organization of earths features and process. Also, it is the study of man and his environment. It additionally concentrates on areas, space relations, and changes of physical phenomena on the earth's surface. It is concerned about how, why, and where human and natural activities happen and how they are interconnected spatially (Mansaray, 1992; Ajayi, 2003; Aderogba, 2012).

Scope is the extent covered by a subject. As indicated by Nigeria Education Research and Development Council, major subdivisions and scope of Geography are: Physical Geography, Mathematical Geography, Biogeography and Human Geography. Abdulkarim (2010) classified these subfields into two broad areas of human Geography and physical Geography. Human components of Geography according to scholars focus on the socio-economic, population and settlement, patterns of locations (Atere, 2006; Obioma, 2008; Abdulkarim, 2010). Physical Geography examines patterns of the natural processes occurring at the Earth surface that provides the natural setting for human activities namely, the study of climate, landforms, Coastal inland and marine waters, vegetation, risks and hazard and soils. In line with this, the Nigerian Educational Research and Development Council (2008) categorized the scope of Geography at senior secondary school level into seven themes (Local Geography, the earth and the solar system, Environment and its resources, Regional Geography of Nigeria, Map reading and Interpretation, Economic and Human Geography and Introductory Geographic Information System). In SS I level, students were exposed to all the seven themes. However, the themes reduced to six at SS II level, and to five at SS III level. The West African Examinations Council and National Examinations Council (2013) detailed the scope of Geography at the secondary school levels into physical, human, regional, and practical Geography to facilitate students' assessments.

The scope of Geography worldwide was portrayed as diverse in nature. That is to say Geography is classified into other discipline such as Biology – (Biogeography), Physics (Geophysics), Medicine (Medical Geography), Economics – (Economic Geography), Politics - (Political Geography) Agricultural Science (Agricultural Geography), Computer Information Science (Geography Information Science) among others. These attributes of Geography make it a dynamic subject of study (Atere, 2006). On the other hand, Boehim (2006) and Aderogba (2012), expressed that Geography prepared student with wide vocational opportunities. For example, a geographer who studies Cartography and Geographic Information System was a Cartographer for Federal Government (offices, for example, Defence Mapping Agency, US Geographical Survey or Environmental Protection Agency or Private Sector like Environmental System Research Institute, Map Liberian, GIS expert for Planners, land designers, Surveyor. Physical Geographer can fit in as weather forecaster; outdoor guide; coastal zone manager; hydrologist; soil conservation/agricultural extension agent. Environmental Studies offered environmental geographer an opportunity to become an environmental manager; forestry technician; park ranger; risky waste planner among others.

Rilwani *et al.* (2014), the quality of Geography as a subject in the senior secondary school lies out in the background training and opportunity it can give to students who need to seek after distinctive sorts of professions, among which are vocations in independent work, professional establishments, paid business in government and commercial enterprises as well as specialized organizations.

2.1.15 Academic achievement in Geography Education

Academic achievements in Geography is the exhibition of knowledge attained or abilities developed by the students in the subject typically outlined by test scores assigned by instructors. It is an evidence of the sorts of learning and its environment in a teaching and learning procedure. Aydın and Coşkun (2011) observed that the scores in examinations and the passing comments in class, usually determine the achievements of the students about the course (Geography). NECO as an examination body has sketched out a few shortcomings resulting to poor achievement of students in previous Geography examination. For example, in May/June 2006, Geography Paper I, question number one dealt with aspect of map work that involved representation of contours. The NECO chief examiners' report on this question revealed poor achievement recorded by student was as a result of poor understanding of map skills by candidates, probably due to inadequate emphasis during teaching and learning process.

Several results as revealed by Sabitu and Nuradeen (2010), Aderogba, (2012), Rilwani *et al.* (2014), have recognized many factors affecting students' academic achievement in Geography as a course of study including class size, laboratories, instructional strategies, textbooks, guidance and counselling services, academic and professional qualification of teachers, teachers' qualities, students' qualities, peer groups, parental and home background, and school environment among others. In continuation, Sabitu and Nuradeen, (2010), further explain that the success of any teaching and learning procedure, which perpetually affect students 'academic achievement relies upon how powerful and productive the teachers are. Teacher's knowledge plays an important role in classrooms, as it can influence teachers 'choice of suitable strategies during the teaching process.

Furthermore, Akintade (2011), stated that, it is very important that a secondary school Geography teacher should be academically articulate in his area of specialization. Zarei and Sharifabad (2012), observed that teachers can be different from one another based on the experience they have attained during teaching. Thus, the influence of teachers' teaching effectiveness on the learning outcome of students as measured by students' academic achievement has been the subject of several studies (Adediwura and Tayo (2007). Rilwani *et al.* (2014), suggest that effective teaching is a significant predictor of students' academic achievement; therefore, effective teachers should produce students of higher academic achievement. According to Ofoegbu (2004), poor academic achievement of students in Nigeria has been linked to poor teacher's performance in terms of accomplishing the teaching task, negative attitude to work and poor teaching habits, which have been attributed to instructional strategy. In this study therefore, the impact of innovative teaching strategy (computer simulation instructional strategy) on academic achievement of Geography students in map reading has been examined.

2.1.16 Nature and goals of geography education curriculum

The period following Nigeria Political Independence denoted an adjustment over the span of Education System and educational program advancement in Nigeria. This has led to increment in schools and school enrolment resulting from free educational system obtainable in Western and Eastern parts, owing to certain benefits enjoyed by educational class thereby putting students on high position in economic wellbeing (Oyeleke, 2013). Education in the long run turns into an open door for getting more support, solace and access to political power in Nigeria thus; the 6-3-3-4 system of education was embraced to be carried out in Nigeria. However, currently Nigeria operate 9-3-4 system of education. The first 9 years is dedicated to basic education. That is, six years for lower basic/primary education; and 3 years for upper basic education), which culminates in the Basic Education Certification Examination (BECE). The following three years is for senior secondary school schooling, which is concluded with the senior school certificate examination (SSCE). Generally, two category of examinees (internal/school and private/external candidates) take the SSCE every year. The internal candidate are those students in their third year in the senior secondary school (SSIII) take their examination in May/June, the external candidates on the other hand, as not in the school system and are composed are those who take the examination around November/December to make up for their deficiencies in certain subject. The last stage of the Nigerian education system takes at least 4 years of study to earn a Bachelor degree, with some courses taking up to 6 years of study. There are three major SSCE conducting bodies in Nigeria namely; West African Examination Council (WAEC); National Examination Council (NECO); National Business and Technical Examination Board (NABTEB). The goals of every level of education, for example, the pre-primary, primary, junior and senior secondary schools and tertiary institutions are obviously spelt out in the National policy on Education (FRN, 2009).

The Nigeria national objectives as expressed in the National Policy on Education (FRN, 2009) are as follows:

i. a free and democratic society;
ii. a just and egalitarian society;
iii. a united, strong and self-reliant nation;
iv. a great and dynamic economy; and
v. a land full of bright opportunities for all citizens.

For the national philosophy to concur with Nigeria's national objectives, education must be tailored towards self-awareness, better human relationship, individual and national viability, effective citizenship, national perception, national solidarity, and additionally social, cultural political, scientific and technological advancement (FRN, 2009). Secondary school education is the training children get after primary education and preceding tertiary education (FRN, 2009). The main objectives of secondary education in the general Nigerian education policy are in Preparation for advanced education so as to make a useful living within the society.

Secondary school education places significance on realization of professional aptitudes, which is professionally tilting at the tertiary stage with a specific end goal to minimize unemployment and produce skilled labour, in science and technology. Ehindero (2006), found that the policy denoted the end of 135 years of colonial rule and impacts on our educational modules. It equally gives a Nigerian and for sure an African touch to the country’s educational framework.

Following these, the Nigerian Educational System has reliably under-gone sweeping changes. The old educational program was enhanced in nature, emphasis was put on Science, Pre-Vocational and Performance based learning, these progressions manifest in the introduction of the 6-3-3-4 organisation of education. Sofowora and Agbedokun (2010), revealed that the recent reorganization and the improvement of the Geography educational module and recent appropriation of the new 6-3-9 system of education at the Senior Secondary levels are extremely remarkable parts of these changes, resulting from these, educators are not more concerned simply with turning out students who are stacked with certainties and wordings in Geography (Sofowora & Agbedokun, 2010). Today, the educational program had changed, it has turned into a matter of examination, enquiry and experiential. Emphasis is presently put on the importance of Geography to life. The new destinations that now manage the detailing of Geography educational modules are:

i. Teaching of Geography ought to give a medium to the child's improvement, to help him get the specialty of utilizing learning or to learn something about his social legacy;

ii. Provide fundamental foundation to citizenship and to intimate the student into a specific method of thought;

iii. Offer a remarkable means of encouraging enquiry and high intellectual development in students;

iv. To help man to live, put himself on the planet and to realize his actual position and what his obligations are;

v. To prepare the students to comprehend other individuals and their surroundings;

vi. Develop positive attitude to race, society, and to different people, groups, situations and places.

At senior secondary schools, students are given choice to study Geography as a core subject (FRN, 2009). Geography is one of the science subjects taught at the senior secondary school level of education in Nigeria. The importance of Geography and geographic studies cannot be over emphasised (Aderogba, 2005; Fellmnan, *et al.*, 2005; Aderogba & Ogunnowo, 2010;). Aside from it being offered at the SSS for Senior Secondary School Certificate Examination, it is a subject taught at the tertiary level and it links with a few other school subjects to make individual an expert. The West African School Certificate Examination Council (WAEC) has been assessing its syllabi over the course of the years to reflect contemporary issues, react to open issues and adjust to realities of time (Aderogba & Ogunnowo, 2010). The National Examination Council (NECO, 2004) likewise prepared its syllabus nearly to the WAEC's which shows areas of interest of Geography syllabus as provided by the two national examination bodies and actualized by schools and universities. The aims and objectives of the program taught at this level in accordance with these examination bodies are:

i. To comprehend the idea of diverse characters and the spatial relationship of the components on the earth surface;

ii. To comprehend the idea of man-environment connection, that is, to analyze and clarify the collaboration of man with his physical and social environment;

iii. To gain the essential learning of the nature and capacity of physical and human situations and comprehension of their connections on the subsequent issues;

iv. To sort out and plan standards as indicated by acquired geographical ideas and apply these standards to translate and dissect spatial issues in the quick and wide environment, and

v. To create aptitudes and methods for precise, efficient and objective geographical assessments to be done both in the classrooms and in nature (West African Examination Council, 2008)

The breakdown of the content of Geography syllabus is grouped into four areas specifically: Elements of Practical Geography (Map Work); Physical Geography; Human Geography; Regional Geography (Sofowora & Agbedokun, 2010). Geography is the study of man-environment relationship; (Hansen, *et al.,* 2007). The primary objectives of Geography education to provide insights into the relationship between common conditions and social activities in distinctive parts of the world and to show a related spatially-arranged ability that can be applied (Hemmer & Hemmer 2017). In accordance with these aims, students of Geography have the ability to perceive collaborations in relationship between the nature and society (economy, governmental issues, and social perspectives) taking into account various regional examples, they can likewise figure out how to comprehend the subsequent structures, procedures and issues included with these associations and to consider answers for these issues. To this end, a comprehension of the Earth as a framework is essential which is the different characteristic frameworks and subsystems of the geosphere.

Hemmer and Hemmer (2017) further found that Geography is a centralizing subject for all parts of geosciences relevant to schools which can improve comprehension of social frameworks in their fundamental spatially applicable essential structures. With this general geographical approach, Geography lessons make an exceptional commitment to the consolation of multi-viewpoint, systematic and critical thinking consideration. Students along these lines secure spatial orientation skills, and additionally examine areas of the Earth at distinctive scales for example, their country and different spots from alternate points of view and as to different issues (Hemmer & Hemmer 2017). Hence, students have the opportunity to be acquainted with various traditional and computerized media subsequently securing a methodological skill that is crucial for self-decided learning, field outings, and projects makes conceivable the consideration of reality outside of school and students own dynamic encounters. Furthermore, it was included that Geography as a school subject makes a significant contribution to interdisciplinary and co-operative assignments in education. Besides, Students gain from examples of numerous ecological subjects, both at home and far away. Hemmer and Hemmer (2017), observed education in development policy and intercultural learning as relevant aspects of Geography teaching in schools. By considering nature, economics, political and social interaction, students acquire important competences in these areas. Because of its contents and importance, Geography is mainly committed to education for sustainable improvement as well as to Global Learning. The aims, methods and contents of map reading which is an aspect of physical Geography creates the foundations for connectible vocational education in many professional areas for example, in planning, environmental protection, tourism and public and private economic development. Iwena (2017), revealed that the idea were intended to contextualize learning, connect regular encounters to the classroom, and raise the familiarity with traditional African sensibilities among students.

2.1.17 Roles of technology in the classroom instruction

The utilization of technology in teacher education to upgrade classroom is such that those promoting for the use of technology depicts a range of potential effects that new technologies have when linked to education. Bull *et al*. (2002) opines that technology application in classroom may be in the aspect of computer assisted instruction. Under this, Geography teachers may utilize the new advancements for word processing, evaluation, record keeping, website page creation and lectures.

In Geography, there has been a various effort at utilizing technology to re-conceptualize the curriculum. The application of ICT using Geography Web-Site and Video was empowered (Sofowora & Agbedokun, 2010). The effort of the Geography Association is a major addition in this regard. Every one of these endeavours is geared towards empowering the utilization of ICT to change teaching and learning of Geography. The methodology utilized was the constructivist/instructivist approach. The instructivist methodology emphasizes the utilization of computer assisted teaching of skills or Geographic information while constructivist methodology includes a dynamic process in which teachers are to help learners develop new thought or ideas as in computer simulation. The present move at reconceptualizing Geography educational module emphasizes the mixture of both instructive and constructivist approach. This is so on the grounds that it is interesting to note that technology help learners to learn in a more important and propelling settings. Accordingly, there has been call for transforming the educational curriculum (Sofowora & Agbedokun, 2010). Balderstone and Lambert (2000), recommended some innovative strategies like; inquiry strategy, project technique, drama, dialogue, modelling, film making and use of ICT. It was also observed that teaching thinking is hard and that it requires few adjustments in teaching style. These scholars therefore require a superior teaching method that will furnish the learner with concrete and genuine experience to exemplify and illuminate more genuinely, some of the principles and ideas in Geography.

Usman (2016) therefore, proposed the integration of the new technologies which would make the subject additionally fortifying and challenging as the researcher further opined that ICT is a vital necessity in teaching Geography. On the need to expand classroom effectiveness and reconceptualize the educational module using innovations Bannert and Milton (2003) said two-third of those who say they discovered school totally dull and uninteresting depict working with ICT is fascinating. Half of those who claim they behave badly at school get so excited and enthusiastic for working with computers that they would prefer not to stop.

There are various types of product of technology that are valuable for teaching Geography. They include; internet, interactive digital television, video, web-based instruction, Intelligent Tutoring Systems, photography, computers/computer Assisted instruction, video conferencing and discussion group. There are capabilities that CSI can do that other media cannot do. CSI has been discovered to be exceptionally powerful in communicating geographical information, cartography, remote sensing, simulation of Geographical System, population forecasting and other Geographical Information Systems. Today, automated and computerized maps have replaced the conventional maps. Michael (2000), spoke of its advantages: The proof plainly demonstrates that CAI teaches at least as well as live teacher on other media that, there is a saving of time to learn, that students react positively to CAI, it can be utilized to perform inconceivable veracity in branching and individualizing instructions, it will perform supernatural occurrences in processing performance information.

2.1.18 Mixed reality technologies: new opportunities for integrating science learning in secondary schools

With emerging technologies, there are expanding possibilities for science learning environments, and designers of science laboratory environments can go beyond purely physical or purely virtual laboratories (or a sequence of one than the other). There are a growing number of technologies that combine digital information with elements of the physical world, for example through the overlaying of digital information onto the real world (augmented reality), the manipulation of physical objects with computational capabilities (tangible interfaces), and the addition of touch-based feedback to computer interfaces (haptic interfaces). These “Mixed Reality” technologies are becoming increasingly less costly and may be of significant benefit to education, but we are only beginning to understand how such technologies can affect learning (Marshall, 2007). By integrating physical actions and objects with digital representations, mixed reality learning environments can be designed to tightly integrate haptic and visual perceptual modalities in ways not possible with purely physical or virtual environments or with sequential combinations of the two.

For example, actions on physical objects can be directly coupled with the formal representations of mathematics and science to allow learners to actively interpret one in terms of the other. Indeed, other researchers suggest that tightly coupling physical objects and actions with digital representations is one area where mixed reality technologies can be used to bridge the “abstraction gap” between everyday experience and the abstract, formal understanding of the domain of interest (Zufferey *et al.,* 2009).

Beyond supporting abstraction, researchers also claim that mixed reality learning environments can support student exploration and reflection, through unique mappings between the physical and digital worlds and new ways of interacting by combining the ease of manipulating physical objects with the flexibility of digital representations (Manches, *et al.*, 2009), and by creating a controlled context for physical interaction with content "from which foundational concepts can be explored and articulated" (Lindgren & Johnson-Glenberg, 2013). In recent years, there have been some initial attempts to use mixed reality environments in science classrooms. For example, SMAL Lab is a platform for semi-immersive, mixed-reality learning where students can interact with dynamic visualizations projected onto the floor through the manipulation of physical objects and through gesture (Tolentino *et al*., (2009); Birchfield *et al.* (2009); Johnson-Glenberg *et al*. (2013). It has been shown to benefit students significantly more than traditional classroom instruction (Lindgren and Johnson-Glenberg, 2013). Another approach of mixing the physical and virtual – adding force feedback to digital simulations has also been shown to support student learning (Bivall, *et al.*, 2011).

Though these approaches show some initial promise, as Lindgren and Johnson-Glenberg (2013) point out, research on the use of mixed reality technologies for learning "has been disparate, driven largely by specific technical innovations and constraints, and often lacking a clear focus on establishing their efficiency in educational contexts. For example, we know very little about how a mixed reality laboratory environment in a classroom would compare to traditional physical laboratories or purely virtual laboratories or to sequential combinations of the two.

2.1.19 The use of computers in the teaching and learning process

Thomas and Hoopers (2012) proffers that authors outline the potential value of the computer regarding particular task(s), its related interface and how they can improve fundamental assistance to both the teacher and the students. Tondeur *et al.* (2007), recognized two distinct kind of computer use by teachers, they figured out that there is the class use of computer whereby teachers use computers as an instrument for presentation and teaching students in the possibilities provided by the computers. The other ways teachers use computers in what is termed the supportive utilization of computers.

In supportive use of computer, Tondeur *et al*. (2007), revealed that teachers use computers for administrative purposes, preparing worksheets for the students and searching for data on the web for lesson preparation. It could be seen from these uses that; the emphasis was on the teacher. The teacher is the person who uses the computer to encourage his or her teaching. The students are taught the computer as a subject; they are trained on how they can use the computer to present assignments or in their quest for data. Brack *et al.* (2003), clarified that any assessment of computer utilization in education relies on its educational uses as characterised by society.

Tondeur *et al.* (2007), analyzed some universal computer curricula to figure out the aims of computer education. They discovered two fundamental aims, one of which was that, children will turn out to be digitally educated with a specific end goal to be arranged for an information-based society. The other aim is that computer ought to be incorporated in the educational program. Taking into account these aims, Tondeur *et al.* (2007), derived two sorts of computers as an educational apparatus. The computer as a subject try to emphasize learning about the computer and its uses. In this, computer is taught as a different and particular subject simply like math or physical science. This kind of computer usage seeks to teach students how to use the computer, the different parts and the essential elements of the computer as an instructive device and the use of the computer in the teaching and learning procedure. This includes the computer to encourage the teacher in the teaching of his or her lessons and how the computer can help the students boost their learning. The computer as an educational apparatus is therefore used to improve the teaching and learning procedure and that it may fit into a range of instructional methodologies, differing from customary innovative (Tondeur *et al.* 2007). These methodologies range from using power point to teach through drill and practice to complex simulations. It could be seen that the use of the computer in these groups can be categorized into two major areas: finding out about computers and gaining from computer (Goldberg & Sherwood, 2003; Tabassum, 2004).

2.1.20 Application of computer simulation in the virtual laboratory

Reesse (2013) saw computer simulation as a technique for teaching or assessing learning of set of courses content that is taking into account a genuine circumstance. The simulation triplicate a real life circumstance as nearly as would be practical, it has enable students to take part as they break down information, settle on choices and take care of the issues inborn in the circumstance. As the simulation continues, students react to the changes within a circumstance by contemplating the outcomes of their choices and ensuing activities and anticipating future issues/arrangements. Amid the simulation students perform tasks that empower them to learn or have their learning assessed.

Thomas and Hoopers (2012) revealed that simulations inspire students by keeping them effectively occupied with the learning process through obliging that critical thinking and choice making skills be utilized to make the simulation run. As the simulation runs, it is displaying a dynamic framework in which the learner is involved hence, participation in simulation empowers students to participate in system thinking and as it improves their comprehension of frameworks and in addition to social and/or science ideas. The students learning process through the utilization of computer simulation is faster than when a human teacher is available that is, learning process in which a student interact and is guided by a teacher through the course of study aimed at accomplishing certain instructional objectives (Azuka, 2003). A simulation incorporates time for reflection and processing which permits students to share their encounters, evaluate their learning and assess their appraisals against the expected results of the simulation. In addition to accomplishing the objectives of the simulation activities, students regularly get to be keen on this present reality framework on which it is based and what makes it work the way it does (Thomas & Hoopers, 2012).

Thomas and Hoopers (2012) further saw computer simulation as an instructional strategy (teaching method) that can be utilized with appropriate learning material at any level from the primary grade through graduate studies. The complexity of a simulation ought to reflect the grade level and the sophistication of the material being taught or assessed. There are published simulations accessible for purchase yet numerous teachers want to make their own. Simulation lessens expense, spares time and diminishes dangers included in practical. Additionally, it gives the students an uncommon chance to experience incident and circumstances that are not typically accessible or hard to embrace in the classroom. Another aspect of simulation is the displaying frameworks where students can construct their own particular demonstrating piece of reality.

However, while simulation just give one part of the representation of the genuine object, sight and multimedia cases offer the likelihood to study parts of reality by showing outlines of certifiable practice that can be examined and contemplated from various viewpoints (Voogt & Van der Akker, 2001). A well outlined simulation streamlines a true framework. Students can therefore, take part in the rearranged framework and figure out how the genuine framework works without spending the days, weeks, or years it would have taken to experience this involvement in the genuine sense. While utilizing simulation students are given the chance to gather their individual encounters, talk about the general standards or thoughts contained in the simulation and relate these thoughts to the present world situation. It is essential for teachers who use simulations to permit time amid the simulation for discussion (Thomas & Hoopers, 2012).

Furthermore, Thomas and Lleras (2009) found that teaching through a simulation requires a time commitment and carefully coordinated hierarchical plan from the teacher. The role of the teacher includes outlining or adjusting the simulation to fit the unique needs of a group of students, teaching contents/abilities necessary to take an interest in the simulation, observing students' interaction, monitoring and changing the simulation as a learning experience, and giving the learning activities with great excitement and interest. In addition, the teacher needs to permit time all through the simulation for discussion, perception and coaching which are superb approaches to evaluate students learning. Also, Thomas and Hooper (2012), observed that using a classroom simulation is a great deal of work yet the accomplishment of students in a well composed, suitable simulation is greatly remunerating for students and teachers and that the use of simulations can be exceedingly motivating.

Therefore, students are effectively occupied with the learning process as they take care of issues and settle on choices as is done in the adult world. Simulations provide a forum in which inventive, divergent thinking is legitimized and esteemed. Computer simulations have shown the possibility to encourage the procedure of highlighting students' misinterpretations and showing conceivable logical originations (Randy & Lara, (nd). Since simulations are considerably more like "real world" than numerous classroom strategies, students do not stop learning even when the class period is over. Their interest carried over into informal out-of-class discussions with different students and adults in which encounters and thoughts are shared and assessed. Enthusiasm bubbles and school participation is high; students get to be educational diplomats as they proceed with their discussions at home. Students portray this kind of learning as true and not boring.

In a study as reported by Gorsky and Finegold (2005), Tao and Gunstone (1997), Trundle and Bell (2005), demonstrated that using computerized interactive simulations, learners can stand up to their convictions by living up to expectations with genuine information, encountering discrepant occasions preselected by the system, or shaping and testing numerous theories they could call their own. Computerized interactive simulations offered opportunities and encouragement to go back and learn the material and try the simulation again, which has led to, in the long run success among students. Different students will volunteer to help with this additional simulation held after school or at lunch in light of the fact that it is entertaining.

2.2 Theoretical Framework

There are diverse meanings of learning which rely on the school of thought one belongs; however, learning is seen by Bigge and Sharmis (2004), as an enduring change in individual that is not proclaimed by hereditary legacy. Enduring changes in individual happen within process of development or learning or through both. On the other hand, teachers can do little about students’ development pattern, their greatest impact is on students’ learning. In addition, Nsofor (2010) viewed learning as a construct which is not directly apparent but only inferred from behaviour or activities of the learning.

Learning is a complex phenomenon that has pulled in a considerable measure of speculations. Different theories receive distinctive methods of learning that goes with the method of instruction. In addition, the educational or the learning theories informed the line and advancement of instructional outline. This study is anchored on constructivism theory of learning.

2.2.1 Constructivist theory of learning

The essential fundamental guideline of Constructivists as revealed by Badmus (2013), discovered that learners have a tendency to find important ideas and reality, through their attempts. Likewise, knowledge is seen by constructivist as an experience resulting from learner's past learning and that an individual learn best when they effectively develop their own particular comprehension. Reality is therefore, built by one's own particular exercises and this was resounded by (Kovalcik & Certo 2007).

Many noticeable constructivist that subscribed to this theory of learning according to free encyclopedia include ; John Dewey (1859–1952), Maria Montessori (1870–1952), Władysław Strzeminski (1893–1952), Lev Vygotsky (1896-1934), Jean Piaget (1896-1980), George Kelly (1905–1967), Heinz von Foerster (1911–2002), Herbert A. Simon (1916–2001), Ernst von Glasersfeld (1917–2010), Paul Watzlawick (1921–2007), Edgar Morin (1921-), Humberto Maturana (1928), Laszlo Garai (1935) and David A. Kolb (1939).

Hassmen *et al.* (2016) opined that Constructivist learning theory is based on the assumption that learning is a self- regulated activity which cannot be controlled from the outside but can be encouraged at best. In addition, constructivism learning theory is a philosophy which enhances students' logical and conceptual growth. The underlying concept within the constructivism learning theory is the role which experiences- or connections with the adjoining atmosphere- play in student education. It argued that people produce knowledge and form meaning based on their experiences. He concluded by saying that two of the key concepts within the constructivism learning theory which create the construction of an individual's new knowledge are accommodation and assimilation. Assimilation causes an individual to develop new outlooks, rethink what were once misunderstood, and evaluate what is important, ultimately altering their perceptions. Accommodation, on the other hand is reframing the world and new experiences into the mental capacity already present. Individuals conceive a particular fashion in which the world operates. When things do not operate within that context, they must accommodate and reframe the expectations with the outcomes. Hence, the primary responsibility of the teacher is to create and maintain a collaborative problem-solving environment, where students are allowed to construct their own knowledge, and the teacher acts as a facilitator and guide. And these relates to student's learning activities.

Learning theory provides an applicable framework for studying the effects of Physical and Virtual Laboratories on learning outcomes in Geography among Secondary School Students. Each learning domain is essential in science and technology education, for cognitive knowledge and skill attainment, a constructivist learning perspective is taken. The constructivist theory of learning, developed by Jean Piaget, has been used commonly in science classroom settings (Narli, 2011). The constructivist learning theory is a theoretical approach that explains how learners construct new knowledge and skills by interacting with their environment and using their prior knowledge. In a learning environment where the constructivism learning theory is practiced, individual learners construct or modify existing knowledge by initially making an interpretation of new experiences until they have constructed a personal view or understanding about the new information (Karagiorgi & Symeou, 2005).

What learners experience and interact with, within a learning environment shapes their understanding and beliefs about new ideas and knowledge. Developing a positive attitude toward the content of science and learning why the concepts are applicable to their lives allow the learners to become aware of the value of the content being discussed and as a result become engaged in the process of learning. When engaged and motivated, students look for ways to find answers to their questions in which they will construct their own understanding about a particular scientific concept. They do not necessarily have to rediscover scientific concepts, but in turn build and construct their own understandings about the scientific concept. “We learn through a continual process of constructing, interpreting, modifying of our own representation of reality that is based on our experiences with reality” (Harper., 2009). Through their daily experiences, scientists discover patterns that shape their own understanding about a scientific phenomenon; this teaching strategy promotes active learning. The constructivism theory of learning allows students to participate actively in activities, construct new knowledge, and gain an understanding about the content under study (Kim and Reeves, 2007). When students are actively seeking answers to the questions they might have about various concepts, they are building new knowledge in a relevant way to which they can relate. In this case, the knowledge is not constructed by the teacher, but rather by the students.

When applied to educational settings, constructivism learning theory identifies learners as individuals that construct knowledge by asking questions and proposing solutions (Yilmaz, 2015). With its popularity in science education and curriculum development, constructivism learning theory involves experiential and discovery learning as well. More specifically, knowledge comprehension through inquiry learning suggests that learners are independent thinkers that take necessary steps to find answers to their questions. The process of learning from a failed science experiment and reflection on experiences reveals the importance of learners' experiences in learning environments and how they can lead to the construction of new knowledge or the modification of existing knowledge.

The existing knowledge indicated that VLEs create a student-centered space where learners are able to take ownership for their learning (Morton, 2015). Although laboratory settings have previously provided these experiences, the costs and limitations are no match for the possibilities that technology has created. VSLs have opened new doors and created opportunities for students to conduct experiments that may be difficult to conduct in traditional science laboratories. In VLEs such as a VSL, students' interactions with the simulations may hinder facilitators' guidance and interaction (Corter *et al;* 2007). As a result, researchers and practitioners wonder about the effectiveness of VLEs in comparison to traditional learning environments. In VLEs, instead of interacting with a real laboratory environment, participants interact with a simulation that represents a real laboratory environment. A key question is whether a VLE can be as effective as real learning environments in promoting students' knowledge comprehension and skill development.

Inquiry, discovery, and experiential learning theories have received considerable attention from science educators and practitioners. Practicing inquiry learning in VSLs has made these technological tools an effective learning environment where students become engaged with the scientific content (Ketelhut & Nelson, 2010). What students experience and discover in a science laboratory may impact their attitude toward science and ultimately influence their performance in secondary science. In this learning process, science becomes a collection of experiences that engage students in practices that can lead to discovery learning; learners will have opportunities to become more aware of the numbers and their own thinking (Mahya, 2017).

Attitudes toward a topic or instructional approach can influence the way knowledge is comprehended and constructed (Pyatt, 2012). In the secondary science classroom, students are expected to actively question, analyze, and discuss new ideas in order to make sense of them and generate their own understanding about the concept that is being discussed. Having a positive attitude toward the subject being discussed will not only enhance students' motivation, but also provide students with a sense of being connected to the topic being discussed. The Nature of Science requires students to engage in thinking and asking meaningful questions. To master these skills, students need to stay motivated and engaged during class time. Engaged learning is generally defined as a situation in which learners are active in their learning and student activities involve active cognitive processes (Iqbal *et al.,* 2010). When students are engaged and participating in the classroom, they are active learners and stay motivated throughout the lesson. Another study by Smith and Cardaciotto (2011) concluded that active learning leads to a variety of positive outcomes, including better student attitudes, greater motivation, improvements in students' thinking and writing, greater memory for information taught, and improved exam performance.

Students with positive attitude are more likely to pay attention during course activity, take time to use effective learning and studying strategies, and seek help from others when needed (Jones, 2009). After reading many similar reviews, it is possible to assert that most educators look for ways to improve students' attitudes toward their subject matter; this will help students stay on task, participate in class discussions, and ultimately improve their content literacy.

The application of constructivism in a current technology has subsequently made it possible to influence learning through better learning procedures (Bonk & King, 2012). Simulation technology has the ability to encourage learning as it allows students to express their opinions to audience. It additionally has impacts on students' feeling to the perspectives of a more distinctive gathering of individuals in this present reality beyond classroom; every one of these conditions is ideal for constructivist learning. A principle in constructivism is to give a logical foundation to the students by teaching them different ideas. The context should place students in a circumstance like the one in which they are going to apply the knowledge where comprehension is considerably more imperative than memorizing fact. Since the majority of the contents of Geography lessons are abstract topics; the truth of the matter is students' comprehension of such subject is essential. For this reason, there is need to utilize constructivist based student focused instructional strategies (Tuysuz, 2010).

However because of the unique way of contents of map reading in Geography (map enlargement, reduction, measurement of distance and area) which serve as an essential part of the computer simulation instructional package on senior secondary Geography students, the development of the package is consequently based on constructivist theory of learning since the package affords Geography learners chances to construct knowledge without anyone else's input as a result of their strong inclusions and interactions with the learning tasks contained in the package.

Furthermore, constructivists give the Learners chance to offer meaningful knowledge resulting from their association with learning task, students must try to offer an effort to give meaning to information when the need arises. They manipulate, find outs, and are innovative to fit their conviction frameworks (Cooperstein & Kocevar-Weidinger, 2004). Accordingly, students' individual abilities, insight and inventive deduction must be accomplished through student focused instructional strategies. The idea of utilizing student focused constructivist based instructional systems is generally acknowledged, since teacher centred, traditional instructional strategies have given insufficient prospects for student to build their own learning (Tuysuz, 2010).

In the constructivist method of learning, the learning procedure is tilted towards the student-centred mode where students get to be dynamic learners and assume more liability for their own learning, and in the process, figure out how to build information all alone and focus their own particular learning results (Onasanya *et al.,* 2003). Cooperstein and Kocevar-Weidinger (2004), opines that in constructive learning, the standard classroom methodology is turned inside out on the grounds that there are no lectures neither there are presentations. For example, from the starting point, students are included in exercises in which they develop skills and secure ideas. Constructivism by and large begins with problems and as learners solve the problems, the assistance of the teacher or instructors is just to guide students in the proper direction and not to specifically impact knowledge.

Brack, *et al.* (2003), were of the view that the improvement of computer instruction ought to be in view of constructivist theory of learning as this will empower the educational planned objectives to be appropriately addressed through the development of reasonable activities with an issue based learning methodology. Brack *et al.* (2003) is also of the view that these objectives cover embedding contents in a genuine context, engaging learners in genuine activity, offering thematic connections across areas and giving obligations that empower learners to collaborate and use apparatuses that expand their awareness in the learning procedure.

Since, most of the contents of science lessons are abstract topics, to make students to understand such topics, it is necessary to use constructivist based student-centered instructional methods (Tuysuz, 2010). Because of the abstract nature of Geography content (map enlargement, reduction, calculation of distance and area) which serve as an integral part of map reading, the development of the package is therefore based on constructivist theory of learning since the package affords Geography learners opportunities to construct knowledge by themselves as a result of their strong involvements and interactions with the learning tasks contained in the computer simulation package.

While, the vast majority of the contents of science lessons are abstract in nature, it is important to use constructivist based student focused instructional strategies (Tuysuz, 2010). Because of abstract nature of Geography topics, the development of the package is therefore based on constructivist theory of learning since the package affords Geography learners opportunities to construct knowledge by themselves as a result of their strong involvements and interactions with the learning tasks contained in the virtual laboratory package.

Bada and Olusegun (2015), identify the benefits of constructivism as;

i. Children learn more, and enjoy learning more when they are actively involved, than when they are passive listeners

ii. Education works best when it concentrates on thinking and understanding, rather than on rote memorization. Constructivism concentrates on learning how to think and understand.

iii. Constructivist learning is transferable. In constructivist classroom, students create organizing principles that they can take with them to other learning setting.

iv. Constructivism gives students ownership of what they learn, since learning is based on students' questions and explorations, and often the students have a hand in designing the assessments as well. Constructivist assessment engages the students' initiatives and personal investments in their journals, research reports, physical models, and artistic representations.

v. By grounding learning activities in an authentic, real- world context, constructivism stimulates and engages students. Students in constructivist classrooms learn to question things and to apply their natural curiosity to the world.

Constructivism promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas. In view of these, constructivist is of the view that knowledge is constructed from experience and an active process in which meaning is developed on the basis of experience. Therefore, and virtual laboratories setting as an interactive environment where students have direct physical involvement with or without laboratory materials in order to study the observable fact was therefore based on constructivist theory of learning since the laboratories affords geography learners opportunities to construct knowledge by themselves as a result of their strong involvements and interactions with the learning tasks contained in the laboratories using physical and virtual tools made available on computer.

2.2.2 Conceptual design model of the study

The model highlights the variables of the study, the independent variables are Physical Laboratory (PL), Virtual Laboratory (VL) and lecture Method (LM) which are the various modes of instruction, the dependent variables of the study are Achievement, Attitude and Retention, they are regarded as the learning outcomes and the moderating variable of the study is gender (Male/Female). The independent variables of the study were assigned to the experimental groups that is, Experimental group I, II and Control group. The design is made manifest in the conceptual model shown as figure 2.1.

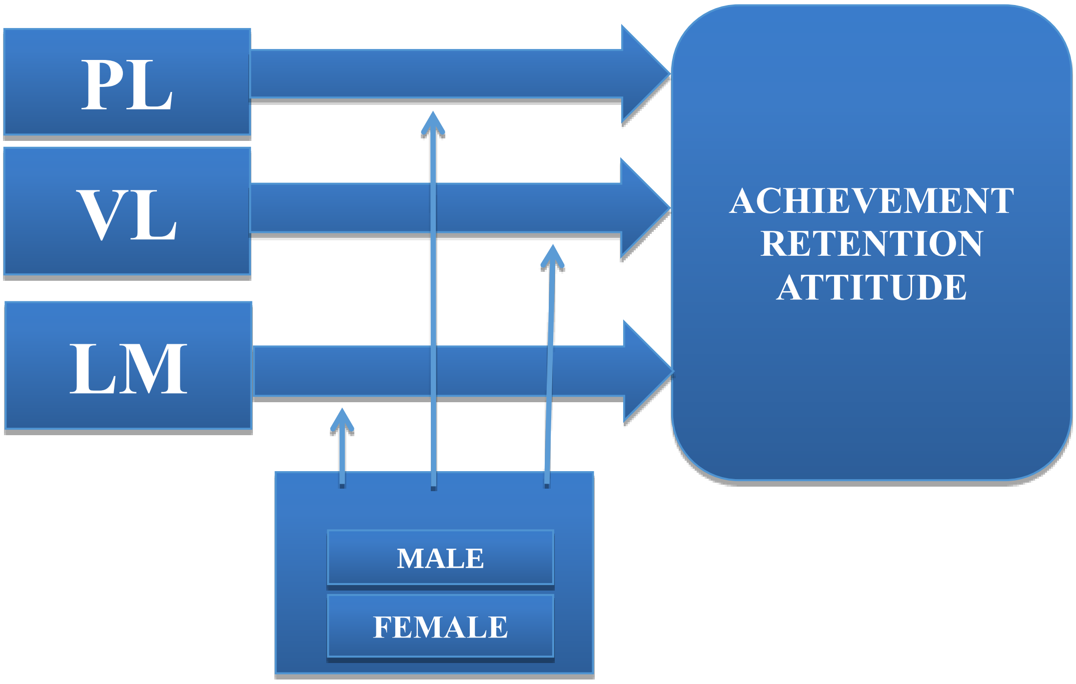

Figure 2.1: Conceptual Model of the Study

2.2.3 Instructional design model for the development of physical and virtual laboratory

Instructional design is defined as the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the process of analyzing learning needs and goals and the development of a delivery system to meet those needs. It includes development of instructional materials and activities; and try out and evaluation of all instruction and learner activities.

To develop a learning package, there are a lot of instructional design models. Examples of such models are:

i. The laboratory method model

ii. Kemp's model

iii. The Experiential Learning Model or cycle. This is also known as 'Kolb's Cycle'.
iv. Dick and Cary Design Model
v. The Hannifen Peck Design Model
vi. The Knirk and Gustafson Design Model
vii. Jerold Kemp Design Model
viii. The Gerlach-Ely Design Model

For the purpose of this study, the Laboratory Method Model, The Experiential Learning Model, Dick and Cary Design Model, The Hannifen Peck Design Model and The Gerlach-Ely Design Model were used.

2.2.4 Laboratory method model

The laboratory model as claimed by Weil *et al.* (2006) was developed by Bethel and Maine while working in the National Training Laboratory, USA. As a matter of classification, they have tried to put it in the family of social interaction models meaning that the model may need a suitable social environment and social interaction for its operation in order to realize the desired personal and social aims of education. The mechanism of the model in terms of its various elements is given here:

Focus: The laboratory method model mainly stands for the students' realization of the following goals or missions; to help the students in the development of their inter-personal or group skills leading to healthy group interaction, participation, and social development, in the development of intra-personal skills for the desired personal awareness and flexibility leading to their healthy social adjustment.

Syntax: The teaching-learning act here requires a laboratory-like setup. However, the word laboratory here does not mean the one used in the teaching of sciences. Work experience in the subjects is almost essential for the operation of this model. Actually, by laboratory-like conditions, in this model it means the place and environment where desired training in the acquisition of interpersonal and intrapersonal skills helpful for the better social development and adjustment may be properly provided. Therefore, the operational activities of the model consist of the following phases:

Phase one: providing opportunity for group work: In this phase students are expected to do some group work. It may be of academic nature as to complete an assignment to a broad area or topic of the school curriculum. There may be a project or work experience relate-related task that may need cooperative efforts of the group.

Phase two: Working in the group for the development of group skills: In this phase, the phase students themselves or under the guidance of the teacher voluntarily distribute their duties for the completion of the group work. Here, a democratic and social environment prevails for learning and getting training for the necessary interpersonal or group skills. The students acquire such skills as a matter of self-experience or are guided in the right direction through influence as well as through the planned efforts made by the teacher.

Phase three: Making provision for the development of intra-personal skills: While performing duties and working in the group for the completion of a group assignment or project, the students on the individual basis may feel one or the other types of difficulties. It may be due variety of reasons such as, inability to identify their own strengths and weaknesses, and lack of flexibility of ability to adjust according to group needs. The teacher now may help them in the task of personal awareness and, accordingly, get adjusted to the needs and requirements of the working group.

In this model, the teacher has to be quite vigilant in observing students' performance regarding their abilities and capacities both as an individual and members of the group. This means that the teacher has to help them or respond in a desired way for providing those experiences and training for the acquisition of intrapersonal as well as interpersonal skills in order to realize the individual and social aims through the organization of an instructional programme.

The social system of the model is both open and structured in so many aspects. On the one hand, it gives quite a free hand to the learners for going ahead in the completion of their group activities according to their own personal abilities and capacities, while on the other hand, it exercises desired control and provide necessary guidance and direction for making them trained in the acquisition of the necessary intra-personal skills. This model requires some additional support such as:

i. A competent and skilled teacher well versed in the art of developing inter-personal and intra-personal skills among the students.

ii. Democratic social classroom environment and other social situations helpful in developing desired social skills among the students for their adequate social adjustment.

2.2.5 Kemp's model

This model was developed based on Kemp's Model which integrates four basic components of instruction. The Virtual Laboratory is defined as a computer-assisted teaching through the integration of computer simulations with laboratory activities. Virtual Laboratory can change the concept of abstract teaching into concrete, linking the concepts learned with everyday life and students can learn at their own pace and needs. In this research, Virtual Laboratory is defined as a tool that students can use to run their own experiments using mouse to control physical actions such as pushing objects, turning objects, lifting objects, changing tools or materials, measuring material and mixing two materials. Animation and simulation concepts are used to allow students to interact with materials and apparatus to see the results of the reaction in an experiment. In addition, the Virtual Laboratory is a science experimental learning module designs with the interest of both students and teachers, and with objectives methods of assessments. So, this study is a package of teaching materials that:

i. Take into account the characteristics of the students,
ii. Learning objectives.
iii. Content based on theory, approach and learning strategies, and
iv. Assessment.

Kemp's Model has been a basic framework in the Virtual Laboratory development process. The Kemp Model has nine elements as shown in Figure 2.2. All elements are related to one another and support each other. This model is holistic and not linear. The elements in this model are not associated with the use of lines or arrows so that designers can build modules in a flexible way. In addition to develop a program does not necessarily use all the nine elements contained in this model. These elements are independent because the elements do not need to be arranged in order and not necessarily started with one particular element. However, in this research, the process of developing the instruction model starts with the process of identifying the problem which the researcher will explain the Virtual Laboratory development process from the "instruction problem" element and ends with the "evaluation instrument" element.

In the process of developing Virtual Laboratory, researchers will build a storyboard before all the information and content is translated into multimedia software. Among the aspects are given attention when preparing storyboards are the sequence of content, the strategic learning of which is using Constructivism Learning Theory and Contextual

Learning Approach, group organization, time and space allocation and the selection of resources that can be used. Other than that the elements outside the Kemp's Model are planning, support services, project management, reviews and evaluations but for this research only review and evaluation elements was applied. This is because time and cost to carry out this research are very limited. Additionally, these two elements are more appropriate to be applied in learning activities. The Evaluation involved in this study is a formative evaluation and summative evaluation in figure 2.2 are as follows.

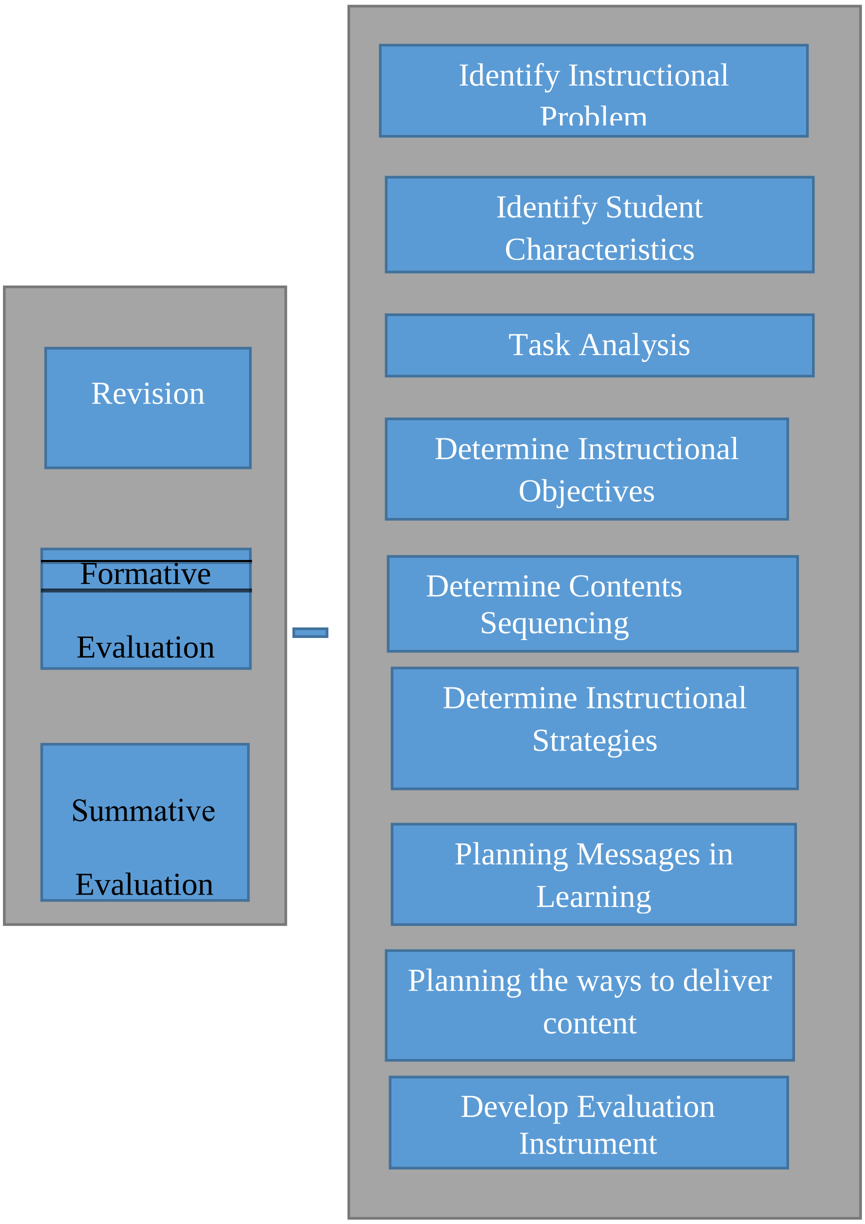

Figure 2.2: Virtual Laboratory development procedure using Kemp's Model

2.2.6 The Experiential learning model

David Kolb is renowned for this work in the development of the experiential learning model or cycle. This is also known as Kolb's Cycle. The Lewinian Experiential Learning Model' as he believes that experiential learning is tied to the intellectual origins of Lewin and Paget as shown in figure 2.3.

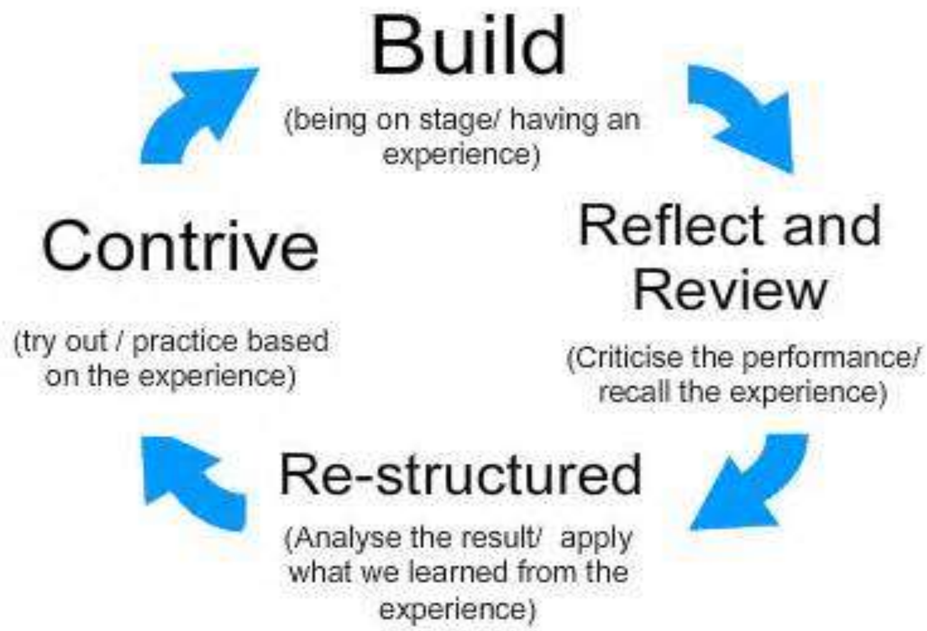

Figure 2.3: Kolb's Cycle of Experiential Learning Model

While the learning cycle can begin at any point, the learning process often begins with a person carrying out a particular action and then seeing the effect of the action. The second step is to understand the effects so that if presented with the same action the learner would be able to anticipate the action that would follow. Step three involves understanding the general principles that the action involved. The last step is concerned with the implementation of the action. Hence, these model been a basic framework in the Virtual Laboratory development process

2.2.7 Dick and Carey instructional design model

Dick and Carey's model is one of the appropriate for this research, it is a straight forward linear process which allows a structured flow to the development of instruction. By identifying entry behaviours and skills of participant's detailed scenarios were developed. This model does not require a formal needs analysis to be performed, but instead allows for the knowledge and skills of particular attending group to be analysed. Criterion referencing allows for the instructional objectives to be developed from what is required of the participant in the experimental environment. From these, a scenario was developed and modified to suit the level of expertise of the group. The type and format of the simulation was also decided upon. This involved part task trainers, low fidelity or high fidelity simulator. The delivery method was based on the objectives and the instructional goals. Formative evaluation was undertaken following each stage. A pilot scenario was run to ensure that the goals and objectives are met. Modifications to scenarios also took place. Summative evaluation was undertaken following the pilot and allows areas for change highlighted prior to the establishment of the programme. Implementation was the actual delivery of the instruction to the learners. It is during this phase that effective and efficient delivery of the material must support the learning outcomes and promote the transfer of knowledge and associated skills to the learner or participant (Yang & Heh, 2007; Braxton, *et al.*, 2011). Evaluation measures the efficiency, effectiveness, value and worth of the instruction. Evaluation must also occur during the instructional design process, as well as following the implementation phase. A formative evaluation takes place between each phase and a summative evaluation measures the overall effectiveness of the instruction. The formative evaluations allow the instruction to be improved before the final version was implemented (Smith & Cardaciotto, 2011).

Dick and Carey Model involve all of the phases described previously in the ADDIE model, commencing with identification of instructional goals and finishes with summative evaluation. This model is suitable for a variety of context areas including primary and secondary schools as well as business and government uses. It is also adaptable for a variety of users ranging from novice to expert, as the step by step descriptions aid with progress through the model as shown in figure 2.4

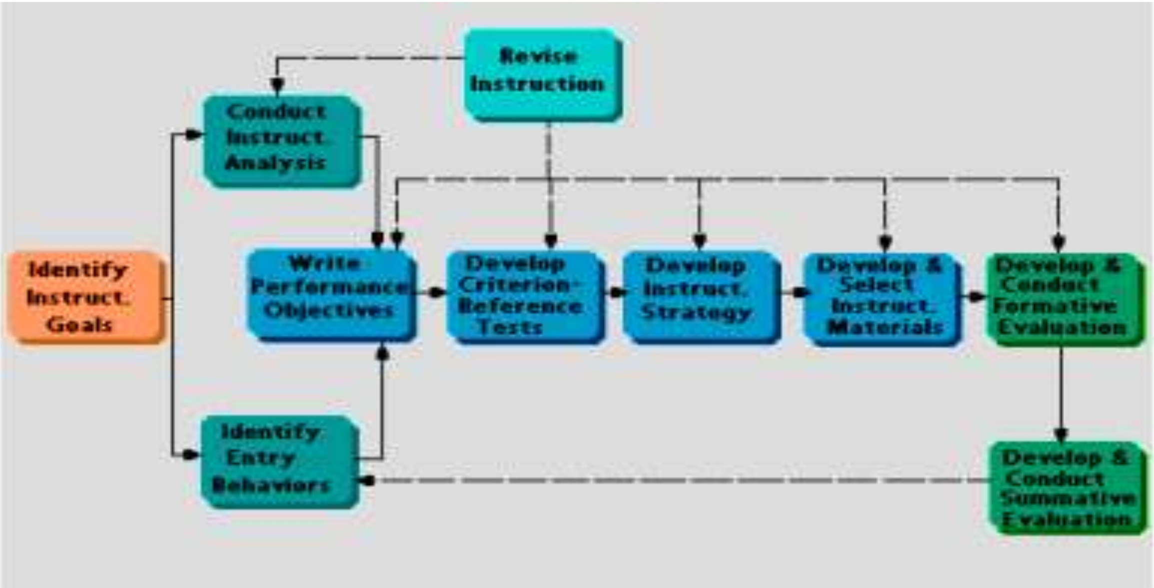

Figure 2.4: Dick and Carey Model

2.2.8 The Hannifen peck design model

The Hannifen Peck Design Mode use a three phase approach, phase one involved needs assessment being performed, this is followed by a design phase and phase three where the development and implementation of the instruction are performed. All phases include a process of evaluation; this is suitable for virtual laboratory. The needs analysis defines the goals and objectives of the programme. The design of the program is based upon the findings from the needs analysis. The development part of stage three involves how the programme was undertaken and implementation is the actual running of the programme. Evaluation and revision are a continual process. This model is one that can be used by an experienced or beginning instructional designer as shown in figure 2.5.

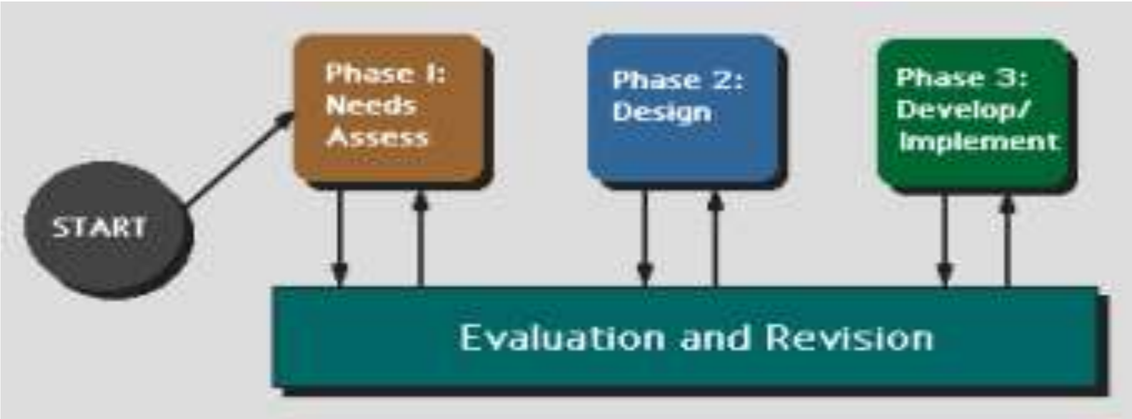

Figure 2.5: Hannifen Peck Design Model

2.2.9 The Gerlach-Ely design model

The Gerlach-Ely Design Model is a prescriptive model that is well suited to secondary and higher education sectors. The model includes strategies for selecting and including multimedia during instruction. It is a model that is suitable for beginning instructional designers who have subject matter and expertise in a context specific area. It is prescriptive in the way that it outlines how a learning environment can be changed. This model differs from the three stages Hannifin and Peck model in that there are individual processes or steps involved with each stage. This model is also good for simulation use, in particular that of scenario development as the stages lend themselves to that of software development. Again, it is a model which can be used by novices or expert designers. Because it is a procedural model, it is suited to simulation as it allows for focus on examples and practice to occur. This may be the way in which part task trainers are utilized within the instruction. Figure 2.6 is also suited to small scale nodular type of instruction which is also suited to the simulation environment.

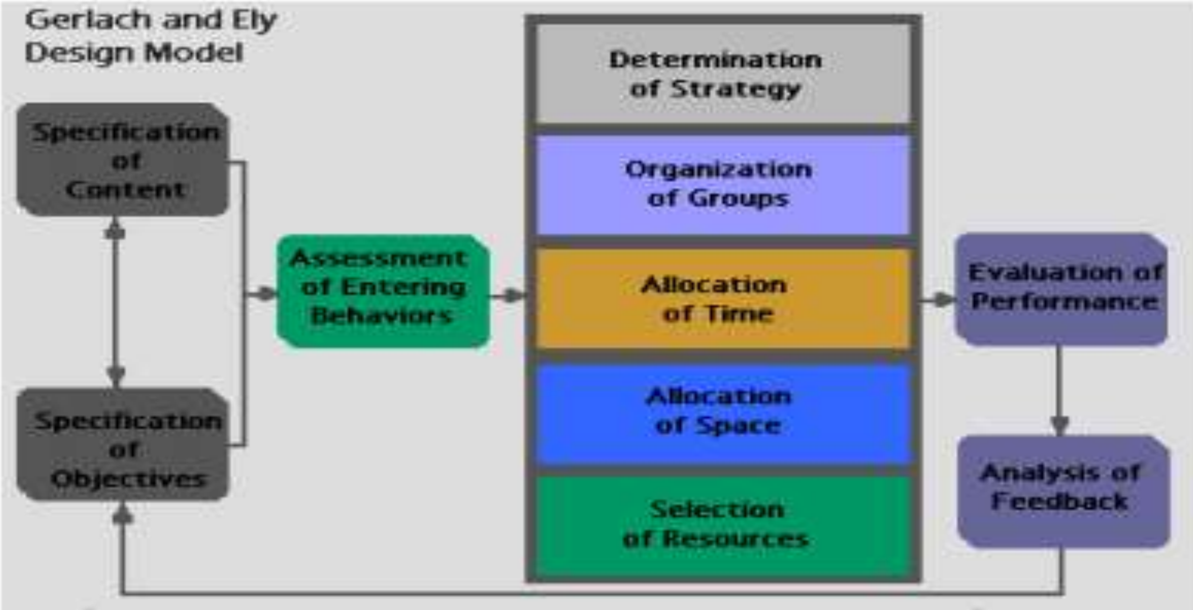

Figure 2.6: Gerlach-Ely Design Model

In summary, all the above mentioned models have base in ADDIE Model which includes analysis, design, development, implementation and evaluation.

Analyse Phase: The gap between the desired outcomes in virtual laboratory development and the students existing skills were clearly stated, in form of goals that are needed to be achieved. The designer defines the goals to be achieved in order to take care of any faults within the system.

Design Phase: In this phase, specific learning objectives, assessment instruments, exercises and content were considered. The design phase is considered as the most critical part of simulation instructional package development Gambari (2010), identified the following four important issues in designing instructional package, namely, User Considerations, Multiple Media, Delivery Control, and Interactivity.

i. **User Considerations:** A basic reality of implementing a learning package is that the user interface is the system to the users. Essentially what users want is for developers to build tools that meet their needs and are user-friendly. That, the very richness and complexity of interactive multimedia could lead to problems if the needs of the user are not given careful consideration. Gambari (2010), observed that instructional packages should take into consideration both, human computer interaction and learning theory. Failure to do so can lead to poorly designed learning package that may mislead the learners.

ii. **Multiple Media:** The main features of computer simulation instruction multimedia can be generalized into three functional groups of multiple media, delivery control and interactivity. CSI Multimedia enables learning package developers the freedom to select from a variety of media elements to express particular message in the form of text or motion to represent a process. In addition, a given piece of information can be delivered using one or more media elements. For example, an image can be employed to illustrate a text-based description. Furthermore, the information originally presented on screen can be supplemented by the use of audio, video and pop-up boxes. Audio can be useful as text can be minimized on the screen. Therefore, multimedia elements could be combined and presented simultaneously and in a variety of ways. Gambari (2010) inferred that media presentation is only one aspect of screen design and media selection must also be considered.

iii. **Delivery Control:** The non-linearity offered by many multimedia learning packages provides a learner greater navigation and freedom to learn. Users may go onto any section and in any order, in a multimedia-learning package. In addition, media such as audio and video can be controlled i.e. pausing, playing and repeating clips. Multimedia learning package could be enhanced further by including links to additional supporting materials, for example to guide a learner if he/she is lost during navigation. Such approach could help the user without consulting the instructor and could be extended to allow users to annotate the material and do their exploration.

iv. **Interactivity:** In general, the term "interaction" refers to the reciprocal action of two phenomena and has both a physical connotation (one entity operating on another) and a psychological connotation (two entities influencing each other's behaviour). User interaction with the computer by way of hardware events usually occurs in the form of mouse clicks, i.e. discrete events (Gambari, 2010). The interaction between user and learning package is thus very important. The degree of interaction with, and control of, the package could increase user motivation by making the user feel more in control if compared to in a linear-type application. Although many learning package provide some interactivity, what makes the difference even in a simple learning package is whether the package allows the user to work at his/her own pace or not (Gambari, 2010).

Development Phase: The actual creation of the learning materials is done at the development phase. When developing the resource materials for the simulation for this study, it was made sure that each item is capable of fulfilling its own specific function; fits into the general context of the exercise; is consistent with all the other materials in the package. This certainly involves a certain amount of 'tuning', i.e. revising or amending particular items as the work progresses in order to produce a self-consistent, balanced package. This stage of the development process can be thought of as a 'black box' into which you feed the basic idea for the exercise and out of which eventually emerges a prototype Computer Simulation Instructional Package. In order to facilitate user control over the lessons, the navigational interface includes moving forward and backward one screen at a time within the lesson. The cycle continues until either the user or the programme terminates the lesson.

Implementation Phase: During implementation, the package was installed on computer for students. It is important to take into account the choice of authoring tool when implementing instructional package. The selection of authoring tool needs to be reduced to one or two necessary for implementing each learning package. Furthermore, there is no one authoring tool that has all the features that meets the subject contents. Thus the developer needs to be aware of the limitations of the available tool. The following factors are to be considered in implementing instructional package:

i. **Suitability:** This is in terms of whether the software possesses the features necessary to implement the learning package. This is an important factor in the comparison of authoring tools, as generic programming languages (3rd Generation Languages) allow the programmer to do anything he/she wants. However, some authoring tools and 4th generation languages are designed for particular functions and are weak in other areas such as scripting.

ii. **Cost:**An important factor to be considered when comparing cost is the time that the developer would take to learn the programming languages. Therefore, in favour of less programming and familiarity with multimedia authoring tools, Macromedia Dream Weaver was used.

Evaluation Phase: To produce an instructionally-sound multimedia courseware package, researchers should always carry out formative evaluation of the product; evaluation at different stages from prototype to final version is important (Gambari, 2010). This prototype CSI package was checked throughout the stages of design and development so that errors could be detected. One of the main purposes of this formative evaluation was to check the basic organisation of the content and how best it could be delivered by this CSI courseware. Two Chief Lecturers that had been teaching geography in the related topics for more than fifteen years were chosen to look at the basic organisation of the content. The courseware was also tested related to its design, development and proper running before summative evaluation was conducted. Its design, development and proper operation were evaluated by educational technology and computer programmers before the instrument was taken for field validation.

2.2.10 Computer technology and gender difference

Gender issues linked to students' achievement; the fundamental centre of great concern in science education is the predispositions and misconceptions about ladies and science, i.e., science is a male enterprise (Erinosho, 2005). Gender as one of the variables investigated in this study could help clarify the assumptions and other associated issues in gender study. It includes differences in the acquisition of scientific knowledge through computer-based learning, the disparity in academic achievement, retention and other laboratory activities in Geography related to the use of computers as investigated by previous studies of Aremu (2008); Isman and Celikli (2009). Contrarily to the above, recent research studies by Akiengin (2011); Yusuf and Afolabi, 2010); Aniodoh and Ngozi (2012) found no significant difference between male and female students in science subjects.

Many research was done on gender issues in science education (Bilesanmi-Awoderu, 2002; Erinosho, 2005; Kennedy, 2000). Numerous scientists have provided reports that there are no more recognizing contrasts in the cognitive, affective and psychomotor skill achievements of students in reverence to gender (Arigbabu & Mji, 2004; Bilesanmi-Awoderu, 2006; David *et al.*, 2004; Freedman, 2002; Stanley,2000; Sungur & Tekkaya, 2003). Be that as it may, Barber and Jozefowicz (1997); Billings (2000); Croxford (2002); Eccles *et al.* (2007) Hyde and McKinley (1997); Aguele and Uhumniah (2008), in their studies found that male students performed better than female students in the cognitive, affective and psychomotor skill achievements. There is strong relationship between gender and reaction to science education. The conceivable impact of gender factor on students' academic achievement in essential science when they are taught using the cooperative learning and traditional techniques was analyzed by this study.

The issue of gender is an imperative one in Science education particularly with expanding emphasis on the ways of boosting man power for innovative improvement as well as increasing the population ladies in science and technology fields (Ogunkola & Bilesanmi-Awoderu, 2000). In Nigeria, and may be the entire of Africa, gender bias is still extremely predominant (Arigbabu & Mji, 2004). This is a perspective to which Onyeizugbo (2003), has likewise implied in indicating out that "sex roles are to some degree rigid in Africa especially in Nigeria. It is a common place to see gender difference manifesting in the everyday life of a normal Nigerian. Certain vocation and professions have customarily been viewed as men's (medicine, engineering, architecture) and others as ladies" (nursing, cooking, typing, arts). Normally, parent call young men to wash cars, cut grass, fix knobs, or climb ladder to remove things. On the other hand, tasks for example, washing dishes, cooking, cleaning et cetera, the exclusive are preserving of the young ladies.

In a nutshell, what are viewed as intricate and troublesome undertakings are dispensed to young men, though young ladies are required to handle the generally simple and less requesting assignments. As a consequence of this way of thinking, the larger society has had a tendency to see young ladies as the "weaker sex". Subsequently, a normal Nigerian youngster goes to class with these altered generalizations. Sex issues, both from the teacher and students, have been reported to influence achievement generally (Erinosho, 2005; Kennedy, 2000; Ogunkola & Bilesanmi-Awoderu 2000).

Conflicting results in gender related research should, on the other hand, be expected as studies differ in their learning settings. These incorporate the technique, population, Geography, research task, and classroom settings. There are no more recognizing contrasts in the cognitive, effective and psychomotor skill achievements of students in relation to gender (Arigbabu & Mji 2004; Bilesanmi-Awoderu 2006; David & Stanley 2000; Sungur & Tekkaya 2003). Young ladies are being empowered and sensitized into developing positive behaviour towards science. In any case, a few scientists still found that there are still huge contrasts in the intellectual, emotional and psychomotor skill achievements of students in as regards to gender (Aguele & Uhumniah, 2008).

Gender issue has been associated with student achievements in science subjects yet with no clear conclusion (Falode, 2014). The study revealed that male students performed better than female students in interactive Physics. At the same time, Anagbogu and Ezeliora (2007) found that female students performed better than their male partners using the science process aptitudes teaching techniques. Notwithstanding, Gambari *et al.* (2012), reported that gender had no impact on student's academic achievement.

Studies on the influence of gender on achievement have not produced conclusive results. Some findings indicated that significant differences existed between the achievement of male and female students while other findings showed that gender factor had no influence on students' performance (Yusuf & Afolabi 2010).

Gender differences in students' achievement have continued to be an issue in the Nigeria educational system and indeed the whole of African countries and the world at large (Farajimakin, 2010). According to Egorova (2016), despite extensive research on gender differences in mathematics achievement, many controversial issues and contradictions remain. Despite this, gender is one issue that has continued to receive attention in recent times especially in science, technology and mathematics education (Hassan, 2015). The gap on mathematics achievement based on gender distribution according to Cimpian *et al.* (2016) deserves unique consideration in schools, since that is where potential mathematicians, computer scientists, and other science, technology, engineering, and mathematics (STEM) professionals tend to reside.

The term gender according to Fan *et al*. (2016) is "a broad analytical concept which highlights women roles and responsibilities in relation to those of men, it refers to all the characteristics of men and women which a particular society has determined and assigned each sex. Ajai and Imoko (2015) refers to gender as those features that distinguish boys and girls, mostly in the cases of men and women, depending on the context, the discriminating features vary from sex to social role to gender identity. Musa *et al*. (2016) sees gender as a term which is socially constructed and could be learned and hence it can be changed. He maintained that gender is consequently concerned with masculinity and femininity as categorized to each sex in the society. Thus, gender differences in mathematics achievement and ability has remained a source of concern as researchers seek out to address the under-representation of women at the highest levels of science, technology and mathematics education (Asante, 2010). Hassan (2015), therefore, posited that gender is important in Science, Technology and Mathematics Education (STM) because it describes the social definition of sex roles rather than distinct biological distinction itself, STM is seen as subject of the male and for the female. In the United states of America (USA) since the 1960's gender has remained persistently an issue of concern (Amaechi, 2018, Farajimakin, 2010). A critical look at gender studies in America and Britain where Nigeria's educational system was adapted from; gender has been an issue in their educational research (Ejieh, 2006). This has however, made it possible for Nigerian mathematics educators to be encouraged from researches conducted on gender issues in mathematics achievement in these countries, as Nigeria educational system was built out of their educational ideologies.

2.3 Empirical Studies

2.3.1 Empirical studies on students' achievement

A study was conducted in Taiwan by Yang and Heh (2007) to see the effect of an internet virtual science laboratory on students' academic achievement. With equal numbers of students in the control and treatment group, pre and post-tests were conducted. Academic achievement, processing skills, and attitudes were the same in both groups in pre-test, while there were higher mean scores in achievement and processing skills in post-test for the treatment group. The attitudes toward computers were still the same in post-test.

The study by Jeffrey *et al.* (2011) investigates the effect of MBL systems on the achievement of high school chemistry students. The sample consisted of 124 college preparatory chemistry students at two high schools in a South Carolina school district. There were 42 participants in the experimental group and 82 participants in the control group. Both experimental and groups completed a pre- and post-test with MBL being the independent variable. Participant scores were broken down by gender, ethnicity, and socioeconomic status in order to identify potential differences. The results revealed no significant differences between the experimental and control groups, and no significant differences in effects of MBL on different segments of the population.

Mallory and Orabi (2012) Evaluating Learning Outcomes in Introductory Chemistry Using Virtual Laboratories to Support Inquiry Based Instruction. A sample of 110 undergraduate students at a university in the south western United States enrolled in Introductory Chemistry participated in this one-week study. Participants were assigned to two groups, both of which completed a virtual and expository laboratory experiment on titration along with motivation questionnaires and quizzes that were completed before and after completed each experiment. The results indicated that the interaction effect of time point and lab order group on motivation and quiz scores was not significant. One group did not show greater motivation and engagement from time 1 to time 3 than the other group nor did one group evidence greater changes in scores pre-test to post-test than the other group. Therefore, the hypotheses that virtual labs are associated with higher student motivation than traditional labs as well as virtual labs are associated with greater learning outcomes than traditional labs were not accepted.

Tatli, and Ayas (2013) examined the effect of a virtual chemistry laboratory (VCL) on students' achievement among 90 students from three different ninth-grade classrooms (an experimental group and two control groups). Study data were gathered with pre and post chemical-changes unit achievement (CCUA) Test, laboratory equipment test (LET), and unstructured observations. The collected data were analyzed using SPSS (version 16.0). Comparisons were made within and between groups. It was concluded that the developed virtual chemistry laboratory software is at least as effective as the real laboratory, both in terms of students' achievement in the unit and students' ability to recognize laboratory equipment.

Resese (2013) investigated whether virtual laboratories could replace traditional hands-on laboratories and whether students could retain the same long-term knowledge in virtual laboratories as compared to hands-on laboratories. This study is a quantitative quasi-experiment that used a multiple post-test design to determine if students using virtual laboratories would retain the same knowledge as students who performed hands-on laboratories after 9 weeks. The study was composed of 336 students from 14 school districts. Students had their performances on the laboratories and their retention of the laboratories compared to a series of factors that might have affected their retention using a pre-test and two post-tests, which were compared using a *t* test. The results showed no significant difference in short-term learning between the hands-on laboratory groups and virtual laboratory groups. There was, however, a significant difference (p = .005) between the groups in long-term retention; students in the hands-on laboratory groups retained more information than those in the virtual laboratory groups. These results suggest that long-term learning is enhanced when a laboratory contains a hands-on component. Finally, the results showed that both groups of students felt their particular laboratory style was superior to the alternative method. The findings of this study may be used to improve the integration of virtual laboratories into science curriculum.

Gambari and Yusuf (2013) examined the attitude of Nigeria secondary school students' towards cooperative learning strategies on secondary school students' performance in physics. Student in the STAD (N=48) and jigsaw II (N=42) perform better than those expose to TAI (N=41) and ICI (N=38) group. The finding revealed that the students in the cooperative learning groups enjoy working together, getting assistance and appreciate solving each other's problem. There was no significant difference between the attitude of students exposed to STAD, jigsaw II and TAI cooperative learning strategies. In addition there was no significant difference between the attitude of male and female students towards cooperative learning strategies. Furthermore, there was no significant difference in the attitude of high, medium and low achievers.

The research by Chien *et al.* (2015) analyzed high school students' performance and eye movement while learning in a simulation-based laboratory (SBL) and a microcomputer-based laboratory (MBL). Although the SBL and the MBL both used computers to collect, graph, and analyze data, the MBL involved manual manipulation of concrete materials, whereas the SBL displayed everything on a monitor. Fifty senior high school students at three urban public high schools in Taipei were randomly assigned to the MBL and SBL set-tings. The participants conducted the Boyle's Law experiment with an accompanying worksheet and completed pre- and post-conceptual tests. FaceLAB and ASL MobileEye were used to record each participant's eye movements in the SBL and MBL settings, respectively. The results showed that lower achievers improved significantly from the pre-to post-conceptual tests. This study concludes that, for e-learning like SBLs, students tend to start off doing an experiment, and then think about the questions on the worksheets, whereas for physical laboratories like MBLs, they tend to think before doing.

Adeniji *et al.* (2018), on the impact of mastery learning on senior secondary school students' achievement and retention in circle geometry. The study employed a quasi-experimental design. 172 high school students were selected through a multi-stage sampling technique. Circle Geometry Achievement Test (CGAT) was the instrument used for collecting data. The study was however authenticated of its validity by an expert and test retest was employed for determining the reliability of the instrument, 0.82 was however obtained which is reliable. The result of the study indicated a substantial difference in favours of treatment group. No gender difference was noticed on the achievement. Similarly, no difference was noticed on the achievement of low, medium and high scoring students in the treatment group. In the same vain, in the post-test mean achievement and retention score a substantial difference was found. In the light of the above, it was therefore suggested that mathematics teachers should be trained on the effective utilization of mastery learning technique for improved mathematics achievement.

Furthermore, Makinde and Yusuf (2018) in Lagos state of Nigeria, investigated the impact of flipped classroom among high school students' achievement and retention in mathematics. The study employed a quasi-experimental design with sample drawn from 268 high school students randomly assigned to experimental and control groups (145 in experimental group and 123 in control group). Performance test was the instrument employed for data collection with reliability coefficient of 0.88 using Cronbach Alpha. ANCOVA was however used for data analysis. The result of the study shows a substantial difference favouring treatment group. The result also revealed treatment improves learners' retention of achievement in mathematics. It was in view of this that flipped classroom approach was recommended as it enhanced students' academic achievement.

Khurana (2018) initiated a study in Delhi India, to find out the impact of hands-on activities in mathematics in relation to achievement and concept retention. 164 pupils form the sample of the study. A self-made test of concept retention was employed for data collection and t-test statistics was used in data analysis. The result of the study indicates a significant difference favouring the experimental group. For the retention of achievement, a significant difference was also noticed in favour of experimental group.

Aliustaoğlu and Tuna (2018) sought to find out the effects of 4MAT model in the teaching of "Transformation Geometry". 4MAT model, is one of the current instructional strategy which provides basis for learners to perceiving and processing knowledge. It was planned by taking into account the four learning styles in a way learner can discover a time interval appropriate for them. 61 high school students in a northern province of Turkey form the sample for the study. The study which lasted for three weeks adopted a pre-test-post-test control group quasi-experimental design. The period of teaching was decided having in mind the time suggested in the textbook and the time assigned for field of activities in studies carried out on 4MAT model. Lesson plans for 4MAT model was employed in teaching the treatment group while control group was taught using 7th grade textbook. Transformation Geometry Knowledge Test designed by the researcher was the instrument used for data collection. The result of the study in relation to academic achievement and retention revealed a substantial difference favouring the treatment group.

Usman (2016) investigated effects of computer simulation instructional package on secondary school geography student's achievement and attitude towards Map Reading in Bida Niger State. The study adopts a quasi-experimental research design. The sample size of the student in the experimental group was eighty two (82) (58 male and 24 female) students captured from the intact class. Similarly, seventy eight (78) (50 male and 28 female) students in the intact class of the second school tagged control school form the sample size for the control group. This gave the total sample size of one sixty (160) students.

The results of the study revealed that there is significant difference in the mean achievement scores of geography students taught map reading using Computer Simulation Instructional Package and those taught using Lecture Method. it was therefore recommended that students and teachers should be exposed to simulated environments in order to promote and encourage social interaction, active learning, learning by doing and learning by experience among other benefits.

2.3.2 Empirical studies on students' attitude

Kirk *et al.* (2006), carried out a research to investigate the attitude of secondary students enlisted in Agricultural and Environmental Science and Technology (AEST) projects and biology/business programs in Mississippi toward information technology over a three-year period (2002-2004) after completion of their separate secondary school courses. The population for the study was secondary students selected in 14 Agricultural and Environmental Science and Technology (AEST) programs and 14 Biology/Business programs from every geographical area of Mississippi. students demonstrate their level of consent to 23 statements in regards to their attitude towards information technology. Every year, students had positive attitude toward information technology. Information technology vocations are interesting for everybody, including females and minorities. One does not require strong math aptitudes or computer programming abilities to be occupied with an IT vocation. Effectively learning through the utilization of information technology help enhance communication abilities and create attractive employment aptitudes.

Dennis (2007), investigated students' attitudes and motivations toward online learning. Students in the online course completed questionnaires on attitude, interest and self-management administered during the first and last week of the online course. Generally, students' attitude toward online learning was more positive during the last week of the course than in the first week. The study however revealed that online course offered a sufficient amount of student to instructor interaction, a high amount of student to material interaction, and a low amount of student to student interaction.

Tunçok and Bezen (2010), investigated students' attitudes are towards computer-assisted language learning and foreign language learning (FLL). Factors affecting students' attitudes and the relationships among computer assisted learning, computer assisted language learning and foreign language learning were explored within the scope of the study. The findings demonstrate that most of the students have positive attitudes towards computer assisted learning, computer assisted language learning and foreign language learning. Age, grade, gender, years of studying English and prior computer assisted learning experience affect students' attitudes.

Mata *et al.* (2012) studied how certain diverse but interconnected variables like background, motivation, and social support might lead to clarification of learner attitudes towards understanding of the defining features of these attitudes in the school environment. The sample of the study consisted of 1719 Portuguese students selected from fifth-to-twelfth grade. The study adapted intrinsic motivation inventory as the instrument for data collection. One unit of the questionnaire named, (In my Math Class) measures students' perceptions of teacher and peer support as well as students' attitudes. The findings indicated positive attitudes towards mathematics and also stressed the main effects of grade and achievement on the attitudes. There was no significant gender difference though the female showed a continuous weakening in attitudes the more they advanced in school. A hierarchical examination by means of structural equation modelling showed that motivation-related variables are the central predictors of attitudes towards mathematics and that teachers and the social support of peers are also significantly important in understanding these attitudes.

In a study carried out by Awofala *et al.* (2013) to find out the impact of framing and Team Assisted Individualized (TAI) instructional strategies, employing 3×2×2 factorial matrixes, with a population of 350 senior secondary SSII students in Nigeria (172 males and 178 females) revealed a significant main effect of treatment and gender on attitude means score of subjects exposed to the TAI strategy. The finding also shows a significant attitude towards mathematics based on gender favouring male gender. There was however no substantial main effect of attitudes toward mathematics on style of categorization among the students. Similarly, substantial two ways interaction effects of treatment and style of categorization and gender on students' attitudes toward mathematics was noticed. Furthermore, no significant interaction effects of treatment and gender on students' attitudes toward mathematics. On the other hand, significant difference existed on the three-way interaction effect of treatment, gender, and style of categorization on students' attitudes toward mathematics. In conclusion, TAI and framing strategies were more effective in promoting students' attitudes toward mathematics. Hence, it was suggested that teaching method can positively change students' attitudes toward mathematics.

Study by Sundara (2014) addressed the effectiveness of a virtual science laboratory in physics instruction in terms of learning outcomes, attitudes, and self-efficacy of students in a Historically Black University College. The study included fifty-eight students (36 males and 22 female) of different science majors who were enrolled in a general physics laboratory course. They were divided into virtual and traditional groups. The results of the first experiment indicated the learning outcomes were higher in the Virtual Laboratory than in the traditional laboratory, whereas there was no significant difference in learning outcomes with either type of lab instruction. However, significant self-efficacy gains were observed. Students expressed positive attitudes in terms of liking as well as interests in performing experiments in virtual laboratories. No gender differences were observed in learning outcomes or self-efficacy. The results of the study indicated that virtual laboratories may be a substitute for traditional laboratories to some extent, and may play a vital role in online science courses.

Falode *et al.* (2015) on the other hand, investigated students' attitude towards e-examination in Federal University of Technology Minna, Nigeria, a total of 280 respondents were sampled for the study. 40 (20 males and 20 female) first year students were selected from each of the seven undergraduate schools in the institution using stratified, purposive and simple random sampling procedures. Findings of the study revealed that students have positive attitude towards e-examinations in Federal University of Technology Minna; there was no significant difference in the mean attitude score of students towards e-examinations across the seven undergraduate schools. Also, there was no significant difference between the attitude of male and female students to e-examination in the institution.

In addition, research by Garrett (2015) investigated the effects of perceptual features of science laboratory environments on learners' conceptions. The study highlight the influence of perception and action on conceptual processes, comparing and combining physical and virtual science laboratories, and technological breakthroughs in “mixed reality” technologies ,this combine physical objects and actions with digital media and how the unique perceptual-motor features of physical, virtual and combined physical virtual laboratory environments shape learners’ understanding of physics concepts. The research consisted of four experimental conditions, corresponding to four different laboratory environments: physical-only, virtual-only, sequential physical-virtual, and integrated physical-virtual. This study employed several different measures to answer the research questions, including concept tests and interviews. The findings indicated that the perceptual-motor features of science laboratory environments did indeed shape learners’ understanding of the underlying science. This research significantly contributes to the literature by examining more deeply how the perceptual-motor aspects of science.

Additionally, Falode *et al.* (2015), investigated the effectiveness of computer simulation instruction on the attitude of geography students towards map reading in Bida, Nigeria. The finding of the students revealed that the attitude of students towards map reading was significant.

A study by Keter *et al.* (2016) This was the focus of the study investigated Effect of Gender on Motivation in Chemistry Lessons when Students are Taught through Computer Based Cooperative Mastery Learning (CBCML) in Bomet County, Kenya. The study sample comprised of 238 form three students from four schools purposively chosen from 21 County co-educational secondary schools in the county. The study involved two Experimental Groups taught through CBCML and two Control Groups taught through the Conventional Teaching Methods (CTM) for six weeks. Solomon Four Non-equivalent Control Group Design was used. A Student Motivation Questionnaire (SMQ) was administered during the pre-test and post-test. The reliability coefficient of the instrument was 0.88, estimated using Cronbach's Alpha Coefficient. Data analysis was carried out using descriptive as well as inferential statistics. The differences between the group means were checked for statistical significance using t-test. The findings of the study showed that the students exposed to CBCML had relatively higher scores in the SMQ than those taught through CTM. Thus, CBCML enhances students' motivation more than CTM irrespective of gender. Therefore chemistry teachers should incorporate the use of CBCML in their teaching.

Bhowmik and Banerjee (2016) studied the relationship between achievement and attitude towards mathematics of secondary school students. The approach used for the study was a descriptive type, involving 394 secondary grade ten students from six diverse high schools. The Mathematics Attitude Scale and Mathematics Achievement Test were the instrument used for data collection. The data was analysed using independent samples t-tests and Pearson's correlation coefficient at 0.05 significant level using SPSS software. The findings revealed that in gender difference there had been significant difference on the students' attitude towards mathematics, though there is no significant difference in achievement in mathematics. Also, there is a significant positive correlation between attitude towards mathematics and achievement in mathematics.

Karjanto (2017) studies the attitude towards mathematics between the students registered in the Foundation Year Programme at Nazarbayev University. The research was carried out quantitatively, an instrument developed by Tapia and Marsh II was adopted for data collection. The inventory comprises of 40 items on the five-point Likert scale. The result indicates a positive correlation between earlier high achievement in mathematics and favourable attitude towards it. There was no significant difference based on gender of students in terms of their attitude towards mathematics.

The study by Mahya (2017) examined cognitive knowledge, attitude toward science, and skill development in virtual science laboratories. The study involved 2 eighth grade Physical Science classrooms at a large urban charter middle school located in Southern California. The Buoyancy and Density Test (BDT), a computer-generated test, assessed students' scientific knowledge in areas of Buoyancy and Density. The Attitude Toward Science Inventory (ATSI), a multidimensional survey assessment, measured students' attitudes toward science in the areas of value of science in society, motivation in science, enjoyment of science, self-concept regarding science, and anxiety toward science. A Virtual Laboratory Packet (VLP), generated by the researcher, captured students' mathematical and scientific skills. Data collection was conducted over a period of five days. BDT and ATSI assessments were administered twice: once before the Buoyancy and Density SL to serve as baseline data (pre) and also after the VSL (post). The findings of this study revealed that students' cognitive knowledge and attitudes toward science were positively changed as expected, however, the results from paired sample *t*-tests found no statistical significance. Analyses indicated that VSLs were effective in supporting students' scientific knowledge and attitude toward science.

Research by Ratamun, and Osman (2018) compared the effectiveness of Virtual Laboratory and Physical Laboratory in students' attitude towards chemistry. The students' attitude towards chemistry is compared by gender and the interaction effect between groups and gender was studied. The participants of this research are Malaysian upper secondary four science stream students. This research involved a total of 147 students, which are 64 male students and 83 female students. The two-way ANCOVA analysis showed that the effectiveness of group on the post attitude towards chemistry lesson scale (ATCLS) mean score was not significant. It concluded that the level of students' attitude towards chemistry is same when experiment is done in VLab or PLab. The effectiveness of attitude towards chemistry on gender was not significant. The analysis also showed that the interaction effect between group and gender in ATCLS is not significant. This means the group's influence on the mean score of ATCLS is not caused by the gender and the gender influence on the mean score of ATCLS is not caused by groups.

2.3.3 Empirical studies on student's retention

The study conducted by Obi *et al.* (2014) explored the effects of Origami instructional approach on JS I students' achievement, interest and retention in geometry. Six research questions and nine hypotheses were formulated to guide the study. The study adopted a quasi-experimental non-equivalent control group design and was restricted to Nsukka local Government Area of Enugu State. Two Co-educational Secondary Schools were drawn for the study using random sampling technique. Out of the two selected schools one was randomly assigned to Origami Group (OG) while the other Group (CG). A sample of 101 JS one students was involved (65 female and 36 male students). The instruments for data collection were geometry achievement test GAT) and geometry interest scale (GIS). Data collected were analyzed using mean, standard deviation and analysis of covariance (ANCOVA). The result of the study revealed that use of Origami in teaching geometry to junior secondary school students enhanced their achievement, interest and retention in geometry. The study also revealed that the use of Origami had no statistically differential effect on male and female students' achievement, interest and retention. Furthermore, there was no significant interaction between gender and instructional approach on students' achievement and interest. On the other hand, the study revealed that, there was a significant interaction effect between gender and instructional material on retention of the concepts taught during the study. Based on the findings, the researcher recommended that use of Origami should be adopted in the teaching of geometry (mathematics) in primary, secondary, and tertiary levels of education system.

Kurumeh *et al.* (2012) investigated Improving students 'retention in junior secondary school statistics using the ethno-mathematics teaching approach in Obi and Oju Local Government Areas of Benue State, the researcher used quasi- experimental design. Intact classes were used for both the experimental and control groups. Ethnomathematics teaching strategy was employed in teaching experimental group while control group was taught using conventional teaching strategy. The instrument, the Statistics Retention Test (SRT) with reliability coefficient of 0.80 was employed for data collection. In analyzing the data, descriptive and inferential statistics such as Mean and Standard deviation and ANCOVA were used to test the research questions and null hypotheses at a 0.05 level of significance.

The result of the study revealed that there was significant difference on retention between students taught using ethnomathematics teaching strategy and conventional teaching strategy in favour of ethnomathematics teaching strategy. In relation to gender achievement, there was no significant difference between ethnomathematics teaching approach and conventional approach based on gender. Thus, it was recommended that ethnomathematics teaching strategy be embraced in schools as it has demonstrated to be a workable alternative in supporting meaningful learning and positively affected students' retention of achievement.

The study of Haghighi (2013) investigates The effect of brain- based learning on Iranian EFL achievement and retention. The experimental study was designed as pre- and post-test control group model, conducted at Civil Aviation Technology College in Tehran, Iran. The study lasted 16 weeks for a total of 63 class hours. During the research process, the experimental group was administered a brain-based learning approach, while the control group was administered a traditional teaching approach. Analysis of post-test achievement and retention tests revealed a significant difference between the groups favouring brain-based learning.

Obi *et al.* (2014) investigated the effects of Origami teaching strategy on Junior secondary I students' retention in geometry. A quasi-experimental non-equivalent pre-test, post-test, control group design was adopted. A sample of 101 junior secondary I students was involved (65 females and 36 male). The instrument for data collection was geometry retention test (GRT). Data collected were however, analyzed using descriptive and inferential statistics such as mean, standard deviation and analysis of covariance (ANCOVA). The result of the study revealed that use of Origami significantly enhanced retention of achievement of geometry among junior secondary school students. The study also revealed no statistically significant difference based on gender on retention of achievement. In addition, there was a significant interaction effect between gender and treatment on retention of the concepts taught during the study. Based on the findings, the researchers recommended that use of Origami should be adopted in the teaching of geometry (mathematics) in primary, secondary, and tertiary levels of education system.

Furthermore, Makinde and Yusuf (2018) in Lagos state of Nigeria, investigated the impact of flipped classroom among high school students' achievement and retention in mathematics. The study employed a quasi-experimental design with sample drawn from 268 high school students randomly assigned to experimental and control groups (145 in experimental group and 123 in control group). Performance test was the instrument employed for data collection with reliability coefficient of 0.88 using Cronbach Alpha. ANCOVA was however used for data analysis. The result of the study shows a substantial difference favouring treatment group. The result also revealed treatment improves learners' retention of achievement in mathematics. It was in view of this that flipped classroom approach was recommended as it enhanced students' academic achievement and retention.

Earlier before the above study, Agwagah (1994) studied the effect of instruction in mathematics reading on pupil's achievement and retention among secondary school students. The objective of the study was to find out the effect of instruction in mathematics reading on the achievement and retention of rural primary school pupils in addition and subtraction of numbers. Two research hypotheses guided the study and quasi-experimental research design was adopted. One hundred and forty two primary four pupils randomly selected from two rural primary schools, one each from Anambra and Enugu states of Nigeria form the sample for the study. ANCOVA was used in analysing the data collected and findings indicated that those students who were taught mathematics reading performed better and retained more of the content taught. This study by Agwagah (1994) is related to the present study in terms of design and approach to data analysis. Conversely, it differs in scope and sample.

2.3.4 Influence of gender on students' academic achievement

Literature in connection with gender and academic achievement exists with divergent opinions and results in mathematics education (Ajai & Imoko, 2015). A large scale study in the USA revealed that there was similarity in mathematics achievement of girls and boys at the high school where a gap existed in earlier decades (Hydea & Mertzb, 2009). They asserted that females performed better than males even for responsibilities that demanded complex problem solving. In confirming this, an alternate body of researchers (Frost *et al.*, 1994); Hyde *et al*., 1990) found out that mathematics performance based on gender differences are diminishing. For example, Perie, *et al.* (2005) found that the gender differences have been narrowing down in the United States of America. The National Assessment of Educational Progress (NAEP) results based on gender rather than other variables revealed that females outperformed their male counterpart. The males made a significant gain over their 1994 score while the females remained the same. They reported a similar trend in the Carolina State Department of Public Instruction (2000).

Similarly, Eccles *et al.* (1993) affirmed in a four-year longitudinal study in Michigan that girls performed significantly higher than boys. But in a study on gender as a predictor of mathematics achievement revealed that significant achievement was in favour of females sub-group (Baharudin & Luster, 1998). Females, in general, as reported in a study supported by Campbell and Beaudry (1998) in a longitudinal study of American youth data, revealed less confidence in their mathematical ability and greater exertion of effort in mathematical classes than males.

Research in Australia shows that mathematics performance between males and females are diminishing and unstable (Forgasz & Leder, 2000). Vale (2008) discovered that several researches carried out between 2000 and 2004 in Australia revealed that there were no substantial differences in achievement in mathematics based on gender, however males were perhaps more likely to achieve higher mean scores.

In a study conducted in Russia by Egorova (2016), on gender differences in mathematical achievement among high school students and to compare various methods for identifying academic achievement, among two populations whose samples represent the Russian population in the relevant age group revealed no significant difference in mathematics achievement based on gender, Sex differences were found in all measures of mathematical achievement.

The first meta-analysis study conducted among 369 samples of school and college students from various countries revealed that females were ahead of males in 14 studies of high school students (Voyer & Voyer, 2014). However, average differences across the samples while showing better performance by girls were little. Preceding analysis of the results of studies with small samples that were not involved in the meta-analysis also established a certain, but quite modest, improvement for girls. Based on the results of standardized tests, the mathematical achievement of males and females is completely reversed; males have higher scores based on standardized methods of accessing mathematics achievement. That is, males perform better in mathematics than females in national mathematics tests as well as in international mathematics competency tests (Mullis *et al.*, 2008; Nosek *et al.*, 2009; Else-Quest *et al*, 2010; Lindberg *et al.*, 2010).

In Africa, survey research conducted by international institute for educational planning during the second southern and eastern Africa consortium for monitoring education quality survey between 2000-2002 show no significant gender difference among south African students. On the other hand, in Tanzania, Kenya, Mozambique, Zanzibar, and Malawi, male students' achievement was significantly higher than female. However, in other schools in South Africa, the differences were not significant.

Also, a study undertaken by Ajai and Imoko (2015) on gender difference in mathematics achievement among 428 senior secondary one (SS I) students, 261 male students and 167 taught using problem-based learning method of instruction of which multistage sampling technique was used from 10 grant-aided and government schools in Nigeria. The design for the study was pre–post-test quasi-experimental and Algebra Achievement Test (AAT), as the instrument for data collection. The finding revealed that there was no significant difference between achievement scores of male and female students taught algebra using PBL. The difference between this study and the current study is the sample and teaching strategy. However, the resemblance between the two studies and the above study is the gender and students' achievement in mathematics.

Musa *et al.* (2016) in their study on achievement goals and academic achievement based on gender difference among senior secondary schools' students in Borno State, Nigeria, with which correlational design was employed with a sample of 827 (414 males and 413 females) students adopting stratified random sampling. The results revealed a significant difference between the achievement of males and females, favouring males in overall academic performance. For learning goal orientation, significant difference was observed favouring male gender, however, for performance-approach and performance-avoidance goals orientation, no gender difference was noticed.

Iwendi and Oyedum (2014) studied the impact of mathematics achievement on gender and age among secondary students in Minna metropolis, Niger State. Stratified random sampling technique was used to select 195 students' intact classes. It was found out that female gender achieved better than males. In accordance with students' age, male students out performed the female students.

Ifamuyiwa (2004) study on the predictive validity of junior secondary mathematics on senior secondary mathematics, further mathematics and physics. The study adopted an ex-post facto design, using 400 students who participated in JSCE in 2010 and SSCE in 2013, and randomly selected from twenty (20) secondary schools – 10 from Delta and 10 from Edo State. The JSCE scores and SSCE scores were extracted from school record files. Regression analysis was used to estimate the parameters of the specified equations. The results established that there is a significant relationship between scores obtained by students in Mathematics at the JSCE and the scores they obtain in the same subject at the SSCE. The results also indicated that location of the State has a significant effect on the scores obtained by students in SSCE Mathematics, results suggest that Mathematics at the JSS should be taken seriously by students to enhance better performance in the subject at SSCE.

Tabassum (2004) in a study on the effect of computer-assisted instruction as a supplementing strategy on the academic achievement of secondary school students in science in Islamabad also examined the influence of gender. Result indicated that computer-assisted instruction was found equally effective for both male and female students. Fagbemi (2004) in another study on the effect of a self-instructional computer-based package on social studies achievement of senior primary school pupils in Niger State, Nigeria also examined the influence of gender on the achievement of pupils taught with the self-instructional computer-based package. Result indicated that male and female students taught social studies with self-instructional computer-based package did not perform significantly different.

Onasanya *et al.* (2006) investigated the effect of Computer Assisted Instructional (CAI) packages on the performance of secondary school students in Introductory Technology in Ilorin, Kwara State, Nigeria. Forty two (42) students were used. A researcher-designed Computer Assisted Instructional package was designed validated and administered to some students of Introductory Technology while the other students were taught the same topic using conventional method. Percentages were used for demographic information while t-test statistical method was used to test the hypotheses at 0.05 level of significance. The result of the findings revealed that students using the

CAI package performed better than those using the conventional method. There was no significance difference between the performance of the male and female students of Intro-Tech exposed to individualized CAI while female students of introductory technology exposed to co-operative CAI performed better than their male counterparts.

Dalton *et al.* (2006)found out the effects of individual and cooperative computer-assisted instruction on student performance and attitudes from five hundred and eighty eight (588) students were randomly selected into individualized and cooperative group. On an attitude measure, interactions were detected between instructional method and gender, as well as among instructional method, gender, and ability. High-ability male and female students reported comparable attitudes toward each instructional method, Low-ability male students responded most favourably, while low-ability female students responded least favourably to individualized methods, and low-ability female students responded most favourably and low-ability male students' least favourably to cooperative methods.

Gambari and Mogbo (2006) conducted a study on the effect of Computer-Aided Learning package on students' Physics achievement at senior secondary school in Minna, Nigeria,. Using a Pretest-Posttest Experimental group design. The reliability coefficient of the research instruments were .71 and .82 using Kuder-Richardson KR-20 and 21 respectively. Some 90 (45 male and 45 female) students from three secondary schools in Minna, Nigeria made-up the sample. The schools were randomly assigned to experimental group I (STAD), experimental group II (LTM) and control group (Individualized Computer Instruction, ICI). Results revealed that the students taught with STAD and LTM performed significantly better than their counterparts taught using individualized computer instruction (ICI). The cooperative learning strategies were found to be gender friendly. Based on the findings, physics teachers should be encouraged to use computer-assisted STAD cooperative teaching strategy to enhance students' academic achievement, retention and motivation in physics.

Rodger, Murray and Cummings (2007) investigate gender differences in achievement of university students who were randomly assigned to either cooperative or competitive teaching methods. After viewing a videotaped instruction on research design, participants completed a mini-assignment either individually in the competitive condition or with a same-gender partner in the cooperative condition. All participants individually completed a multiple-choice test to assess achievement. Although no differences were found on the multiple-choice test, on the mini-assignment, women scored significantly higher in the cooperative than in the competitive condition, whereas men performed equally in both conditions.

Anagbogu and Ezeliora (2007) conducted a research to examine gender differences in scientific performance of boys and girls in some selected secondary schools in Awka Education Zone, in Anambra State. The boys and girls were assigned to experimental and control groups respectively. The study showed that girls performed better than boys did. Ifamuyiwa and Akinsola (2008) conducted a study on the effects of self and cooperative-instructional strategies on senior secondary school students' attitude towards Mathematics. The moderating effects of locus of control and gender were also investigated. Students from six purposively selected secondary schools in Ijebu-North Local Government Area of Ogun State participated in the study. Findings showed that the treatments had significant main effect on students' attitude towards Mathematics. The participants exposed to self-instructional strategy had the highest post-test mean attitude score. The study found no significant main effects of locus of control and gender on the participants' attitude towards Mathematics.

Geist and King (2008) reviewed Different, not better: Gender differences in mathematics learning and achievement. This article reviews the literature and research on differences in boys and girls and concludes that there are differences in the way boys and girls learn and process mathematics and that this difference is not being taken into account by our educational system. The assumption is that there is a difference between boys and girls that make boys predisposed to do better in mathematics. Data from the National Assessment of Educational Progress disputes this assumption. The NAEP shows a gap of only 2 points between girls and boys and that has developed only in the last decade.

Iwendi (2009) investigated the influence of gender and age on the mathematics' achievement of secondary students in Minna metropolis, Niger State. One hundred ninety-five students from intact classes were selected by stratified random sampling from purposively chosen schools. The findings showed that younger female students outperformed their male counterparts, whereas the older male students performed better than older female students.

Gambari *et al.* (2012) examined examined the influence of virtual laboratory strategy on the achievement of secondary students in physics practical in Minna, Nigeria. Pretest, posttest experimental and control groups design was adopted. Three hypotheses were formulated at 0.05 level of significance. Two co-educational secondary schools were selected from Minna metropolis for this study. The sample consists of thirty two (32) senior secondary two (SS II) physics students. 16 students were randomly selected from each school and assigned Experimental and Control groups. The experimental group (n =16) was exposed to virtual laboratory strategy while the control group (n = 16) was exposed to conventional laboratory method. Two research instruments were used in this study: (i) Practical Physics Achievement Test (PPAT) was used as a testing instrument, it comprised of 40-item multiple-choices physics achievement test; (ii) Virtual

Laboratory Strategy Package (VLSP) was used as a treatment instrument, made up of three components (text, video and simulated experiment). The instruments were validated by experts. The Kudar-Richardson (KR=21) formula yielded 0.92 reliability coefficient. t-test, mean and standard deviation were used to test the hypotheses at 0.05 levels of significance. The results from the findings revealed that students' taught physics practical using virtual laboratory strategy performed better than those taught using conventional laboratory method. There was no significant difference between the mean achievement scores of male and female students taught physics practical using virtual laboratory strategy. Students' taught physics practical using virtual laboratory strategy performed better in retention test than those taught using conventional laboratory method. it was recommended that virtual laboratory strategy should be used to supplement physics practical in conventional laboratory setting or adopted as alternative in the absence of physics standard condition for laboratory activities.

2.3.5 Summary of reviewed literature

From the literature reviewed, it can be seen that researchers and specialists have worked differently on the issues and prospects of Geography. The significance of Geography as a subject in the school educational program examined, highlighted, and described and citation of various work on achievements, attitude, and retention in Geography at the senior secondary school level in Nigeria. The writing on the conceptual framework looked into the physical and virtual laboratory, laboratories in the 21st century, and several works on physical and virtual laboratories. Additionally, the theoretical framework evaluated broadly; the work is anchored on constructivist theory.

From the review of literature carried out on theoretical framework and for the development of virtual laboratory, authors and researchers revealed how constructivism bolstered the use of instructional packages as this will enhance the development of actual activities with a problem-based learning approach which assists learners to be keenly involved and construct facts within the limit of the learning environment, the development of the package was consequently, based on the constructivist theory of learning In order to permit Geography learners to construct knowledge by themselves, have strong connection and interactions with learning tasks.

The researches carried out in the laboratory on students' achievement establish that laboratories enhance students' achievement in science subjects. While bulk of these studies were carried out in various concepts in sciences subjects on students in both developed and developing countries, this present study examined the effects of Physical and Virtual Laboratories on learning outcomes in Geography among Senior Secondary School Students in North-Central Nigeria.

The review of literature carried out on effect of gender on students' academic performance revealed that while some studies clarify that gender does not influence students' academic achievement, some show that it influences but in support of male gender while, some also go in support of female. In addition, the review of literature carried out on the attitude of Geography students' academic achievement revealed that while some studies revealed that most of the students have positive attitudes towards geography and other science subject in secondary schools some studies show that students' attitude towards computer is not encouraging

However, from the review, it was noted that many of the studies were focused on some parts of science education, few researchers have looked into the different effect of laboratory approaches on students' academic performance in Geography. In addition, some of these studies did not make use of computer as a means of instructional delivery.

Based on these facts, the present study examined the effect of physical and virtual laboratory.

This study is different from numerous researches reviewed in the following ways: geographical scope of the study, subject scope, time scope sample size, subject area, instructional approach, computer software, and method of data analysis. Also, most of the studies reviewed were carried out in developed countries and those conducted in Nigeria were in urban centres different from where this present study was conducted.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

The study adopted quasi-experimental research design, in which pre-test, post-test non-equivalent group design was used. The design entails the use of non-randomized sample where the researcher cannot randomly sample and assign subjects hence intact classes were used. This is because the school activities did not allow randomization of the subjects of the study without disrupting the school programmes, therefore separate intact classes were used as experimental group I, experimental group II and control group respectively. The research design layout is shown in Table 3.1.

Table 3.1 Research Design Layout

Grouping	Pre-test	Treatment	Post-test	Post-posttest	Attitude
Experimental Group I (PL)	O_1	X_1	O_2	O_3	O_4
Experimental Group II (VL)	O_5	X_2	O_6	O_7	O_8
CONTROL Group (LM)	O_9	X_0	O_{10}	O_{11}	O_{12}

Where:

O_1, O_5, O_9 = Observation of pre-test for the experimental and control groups

O_2, O_6, O_{10} = Observation of post-test for the experimental and control groups

O_3 O_7 O_{11}= Observation of post-posttest for the experimental and control groups

O_4 O_8 $O_{12=}$ Observation of attitude for the experimental and control groups

X_1; = Physical Laboratory

X_2, = Virtual Laboratory

X_o; = Lecture Method

3.2 Population of the Study

The population for this study was the entire 819,908 geography students in the Senior Secondary school of 2018/2019 session in North Central Nigeria. The target population was senior secondary school Geography students in SSII. The choice of year two senior secondary school class was based on the fact that it is the most stable class, which were neither learning geography for the first time nor were they preparing for any examinations, which could jeopardize the outcome of this study. The geography concepts focused are seen as complex and falls under the SSII syllabus and scheme of work.

3.3 Sample and Sampling Techniques

The sample of this study was 768 students (Exp I; 242= Males= 147, Females= 95); (Exp II; 269= Males= 159, Females= 110); (Control group; 257= Male=185, Female= 72) from 12 co-educational public senior secondary schools in North-Central Geopolitical Zone of Nigeria as seen in the demographic distribution of samples for the research study in (appendix D page 198). The zone comprises Niger, Kwara, Kogi, Benue, Plateau, Nasarawa states and the Federal Capital Territory (FCT). The states in the zone were clustered into three regions A, B and C. Out of the three regions, one state was selected in each region using random sampling

Subsequently, four schools were purposively chosen from the state and assigned to the experimental group; I, four schools assigned to experimental group II and four schools assigned to Control Group. The reason for the purposive sampling of the schools was to select schools with the same environmental conditions, such as manpower, gender composition, exposure to computer use, and school type (public schools).

Separate schools were used for the research study to avoid the interaction of subjects during and after the treatment process. An intact class was selected randomly from each sampled arms and used for the study. The stream (Arm) of each school selected from the three states was assigned to; experimental group I, experimental group II, and control group.

3.4 Research Instruments

Three research instruments used for this study were: treatment Virtual Laboratory Package (VLP), Test instrument Geography Achievement Test (GAT) and Questionnaire on the attitude of students towards Geography (QASG).

3.4.1 Treatment instrument

3.4.2 Development of virtual laboratory package (VLP):

. **Development of virtual laboratory package (VLP):**

Virtual laboratory package on Nigerian Secondary school Geography Concepts enables geography students' hands on experience in the areas of contour representation of land forms, cross section drawing and representation of relief features on the maps and how it actually looks like in reality; these was developed by the researcher through the following procedures:

i. Straight line was drawn on computer to join the two point X and Y,
ii. A straight edge of piece of graph was then placed on the map along the line of section (X-Y) through computer simulation.

iii. Point Y-X was marked on graph paper where each contour line is crossed to note the height of the contour.
iv. Point of intersection was marked at appropriate height.
v. The lines were join up the various point and cross section was completed.

This procedures were achieved by using Adobe Flash Professional as the development environment and Actionscript 3.0 for the logic.

Adobe flash professional is a multimedia authoring and computer animation program developed by Adobe Systems. This program helps in developing interactive animations, games, images, presentations and other media.
ActionScript 3.0 is a powerful, object-oriented programming language that signifies an important step in the evolution of the capabilities of the Flash Player runtime. ActionScript is used primarily to develop websites and software targeting the Adobe flash player platform, used on web pages in the form of embedded SWF files.

The virtual laboratory is a combination of different keyframes arranged in a timeline; each keyframe contains different entities, e.g. texts, images, audio files, buttons. The timeline is arranged in such a way that it plays different scenes from the combination of key frames depending on user interaction (click of a button or graphic).

Development of Virtual laboratory manual

On the other hand in the physical laboratory set up, students were instructed to construct a straight line using a model to join the two point X and Y, a straight edge of improvised piece of graph was then placed on the models along the line of section (X-Y), point Y-X was marked on the graph subsequently, each contour line crossed to note the height of the contour. They were further instructed to mark out point of intersection at appropriate height to join up the various point to complete cross section. Then features were marked with different alphabets to represent different features as identified by students.

3.4.3 Development of test instrument

Geography Achievement Test (GAT) consisted of 30 multiple-choice items drawn from the three concepts taught. It was made up of four option answer (A-D) with only one correct answer. The Geography achievement test was used for the pre-test, post-test and retention test, at each point in the administration, the questions were reshuffled to create an impression as if the questions differ from one another. The test was used to obtain data on students' achievement before and after the treatment. This was to determine the possible pre-existing differences in the overall aptitude between the experimental and control groups.

3.4.4 Development of test instrument (GAT)

Geography achievement test comprising of 30 multiple choice items was developed by the researcher. The test was designed to measure the six levels of cognitive domain of the students. The number of items measuring each domain level is shown in table of specification in table 3.2. The necessary procedure for test development i.e. preparation of table of specification. The students were required to indicate the correct answers by ticking or circling the right answers corresponding to the questions. Only one option was the correct answer from the options A-D. The test was comprise of two sections which the students were expected to respond to, these includes; section A; designed to obtain information on students' biography such as; school, class sex and date. Section B will elicit information on the student cognitive level based on learned materials, the test items covered different levels of understanding based on Bloom's taxonomy of educational objectives (i.e. Knowledge, comprehension, analysis, synthesis, activity and application of knowledge). See Table 3.2 below.

Table 3.2: Table of Specification

Content	Knowledge	Comprehension	Application	Analysis	Synthesis	Activity	Total
Topic 1	2	2	2	1	2	1	**11**
Topic 2	2	2	2	2	1	1	**9**
Topic 3	2	2	1	2	1	2	**10**
Total	6	6	5	5	4	4	**30**

3.4.5 Questionnaire on attitude of students towards geography

Questionnaire on Attitude of Students towards Geography (QASG) was divided into two parts, Part one consisted of bio-data of students, while part two consisted of twenty items on the attitude of students. Students were required to respond to the options that correspond to their opinions on the following: strongly agreed (SA), Agreed (A), Disagreed (D), Strongly Disagreed (SD), and. The items were scored on the basis of the weight of each point. That is, 4, 3, 2, 1 for SA, A, D, SD for the items respectively (Appendix E, Page 200).

3.5 Validation of Instruments

Virtual laboratory Package was validated by Educational Technology expert in the Department of Educational Technology, Federal University of Technology, Minna. The expert determined appropriateness of the package in terms of clarity, navigation, simplicity and logical presentation of the simulated concepts of the package. The experts verifies the suitability of the graphics, simulations, text, colours, sharpness, clarity and clarity of the voice recording (narration). Geography.

Achievement Virtual Laboratory development procedure using Kemp's Model (2007).t Test (GAT) was validated by Geography experts from Geography Department, Federal University of Technology, Minna, and a Geography teacher from secondary school not among the schools in the study area. The QASG was validated each by an expert of counselling psychology from Ibrahim Badamasi Babangida University, Lapai. These experts examined the face and content validity of the instrument using the following criteria: the simplicity of the Formats and its suitability for the level of students, the subject matter coverage and accuracy. The instruments were later edited and modified based on the comments, criticisms, and suggestions of the experts. After the validation, the instruments were then used for the study.

3.6 Reliability of Research Instruments

In order to determine the reliability of the instruments, a pilot test was conducted within the targeted population but outside the school sampled for the study. The result obtained from pilot test conducted was used as reliability test of the instruments. The test was administered to SS II Geography students, randomly selected using test re-test method. Pearson Product Moment Correlation formula was used to determine the reliability coefficient of GAT which yielded 0.76 while, Cronbach Alpha formula was used for QASG which yielded 0.70 indicating that the instrument is reliable for the study (Appendix I page 244).

3.7 Method of Data Collection

The researcher visited the school authorities of all the sampled schools before the commencement of the experiment to seek for their official permission with a letter from the Head of Department, Educational Technology, Federal University of Technology, Minna to use their students and to intimate the subject teachers of researcher's intentions. These was followed by random selection of classes (Arms) that was used for the study in all the twelve schools. To control teacher-effect factor, the Geography teachers of the sampled school were trained as research assistants for a period of one week on the implementation of the instruments. The training of the research assistants was based on the objectives, modalities and procedures involved in using VL, PL and CLM. The role of the research assistants was to help the students solve any problem that may arise from the usage of PL and VL, by ensuring that they follow the instructions strictly and maintain discipline during and after the treatment session.

To control or minimize teacher quality variables and ensure homogeneity of standard, the researcher prepared a lesson plan which was used by trained research assistants in teaching the entire PL, VL and CLM groups. During the third week, an achievement test was administered to all sampled participants in the zone as a pre-test to determine their entry behaviour in the subjects. Treatment commenced in the fourth to seventh week in all the sampled schools in the state. Subsequently, the test instrument (GAT) and questionnaire on the attitude of students towards Geography (QASG) were administered to all the sampled schools in the zone at the eighth week as post-test. At each point of GAT and QASG administration (pre-test, post-test and delayed post-test) the test items were reshuffled so that they differ from the first one to create an impression that the pre-test, post-test and delayed post-test questions were different from one another.

After two weeks of post-test administration, all the sampled schools in the zone were subjected to a retention test at the 12th week, as seen in the research data collection design below. The scores of pre-test and post-test were collected and subjected to data analysis. For the scoring purpose, each item in (GAT) was scored one mark (30 marks).

The design below illustrates the data collection process involving the three independent variables of the study such as VL, PL and CLM, the treatment period, administration of pre-test and post-test in each of the three zones of the study and in each of the four schools sampled as shown in figure 3.1.

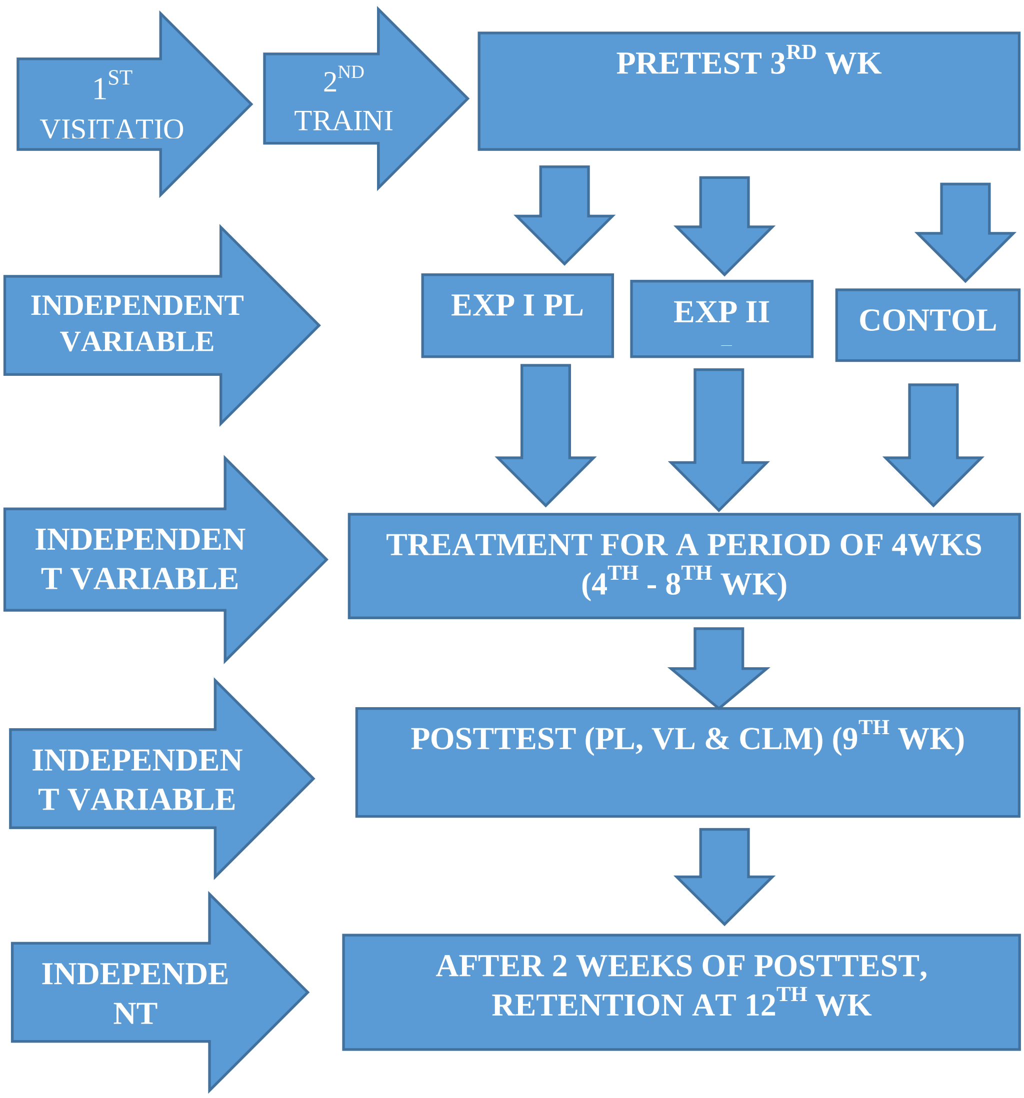

Figure 3.1: Research Data Collection Design (RDCD)

3.8 Method of Data Analysis

The data collected were analyzed using inferential and descriptive statistics, mean and standard deviation were used to answer research questions using Statistical Package for Social Sciences (SPSS) version 23. The significance of the statistical analyses was ascertained at 0.05 alpha level of significance. Geography Achievement Test (GAT) a 30 – item covering topics in physical Geography was used to collect data for both pre and post achievement test, while Questionnaire on Attitude Students Towards Geography (QASG) was used for collecting data on attitude of students towards geography. Objectives 1, 2, 3, 4,5 and 6 were achieved by administering GAT while, objective 7, 8 and 9 were achieved by administering attitudinal questionnaire. Since difference existed at pre-test, ANCOVA statistics was used for GAT analysis. However, ANOVA statistics was used for QASG analysis. The pre-test scores were used as covariate the post-test scores. Where significant difference is observed on the effects of the three modes of instructions, multivariate analysis was conducted (Sidak Post hoc)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Pre-test of Experimental I, Experimental II and Control Group

The purpose of pre-test given to experimental group I, experimental group II and the control group was to establish the equivalence of the three groups before the commencement of the study. To analyze the pre-test scores, the mean scores and standard deviations of the groups were computed and compared using Analysis of Variance (ANOVA). The results of the analyses are presented in Table 4.1 and 4.2

Table 4.1: Mean and Standard Deviation of Scores of Experimental I, II and Control Group

Groups	N	$\bar{X}$	SD
Experimental I	242	44.68	10.63
Experimental II	269	43.02	11.47
Control Group	257	40.25	11.31

Table 4.1 presents Mean and Standard Deviation scores of geography students in Experimental Group I (physical laboratory), Experimental Group II (virtual laboratory) and Control Group (lecture methods) at pre-test. The analysis of the table shows that Experimental Group I had mean scores of 44.68 with standard deviation of 10.63, Experimental Group II had mean scores of 43.02 with standard deviation of 11.47 the Control Group had mean scores of 40.25 with standard deviation of 11.31 at pre-test. The Experimental Group I has a higher mean score than the experimental group II and control group at pre-test. This implies that the experimental group I has a higher achievement score than the experimental group II and control group at pre-test. As a

result of this detected difference in mean achievement scores, ANOVA was carried out to determine whether the observed difference in the mean score are significant.

as shown in Table 4.2

Table 4.2: Summary of ANOVA Result of Pre-test Mean Scores of Experimental Group I, II and Control Group

Group	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2508.167	2	1254.084	10.075	.000
Within Groups	95219.286	765	124.470		
Total	97727.453	768			

*: Significant at 0.05 level

Table 4.2 shows the ANOVA comparison of pre-test scores of Experimental Group I, Experimental Group II and the Control Group. An examination of the Table shows a significant difference in the pre-test scores of the three groups ($F_{(2,765)} = 10.075$ $p < 0.05$). This implies that the three groups were not equivalent before treatment was administered. Hence, Analysis of Covariance (ANCOVA) was used to test the hypotheses generated from this research.

4.2 Post-Test Results for the Achievement Scores of Experimental I, II and Control Groups

Research Question One:

Is there any difference in the mean achievement scores of students taught Geography using physical laboratory, virtual laboratory and lecture method?

In answering research question one the pre-test and post-test mean achievement scores of experimental group I, II and control group were analyzed using mean and standard deviation as shown in Table 4.3

Table 4.3: Mean and Standard Deviation of Pre-test and Post-test Achievement Scores of Experimental Group I, II and the Control Group

Group	N	Pre-test		Post-test		Mean difference
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental Group I	242	44.69	10.63	80.62	9.68	35.93
Experimental Group II	269	43.02	11.47	78.02	11.47	35.00
Control Group	257	40.25	11.31	73.12	11.56	32.87

Table 4.3 shows the mean and standard deviation achievement scores of experimental group I, experimental group II and control groups at pre-test and post-test. From the result, it can be deduced that the mean and standard deviation scores at pre-test and post-test for Experimental Group I (physical laboratory) as = 44.69, SD= 10.63 and $\bar{X}$= 80.62, SD= 9.68 respectively. This gives the mean difference of 35.93 in favour of post-test. Similarly, the mean and standard deviation scores at pre-test and post-test for Experimental Group II (virtual laboratory) are $\bar{X}$= 43.02, SD= 11.47 and $\bar{X}$= 78.02, SD= 11.47 respectively. This gives the mean difference of 35.00 in favour of post-test. On the other hand, the mean and standard deviation scores at pre-test and post-test for the Control Group (lecture methods) are $\bar{X}$= 40.25, SD= 11.31 and $\bar{X}$= 73.12, SD= 11.56 respectively. This gives the mean difference of 32.87 in favour of post-test. The table also reveals that Experimental Group I, II and control group had a mean gain of 35.93, 35.00 and 32.87 respectively and with experimental group I having the highest mean gain of 35.93. As a result of this identified difference in mean achievement scores,

hypothesis I was tested at 0.05 level to determine if the observed difference was significant.

Research Question Two:

Is there any difference in the mean achievement scores of male and female Geography students taught Geography using physical laboratory?

4.2.1 Post-test results of Male and Female Geography students of experimental Group I

Research Question Two

In answering research question two the post-test mean achievement scores of male and female students taught geography using physical laboratory were analyzed using mean and standard deviation as shown in Table 4.4.

Table 4.4: Mean and Standard Deviation of Achievement Scores of Students taught Geography through Experimental I (Physical Laboratory) based on Gender

Gender	N	Pretest $\bar{X}$	SD	Posttest $\bar{X}$	SD	Mean diffrence
Male	147	45.02	10.38	80.57	9.4071	35.55
Female	95	44.15	11.04	80.71	10.1467	36.56

Table 4.4 shows the mean and standard deviation of male and female students taught Geography using physical laboratory at pre-test and post-test. From the table, it can be deduced that the mean and standard deviation scores at pre-test and post-test for the male students) are $\bar{X}$= 45.02, SD= 10.375 and $\bar{X}$= 80.57, SD= 9.407 respectively. This gives the mean difference of 35.55 in favour of post-test. Similarly, the mean and standard deviation scores at pre-test and post-test for the female students are $\bar{X}$= 44.15,

SD= 11.041 and $\bar{X}$= 80.71, SD= 10.362 respectively. This gives the mean difference of 36.56. in favour of post-test. As a result of this identified difference in mean achievement scores, ANCOVA was used at 0.05 level to determine if the observed difference was significant as presented in table 4.4.

4.2.2 Post-test results of Male and Female of experimental Group II

Research Question Three:

Is there any difference in the mean achievement scores of male and female Geography students taught Geography using virtual laboratory?

In answering research question three the post-test mean achievement scores of male and female students taught geography using virtual laboratory were analyzed using mean and standard deviation as shown in Table 4.5

Table 4.5: Pre-test and post-test achievement scores of male and female students taught Geography through virtual laboratory

Group	N	Pre-test		Post-test		
		$\bar{X}$	SD	$\bar{X}$	SD	Mean
Male	159	44.30	10.88	79.27	10.92	34.97
Female	110	41.18	12.07	76.09	11.97	34.91

Table 4.5 shows the mean and standard deviation of male and female students taught Geography through virtual laboratory at pre-test and post-test. From the table, it can be deduced that the mean and standard deviation scores at pre-test and post-test for the male students are X= 44.30, SD= 10.88 and X= 79.27, SD= 10.92 respectively. This gives the mean gain of 34.97 in favour of post-test. Similarly, the mean and standard deviation scores at pre-test and post-test for the female students are X= 41.18, SD= 12.07 and X= 76.09, SD= 11.97 respectively. This gives the mean gain of 34.91in

favour of post-test. As a result of this identified difference in mean achievement scores, hypothesis 3 was tested at 0.05 level to determine if the observed difference, ANCOVA was employed at 0.05 to determine if the observed mean difference was significant as presented in Table 4.5.

4.2.3: The results on retention score of experimental i, ii and control group

Research Question Four

What is the difference in the mean retention scores of students towards geography after being taught physical laboratory, virtual laboratory and lecture method?

In answering research question four the retention scores of experimental group I, II and control group were analyzed using mean and standard deviation as shown in table 4.6.

Table 4.6: Mean and Standard Deviation of Retention of Experimental Group I, II and the Control Group

Group	N	Posttest $\bar{X}$	SD	Retention $\bar{X}$	SD	Mean difference
Experimental Group I	242	80.62	9.68	72.63	9.243	7.99
Experimental Group II	269	78.02	11.47	68.08	11.510	9.94
Control Group	257	73.12	11.56	65.04	11.61	8.08

Table 4.6 shows the mean and standard deviation retention scores of experimental group I, II and control group at post-test and retention-test. From the table, it can be deduced that the mean and standard deviation scores at post-test and retention test for experimental group I are $\bar{X}$=80.62, SD= 9.68 and $\bar{X}$= 72.63, SD= 9.243 respectively. This gives the mean gain of 7.99 in favour of retention test. Similarly, the mean and standard deviation scores at post-test and retention-test for the experimental group II are $\bar{X}$= 78.02, SD= 11.47 and $\bar{X}$= 68..08 SD= 11.51 respectively. This gives the mean

difference of 9.94 in favour of post-test. On the other hand, the mean and standard deviation scores at post-test and retention test for Control group are $\bar{X}$= 73.12, SD= 11.56 and $\bar{X}$= 65,04, SD= 11.61 respectively. This gives the mean gain of 8.08 in favour of post-test. As a result of this identified difference in mean retention scores.

4.2.4 Post-test retention scores for male and female in experimental group I (physical laboratory)

Research Question Five

Could there be any difference in the mean retention scores of male and female students taught Geography using physical laboratory?

In answering research question five the post-test mean retention scores of male and female students taught Geography using physical laboratory were analyzed using mean and standard deviation as shown in table 4.7.

Table 4.7: Mean and Standard Deviation of Retention scores of Male and Female Students taught Geography through Physical Laboratory

Group	N	Post-test $\bar{X}$	SD	Retention $\bar{X}$	SD	Mean difference
Male	147	80.56	10.50	65.72	11.58	14.84
Female	95	80.71	11.40	62.83	9.24	17.88

Table 4.7. shows the mean and standard deviation of male and female students taught Geography using physical laboratory at post-test and retention-test. From the table, it can be deduced that the mean and standard deviation scores at post-test and retention test for the male students are $\bar{X}$= 80.56, SD= 10.503 and $\bar{X}$= 65.72, SD= 11.576 respectively. This gives the mean gain of 14.84 in favour of posttest. Similarly, the mean and standard deviation scores at post-test and retention-test for the female students

are $\bar{X}$= 80.71 SD= 11.40 and $\bar{X}$=62.83, SD= 9.240 respectively. This gives the mean gain of 17.88 in favour of posttest.

4.2.5 Post-test of retention scores for male and female in experimental group ii (virtual laboratory)

Research Question Six:

Could there be any difference in the mean retention scores of male and female students taught Geography using virtual laboratory?

In answering research question six the post-test mean retention scores of male and female students taught geography using virtual laboratory were analyzed using mean and standard deviation as shown in Table 4.8

Table 4.8: Mean and Standard Deviation of Retention scores of Male and Female Students taught Geography through Virtual laboratory

Group	N	Post-test		Retention		
		$\bar{X}$	SD	$\bar{X}$	SD	Mean difference
Male	159	79.27	10.92	74.85	12.232	4.42
Female	110	76.09	11.97	71.43	15.53	4.66

Table 4.8 shows the mean and standard deviation of male and female students taught Geography using virtual laboratory at post-test and retention-test. From the table, it can be deduced that the mean and standard deviation scores at post-test and retention test for the male students) are $\bar{X}$= 79.27, SD= 10.92 and $\bar{X}$= 74.85, SD= 12.232 respectively. This gives the mean difference of 4.42 in favour of post-test. Similarly, the mean and standard deviation scores at post-test and retention-test for the female students are $\bar{X}$= 76.09, SD= 11.97 and $\bar{X}$=71.43, SD= 15.53 respectively. This gives the mean difference of 4.66 in favour of post-test.

4.2.6 Post-test results on attitude of experimental I and II and control group

Research Question Seven

What is the difference in the mean attitude score of Geography students taught using physical, virtual laboratories and those taught with lecture method?

In answering research question seven the attitude scores of experimental group I, II and control group were analyzed using mean and standard deviation as shown in table 4.9.

Table 4.9: Mean and Standard Deviation of Attitude of Experimental Group I, and II and Control Group

Group	N	$\bar{X}$	SD
Experimental I	242	81.12	9.201
Experimental II	269	77.97	11.484
Control	257	72.97	11.670

Table 4.9 reveals the mean and standard deviation of attitude of students taught Geography through in Experimental Group I (physical laboratory), Experimental Group II (virtual laboratory) and those taught using lecture methods in the Control Group. From the Table, it was observed that the mean of the three groups differ at post-test where Experimental Group I had the highest mean of 81.12 with standard deviation of 9.20, followed by Experimental Group II which had mean of 77.97 with standard deviation of 11.49 while the Control Group had mean of 72.97 with standard deviation of 11.67.

4.2.7 Post-test result of attitude of male and female using physical laboratory in Experimental Group I

Research Question Eight

Would there be any difference in the mean attitude scores of male and female students to Geography after being taught using physical laboratory?

In answering research question eight the post-test mean attitude scores of male and female students taught geography using Physical laboratory were analyzed using mean and standard deviation as shown in Table 4.10.

Table 4.10: Mean and Standard Deviation of Attitude of Male and Female Students taught Geography through physical laboratories

Gender	N	$\bar{X}$	SD
Male	147	81.05	9.20
Female	95	81.22	9.25

Table 4.10 reveals the mean and standard deviation of attitude of male and female students taught Geography through physical laboratory. From the Table, it is observed that there is difference between the mean attitude of the two groups at post-test where male students had mean attitude of 81.05 with standard deviation of 9.20 while their female counterparts had mean attitude of 81.22 with standard deviation of 9.25.

4.2.8 Post-test results of attitude of male and female using virtual laboratory in Experimental Group II

Research Question Nine

Would there be any difference in the mean attitude scores of male and female students to Geography after being taught using virtual laboratory?

In answering research question nine the post-test mean attitude scores of male and female students taught geography using virtual laboratory were analyzed using mean and standard deviation as shown in Table 4.11

Table 4.11: Mean and Standard Deviation of Attitude of Male and Female Students taught Geography Using Virtual laboratories

Gender	N	$\bar{X}$	SD
Male	159	79.26	10.88
Female	110	76.12	12.12

Table 4.11 reveals the mean and standard deviation of attitude of male and female students taught Geography using Virtual Laboratory. From the Table, it is observed that there is difference between the mean attitude of the two groups at post-test where male students had mean attitude of 79.26 with standard deviation of 10.88 while their female counterparts had mean attitude of 76.12 with standard deviation of 12.12.

4.3 Hypotheses

Hypothesis One (HO_1): There is no significant difference in the mean achievement scores of Geography Students taught using physical laboratory, virtual laboratory and those taught with lecture method.

To find out whether any significant difference existed in the post-test means achievement scores of Geography Students taught using physical laboratory, virtual laboratory and those taught with lecture method, the analysis of covariance (ANCOVA) was used. Table 4.12 presents the result of the analysis of covariance using the pretest scores of students in the three achievement levels as covariates.

Table 4.12 Summary of the analysis of Covariance (ANCOVA) of Post-test Achievement Scores of Experimental Group I, II and the Control Group

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	284200.989[a]	3	94733.663	1474.45	.000
Intercept	77412.697	1	77412.697	1204.87	.000
Covariate(Pre-test)	37940.144	1	37940.144	590.488	.000
Treatment	212564.310	2	106282.155	1654.12	.000
Error	49088.631	764	64.252		
Total	3737296.000	768			
Corrected Total	333289.620	767			

Significant at 0.05 Level Table 4.12 shows the ANCOVA result of the comparison post-test scores of students in Experimental Groups I, II and the Control Group. An examination of the table shows ($F_{(2, 764)} = 1654.12$, $p < 0.05$). On the basis of this, hypothesis one was not accepted. Therefore, there was significant difference in the achievement test scores of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method. To locate where significant difference exists as the ANCOVA indicates that there is significant difference among the groups, there is need to find out which is responsible. This is presented in Sidak post-hoc in Table 4.13

Table 4.13: Sidak post-hoc Analysis of the Post-test Mean Achievement Scores of students in Experimental Group I, II and the Control Group

Treatment	Experimental I	Experimental II	Control
Experimental I	-	1.553	36.457*
Experimental II	1.553		34.905*
Control	-36.457	34.905*	-

Table 4.13 showed the Sidak post-hoc analysis of achievement scores of students in Experiment Group I, II and the Control Group. The table indicates that significant difference exits between the achievement scores of students in experimental group I and experimental group II (mean difference = 1.553). it also shows that significant difference exits between the achievement scores of students in experimental group I and control group (mean difference = 36.457) and also between experiment group II and control group (mean difference = 34.905).

Hypothesis Two (HO_2): There is no significant difference in the mean achievement scores of male and female students taught Geography using physical laboratory.

In order to find out whether any significant difference existed in the posttest achievement means scores of male and female students taught Geography using physical laboratory, the analysis of covariance (ANCOVA) was used. Table 4.14 presents the result of the analysis of covariance using the pretest scores of students as covariates

Table 4.14: Summary of the Analysis of Covariance (ANCOVA) of Post-test Achievement Scores of Male and Female Students taught Geography using Physical Laboratory (Experimental I)

Source	Sumof Squares	Df	Mean Square	F	Sig.
Corrected Model	19854.539[a]	2	9927.270	864.504	.000
Intercept	23343.117	1	23343.117	2032.805	.000
Covariate (Pre-test)	19853.398	1	19853.398	1728.908	.000
Gender	45.314	1	45.314	3.946	.048
Error	2744.486	239	11.483		
Total	1595492.000	242			
Corrected Total	22599.025	241			

*: Significant at 0.05 level

Table 4.14 showed the ANCOVA result of the comparison post-test scores based on gender of students taught Geography using physical laboratories. An examination of the table shows a significant difference male between and female students ($F_{(1, 241)} = 3.946$, $p < 0.05$). On the basis of this, hypothesis two was not accepted. Therefore, the result revealed that there was significant difference between male and female students taught Geography using physical laboratory.

Hypothesis Three (HO_3): There is no significant difference in the mean achievement scores of male and female students taught Geography using virtual laboratories.

To find out whether any significant difference existed in the posttest achievement means scores of male and female students taught Geography using virtual laboratory, the analysis of covariance (ANCOVA) was used. Table 4.15 presents the result of the analysis of covariance using the pretest scores of students as covariates

Table 4.15: Summary of the Analysis of Covariance of Post-test Achievement Scores of Male and Female Students taught Geography through Virtual Laboratory

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	34944.961[a]	2	17472.481	31659.747	.000
Intercept	21881.870	1	21881.870	39649.462	.000
Covariate (Pre-Test)	34287.661	1	34287.661	62128.480	.000
Gender	1.986	1	1.986	3.599	.059
Error	146.801	266	.552		
Total	1670440.000	269			
Corrected Total	35091.762	268			

*: Significant at 0.05 level

Table 4.15 showed the ANCOVA result of the comparison post-test scores of male and female students taught Geography using virtual laboratory. An examination of the table shows that there is no significant difference based on gender of the two groups ($F_{(1,266)} = 3.599$, $p > 0.05$). On the basis of this, hypothesis three was accepted. Therefore, the result revealed that there was no significant difference between male and female students taught Geography using virtual laboratory.

Hypothesis HO_4: There is no significant difference in the mean retention score of Geography student after being taught using physical laboratory, virtual laboratories and lecture method.

To find out whether any significant difference existed in the posttest means retention scores of Geography Students after being taught using physical laboratory, virtual laboratory and those taught with lecture method, the analysis of covariance (ANCOVA) was used. Table 4.16 presents the result of the analysis of covariance using the pre-test scores of students in the three achievement levels as covariates.

Table 4.16: Summary of the Analysis of Covariance of Post-test Retention Scores of Students taught Geography through Physical laboratory, Virtual Laboratory and Lecture Method

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	80989.618[a]	3	26996.539	1148.457	.000
Intercept	79135.926	1	79135.926	3366.512	.000
Covariate (pre-test)	72578.203	1	72578.203	3087.541	.000
trtmt	2249.318	2	1124.659	47.844	.000
Error	17959.195	764	23.507		
Total	4695024.000	768			
Corrected Total	98948.812	767			

*: Significant at 0.05 level

Table 4.16 showed the ANCOVA result of the comparison of retention score of students taught Geography using physical laboratory, virtual laboratory and lecture method. An examination of the table shows that there is significant difference between the mean retention scores of the three groups ($F_{(1,\ 764)} = 47.85$, $p < 0.05$). On the basis of this, hypothesis four was not accepted. Therefore, the result revealed that there was significant difference in the mean retention scores between the three groups.

Hypothesis Five $HO_{5:}$ There is no significant difference in the mean retention score of male and female Geography student taught using physical laboratory.

In order to find out whether any significant difference existed in the posttest retention means scores of male and female students taught Geography using physical laboratory, the analysis of covariance (ANCOVA) was used. Table 4.17 presents the result of the analysis of covariance using the pretest scores of students as covariates.

Table 4.17: Summary of the Analysis of Covariance of Post-test Retention Scores of Male and Female Students taught Geography through Physical Laboratory

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	995.908[a]	2	497.954	3.216	.042
Intercept	9485.460	1	9485.460	61.260	.000
Covariate (Posttest)	790.816	1	790.816	5.107	.025
Gender	202.392	1	202.392	1.307	.254
Error	36852.025	238	154.840		
Total	904968.000	242			
Corrected Total	37847.934	241			

*: Significant at 0.05 level

Table 4.17 showed the ANCOVA result of the comparison of post-test retention scores of male and female students taught Geography using virtual laboratory. An examination of the table shows that there is no significant main difference between the mean scores of the two groups ($F_{(1,238)} = 1.307$, $p > 0.05$). On the basis of this, hypothesis five was accepted. Therefore, the result revealed that there was no significant difference in the retention scores of male and female students taught geography using virtual laboratory.

Hypothesis Six HO_6: There is no significant difference in the mean retention score of male and female Geography student taught using virtual laboratory.

In order to find out whether any significant difference existed in the posttest achievement means scores of male and female students taught Geography using virtual laboratory, the analysis of covariance (ANCOVA) was used. Table 4.18 presents the result of the analysis of covariance using the pretest scores of students as covariates

Table 4.18: Summary of the Analysis of Covariance of Post-test Retention Scores of Male and Female Students taught Geography through Virtual Laboratory

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	85.342[a]	2	42.671	.204	.816
Intercept	21768.051	1	21768.051	104.056	.000
Covariate (Posttest)	82.846	1	82.846	.396	.530
Gender	4.653	1	4.653	.022	.882
Error	55646.108	266	209.196		
Total	1436581.000	269			
Corrected Total	55731.450	268			

Table 4.18 showed the ANCOVA result of the comparison retention test scores based on gender of students taught Geography using virtual laboratory. An examination of the table shows no significant difference of male and female students ($F_{(1,266)} = .022$, $p > 0.05$). On the basis of this, hypothesis six was accepted. Therefore, the result revealed that there was no significant difference between male and female students taught Geography using virtual laboratory.

Hypothesis Seven (HO_7): There is no significant difference in the mean attitude scores of students towards Geography after being taught using physical, virtual laboratories and those taught with lecture method.

In order to find out whether any significant difference existed in the posttest attitude means scores of students towards Geography after being taught using physical, virtual laboratories and those taught with lecture method, the analysis of variance (ANOVA) was used. Table 4.19 presents the result of the analysis of variance.

Table 4.19: Summary of Analysis of Variance of Post-test Attitude of Experimental Group I, II and the Control Group

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	8486.031	2	4243.015	35.840	.000
Within Groups	90567.051	765	118.388		
Total	99053.082	767			

The Table 4.19 shows that there was a significant difference in the attitude scores of students in the three intervention groups at post-test ($F_{(2,765)} = 35.840$, P=.000, $P < 0.05$). Therefore, hypothesis seven was not accepted. That is, there was a significant difference in the mean attitude scores of students towards Geography after being taught using physical, virtual laboratories, and Lecture method.

Since it was established that there was a significant difference in the post-test scores of the groups, Sidak post-hoc analysis was done to locate the direction of the difference among the treatment groups. The results of this post-hoc analysis is as shown in Table 4.20.

Table 4.20: Sidak Post-hoc Analysis of the Post-test Mean Attitude Scores of students in Experimental Group I, II and the Control Group

Treatment	Experimental I	Experimental II	Control
Experimental I		13.15	38.15
Experimental II	13.15		-5.001
Control	-8.15	5.001	

Table 4.20 shows the Sidak post-hoc analysis of attitude scores of students in Experiment Groups I and II, and the Control Group. The table indicates that a significant difference exists between the attitude scores of students in the experimental group I and experimental group II (mean difference = 3.15) in favour of experimental group 1. It also shows that significant difference exists between the attitude scores of students in experimental group I and control group (mean difference = 8.15) in favour of experimental group 1. Also, the table shows that significant difference exists between experimental group II and control group (mean difference = 5.00) in favour of experimental group II. The implication is that physical laboratory improved the attitude of students better than virtual laboratory and lecture method while virtual laboratory improved students' attitude towards geography better than lecture method.

Hypothesis Eight (HO_8): There is no significant difference in the attitude scores of male and female students to Geography after being taught using physical laboratory.

In order to find out whether any significant difference existed in the posttest attitude means scores of male and female students taught Geography using physical laboratory, the analysis of variance (ANOVA) was used. Table 4.21 presents the result of the analysis of covariance.

Table 4.21: Summary of Analysis of Variance (ANOVA) of Post-test Attitude of Male and Female Students taught Geography using Physical Laboratory

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.568	1	1.568	.018	.892
Within Groups	20487.971	241	85.012		
Total	20489.539	242			

The Table 4.21 indicates further that there was no significant difference between male and female post attitude scores of students after being exposed to physical laboratory (F $(1,_{241})$ = 018 P=.892 P > 0.05). Based on this, hypothesis 8 was accepted. Therefore, the result revealed that there was no significant difference between the attitude of male and female students taught Geography using physical laboratory.

Hypothesis Nine (HO_9): There is no significant difference in the mean attitude scores of male and female students to Geography after being taught using virtual laboratory.

In order to find out whether there is significant difference in the posttest attitude means scores of male and female students taught Geography using virtual laboratory, the analysis of variance (ANOVA) was used. Table 4.22 presents the result of the analysis of variance using the pretest scores of students as covariates.

Table 4.22: Summary of Analysis of variance (ANOVA) of Post-test Attitude of Male and Female Students taught Geography using Virtual Laboratory

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	639.937	1	639.937	4.923	0.27
Within Groups	34573.824	266	129.977		
Total	35213.761	268			

*: Significant at 0.05 level

As a result of this identified difference in mean attitude scores, hypothesis two was tested at 0.05 level. The Table 4.22 indicates that there was no significant difference between male and female post attitude scores of students after being exposed to a virtual laboratory ($F(1,266) = 4.923$ $P=0.27$ $P > 0.05$). Based on this, hypothesis two was accepted. Therefore, the result revealed that there was no significant difference between the attitude of male and female students taught Geography using a virtual laboratory.

4.4 Summary of Findings

From the data analysis and the results obtained from this research, the findings were recorded and summarized as follows:

1. There was significant difference in the achievement scores of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method.
2. There was significant difference between achievement scores of male and female students taught Geography using physical laboratory.
3. There was no significant difference between achievement of male and female students taught Geography using virtual laboratory.
4. There was significant difference in the retention score of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method.
5. There was no significant difference in the retention scores of male and female students taught geography using physical laboratory**.**
6. There was no significant difference in the retention scores of male and female students taught geography using virtual laboratory.

7. There was significant difference in the mean attitude scores of students taught Geography using physical, virtual laboratory and lecture method
8. There was no significant difference in the mean attitude scores of male and female post attitude scores of students after being exposed to physical laboratory
9. There was no significant difference in the mean attitude scores of male and female post attitude scores of students after being exposed to virtual laboratory

4.5 Discussion of Results

Findings from this study revealed that the use of Physical and Virtual Laboratory in teaching Geography improved the achievement of students. Results from the tested hypotheses also show that both learning strategies did not only enhance students' achievement but also facilitate retention of physical Geography concepts. Their attitude towards geography was positive and favourable.

Finding on the achievement of students taught Geography using Physical Laboratory, Virtual Laboratory and those taught with Lecture Method

The result on the achievement of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method showed that treatment using physical laboratory produced significant difference on students' achievement in geography. Based on the above results, it was inferred that the significant difference observed may be credited to uniqueness and practical nature of physical laboratories. The significant difference observed could also be attributed to the peculiarity and importance ascribed to learning action between learner and teacher that was stressed within the framework of instruction, the finding therefore, indicated that physical laboratory had enhancing effect on the students' achievement in geography despite which Virtual laboratory could be used to complement physical laboratory. The enhancing effect of physical laboratory on the students' achievement in geography improves the proficiency level of the students by teacher's extra help to those who need it. It allows individual student to study in a comfortable place and environment and also ensure that instruction is the same from student to student. This helps the teacher to keep track of student's performance accordingly. The concretization of learning through physical laboratory makes learning straight forward and supports a constructivist approach to learning. Students learn better by doing through development of alternative realities. The result of this study considering the above therefore is consistent with the results reported by Reese (2013) which showed statistical significant differences in students' achievement defined by averages on quiz scores in virtual labs compared with traditional face-to-face laboratories and traditional laboratories.

This result is also in conformity with the similar study by Garrett, (2015) that investigates the ways in which the unique perceptual-motor features of science laboratory environments can affect students' learning. The findings indicated that the perceptual-motor features of science laboratory environments did indeed shape learners' understanding of the underlying science concepts

However, the result was opposed by the findings of Sundra (2014) that indicated Virtual Laboratory had higher learning outcome than the control. The finding revealed no significant difference in either of the laboratory instructions. The findings of this research were also opposed by earlier findings of Falode (2014). The study evaluated a virtual laboratory package on selected physics concepts for Nigerian secondary schools using Bates' "ACTIONS". The result showed that there was no significance difference in the mean achievement scores of students taught physics using the virtual physics laboratory package and those taught using conventional laboratory, In conclusion, contrary to the findings of this study, Mallory and Orabi (2012) Evaluating Learning Outcomes in Introductory Chemistry Using Virtual Laboratories to Support Inquiry Based Instruction. The results indicated that the result was not significant. Therefore, the hypotheses that virtual labs are associated with higher students' motivation than traditional labs as well as virtual labs are associated with greater learning outcomes than traditional labs were not accepted.

Findings on the Influence of Gender on the Achievement of Students Exposed to Physical Laboratory

The result of the analysis on the influence of gender on the performance of students exposed to Physical Laboratory indicated that both male and female students that were taught Geography using physical laboratory perform significantly different. The difference in the achievement of male and female geography students after being exposed to physical could be attributed to the uniqueness and importance credited to collaboration between learner and teacher that was emphasized within the framework of instruction. This is in agreement with the research results of Yusuf and & (2010) Ajai and Imoko (2015), revealed that there were significant differences in the academic achievement based on gender. Similarly, and in line with the result of this study, Olson (2002) Gimba (2003), Anagboju and Ezehiora (2007), Contini *et al.* (2016), notice that female learners outperformed their male counterparts. In contrast, Ifamuyiwa (2004), Strand *et al* (2006), Preckel *et al*. (2008), Kovas *et al*. (2015), Musa *et al*. (2016), in their separate researches reported that male students outperform their female counterparts in science subjects at secondary school level.

On the other hand, the result of this study tends to contradict with the report of other researches such as Orabi (2007), Vale (2008), and Daniel and Moses (2008) Iwendi and Oyedum (2014), Egorova (2016), the results revealed no gender differences in achievement of males and females in mathematics and science subjects. This is supported by a larger scale research, such as Trends in International Mathematics and Science Study (TIMSS) that found out that “there were no gender differences in 22 of the 42 countries that tested at Year 8, including Australia” (Thomson *et al.,* 2012).

This finding disagrees with the recent findings of Ratamun and Osman (2018) the result of the finding showed that the interaction effect between group and gender in Virtual Laboratory and Physical Laboratory towards chemistry is not significant. This means the group’s influence on the mean score of attitudes towards chemistry lessons ATCLS is not caused by the gender and the gender influence on the mean score of ATCLS is not caused by groups. Similarly, the findings of Reesse (2013), disagree with the outcome of this study, the results showed no significant difference in short-term learning between the hands-on laboratory groups and virtual laboratory groups suggest that long-term learning is enhanced when a laboratory contains a hands-on component. Also opposing the result of this study is the work of Mahya (2017). The finding revealed that students’ cognitive knowledge and attitudes toward science were positively changed as expected, however, the results from paired sample *t*-tests found no statistical significance. It can be deduced that the use physical laboratory enhanced the performance of female students than the male students.

Findings on the Influence of Gender on the Achievement of Students Exposed to Virtual Laboratory

The result of the analysis on influence of gender on the achievement of students exposed to Virtual Laboratory indicated that both male and female students that were taught Geography Practical using virtual laboratory do not perform significantly different. The similarity in the achievement of male and female geography students after being exposed to virtual laboratory could be the result of the fact that students irrespective of gender have positive interest towards working and performing series of activities in an environment that emphasizes collaboration, social interaction and exchange of ideas. This finding agrees with the earlier finding of Gambari *et al.* (2012) who found that there was no significant difference between the mean achievement scores of male and female students taught physics practical using virtual laboratory strategy. This finding is also in agreement with the findings of Onasanya *et al.* (2006) and Tabassum (2004) who found that gender factors had no influence on students' performance. This finding however, contradicts the findings of Ifamuyiwa (2004) and Jacobs and Osgood (2002) who found that male students taught using computer-assisted instruction performed better than their female counterparts. Similarly, it contradicts the findings of Iwendi (2009) and Anagbogu and Ezeliora (2007) who found that female students performed better than male students. The finding is also not in agreement with the findings of Wang *et al.* (2009) who found that male students significantly performed better than their female counterparts.

It can be deduced that the use virtual laboratory enhanced the performance of both male and female students alike. Therefore, final conclusion on the gender influence on students' achievement seems inconclusive and remains very interesting.

Finding on the Retention of Students Taught Geography Using Physical Laboratory, Virtual Laboratory and those Taught with Lecture Method

The result indicated that treatment using physical laboratory produced significant difference in students' retention of achievement in geography. The result on the retention of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method showed that treatment using physical laboratory produced significant difference on students' retention in geography. The difference in the retention of geography students after being exposed to virtual laboratory could be attributed to distinctiveness and real nature of learning strategies and duration between the post-test and the retention test.

This result on the retention of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method is in consonance with the study of Khurana (2018) initiated in Delhi India, to find out the impact of hands-on activities in science in relation to achievement and concept retention. The result of the study indicates a significant difference favouring the experimental group. Similarly, the result of this study confirms the study carried out by Aliustaoğlu, and Tuna (2018) which sought to find out the effects of 4MAT model on the teaching of “Transformation Geometry. The result of the study in relation to academic achievement and retention revealed a substantial difference favouring the treatment group.

In the same way, the result is in compliance with the study of Haghighi (2013) targeted at finding out the effects of brain-based learning in sophomore students’ academic achievement and retention. The finding of the study shows a substantial difference on achievement and retention in favour of brain-based learning. Also supporting this current study is the results of Kurumeh *et al.* (2012), Agwagah (1994), and Obi *et al.* (2014) whose studies were respectively meant to investigate the impact of the van Hiele model over conventional strategy on retention of achievement.

Likewise, in agreement with this study is the study carried out in Ilorin, Nigeria, by Adeniji *et al.* (2018), on the impact of mastery learning on senior secondary school students' achievement and retention in geometry. The result of the study indicated a substantial difference in favour of treatment group. In the same vain, in the post-test mean achievement and retention score a substantial difference was found. It is on this note that it was suggested that geography teachers should be trained on the effective utilization of mastery learning technique for improved mathematic achievement.

The result of this study favouring treatment group could be attributed to view of Kurumeh *et al.* (2012) who maintained that incorrect, insufficient and restricted teaching strategy employed by teachers is responsible for learners' inability to comprehend and recollect the rudimentary science principles and logical facts.

In the view of this, Iji (2010), added that man is gifted with restricted ability for memorizing, therefore, to properly and efficiently apply all that was learnt, retention must have to play an important role. It is on the account of this that effects of physical and virtual laboratory were employed in this study to see if it will increase learners' retention of achievement. Nevertheless, the teaching strategy however proved to improve retention of achievement. The observed improvement may be credited to the uniqueness of the treatment administered.

Contrary to the finding of Usman (2016), it was also found out that there is no significant difference in the mean achievement scores of male and female geography students taught map reading using Computer Simulation Instructional Package.

Findings on the influence of gender on the retention scores of students exposed to physical laboratory

The result indicated no significant difference existed between the retention score of male and female geography students taught using physical laboratory. It can be deduced that the use of physical laboratory enhanced the retention of both male and female students because of the uniqueness of the treatment instrument used for the two groups. This concurs with the result of Kurumeh *et al*. (2012) on the effect of the ethno mathematics teaching approach and gender on junior secondary three student retention that confirmed no substantial difference between treatment and control group. Supporting the above finding, the work of Obi *et al.* (2014) on effect of origami instructional approach is in agreement with the current study. The result revealed that the use of origami had no statistical differential effect on male and female. The result of the study by Makinde and Yusuf (2018) opposed the result of this study. The result revealed that there was significant difference on the retention score of male and female students taught using flip classroom. The result also revealed treatment improves male students' retention. It was in view of this that flipped classroom approach was recommended as it enhanced male students' academic achievement and retention. The finding of the study by Haghighi (2013) revealed that there was substantial difference on achievement and retention in favour of brain-based learning. Therefore, the result disagrees with the result of current study.;

Findings on the Influence of Gender on the Retention Sores of Students Exposed to Virtual Laboratory

The result revealed no significant difference existed between the retention score of male and female. Therefore, the result shows that gender had no influence on the retention of geography students taught using virtual laboratory. It can be inferred that the use of virtual laboratory enhanced the retention of both male and female students. The equivalence in the retention of male and female geography students after being exposed to virtual laboratory could be the result of the distinctiveness of the treatment instrument used for the two groups.

This coincides with the result of Kurumeh *et al*. (2012) on the effect of the teaching approach and gender on junior secondary three student retention that confirmed no substantial difference between treatment and control group. Following the above finding, the work of Obi *et al.* (2014) on effect of origami instructional approach is in conformity with the current study. The result revealed that the use of origami had no statistical differential effect on male and female. However, the result of the study by Makinde and Yusuf (2018) opposed the result of this study. The result showed that there was significant difference on the retention score of male and female students taught using flip classroom. The result also revealed treatment improves male students' retention. The finding of the study by Haghighi (2013) revealed that there was substantial difference on achievement and retention in favour of brain-based learning. Therefore, the result disagrees with the result of current study.

Finding on the Mean Attitude scores of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method

The finding indicated that treatment using Physical and virtual laboratories improved students' positive attitude towards Geography. Therefore, result shows that there was significant difference in the mean attitude scores of students taught Geography using physical laboratory, virtual laboratory and those taught with lecture method. The justification for this finding is because students naturally show good dispositions towards learning activities that make them active participants (such as physical and virtual laboratories) unlike the lecture method where they are passive during the teaching and learning process, hence the noticeable difference in their attitude towards the subject when exposed to the different strategies.

Based on the above results, it was inferred that the significant difference observed may be credited to the opinion of Ma and Kishor (1997) who stressed that there is a general acceptance that learners are captivated more efficiently when attracted by what they study and as such will accomplish better in science subjects.

In agreement with the finding of this study, the result on the attitudes of students in virtual labs by (Pyatt (2012), showed better performance in the virtual lab experiences and also positive attitudes towards both physical and virtual experiences. It is observed that the students have a higher equipment usability and a higher degree of open-endedness towards virtual experiences.

In a recent study by Keter *et al.* (2016) about changes in attitudes towards sciences among 238 Kenyan students also found that simulations in virtual laboratory can change attitudes and motivate students to learn science subject. However, the result was found to be significant. Also to buttress the finding of this study is Awofala *et al.* (2013) employing pre-test and post-test control group quasi experimental design (3×2×2 factorial matrix), with a population of 350 senior secondary SSII students in Nigeria (172 males and 178 females). The analysis of covariate and scheffe test results revealed a substantial main effect of treatment and gender on attitude mean score of subjects exposed to the strategy. This is supported by Sunzuma *et al*. (2013), and Mata *et al.* (2012), there studies were respectively meant at carrying the effect of the Van Hiele's model on learners' attitude towards science subjects. The result of this study is also supported by Karjanto (2017) who studies the attitude towards mathematics between the students registered in the Foundation Year Programme at Nazarbayev University. The result indicates a positive correlation between earlier high achievement in mathematics and favourable attitude towards it. Additionally, Falode *et al.* (2016), investigated the effectiveness of computer simulation instruction on the attitude of geography students towards map reading in Bida, Nigeria. The finding of the students revealed that the attitude of students towards map reading was significant.

Also, in agreement with the current study is the work of Bhowmik and Banerjee (2016) on the relationship between performance and attitude towards science. The approach used for the study was a descriptive type, involving 394 secondary grade 10 students from six diverse high schools. The results revealed that there is a significant positive correlation between attitude towards science.

In line with current study is the research conducted by Mata *et al.* (2012) on how diverse but interconnected variables might lead to clarification of attitude of students toward science subjects and understanding of the essential features of these attitudes in the context of school. The finding indicated favourable students' attitudes towards sciences, in addition the main effects of achievement on the attitudes and grade was positive. A hierarchical examination indicated that motivational related variables are essential predictors of attitudes to the subject and significantly important in understanding these attitudes are teacher and the social support from peers.

Findings on the Influence of Gender on the Attitude of Students Exposed to Physical Laboratory

The result on the effect of physical laboratory on attitude scores of geography students based on gender shows that gender had no influence on the attitude of students towards geography. It can be deduced that the use of physical laboratory enhanced the attitude of both male and female students because of the uniqueness of the treatment instrument. This is an indication physical minimizes gender differences. The sameness in the attitude of male and female geography students after being exposed to physical could be the result of the fact that students have positive interest towards working and performing series of activities in an environment that emphasizes teamwork, group effort and exchange of ideas.

This concurs with the results of Karjanto (2017) on attitude towards arithmetic between the students registered in the Foundation Year Programme at Nazarbayev University. The result revealed no significant difference based on gender of students in terms of their attitude towards the subject. The result of the current study is also in agreement with the result of Mata *et al.* (2012), the result revealed that there was no significant gender difference though the female showed a continuous weakening in attitudes the more they advanced in school.

In disagreement with the study is the result of Bhowmik and Banerjee (2016) in which descriptive approach was employed on 394 secondary grade ten students from six diverse high schools. The result revealed that there was significant gender difference on the students' attitude towards sciences. The study of Awofala *et al.* (2013) is also in contradiction with the current study. The study employed a 3×2×2 factorial matrixes, with a sample of 350 senior secondary SSII students in Nigeria. The result also shows that males had significant attitudes toward science subjects than female.

Findings on the Influence of Gender on the Attitude of Students Exposed to Virtual Laboratory

The result on the effect of virtual laboratory on attitude scores of geography students based on gender shows that gender had no influence on the attitude of students towards geography. It can be deduced that the use of virtual laboratory enhanced the attitude of both male than female students, this could be the result of the fact that students have positive attitude towards operating and executing series of activities in an environment that emphasizes teamwork, social interaction and exchange of ideas.

This is in agreement with the results of Karjanto (2017) on attitude towards arithmetic between the students registered in the Foundation Year Programme at Nazarbayev University. The result revealed no significant difference based on gender of students in terms of their attitude towards the subject. The result of the current study is also in agreement with the result of Mata *et al.* (2012), the result revealed that there was no significant gender difference though the female showed a continuous weakening in attitudes the more they advanced in school.

However, the result contradicts with the result of Bhowmik and Banerjee (2016), the finding revealed that there was significant gender difference on the students' attitude towards sciences. The study of Awofala *et al.* (2013) is also in disagreement with the current study, the result shows that males had significant attitudes toward science subjects than female.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.3 Contributions to Knowledge

1. The discovery of innovative learning strategies (physical and virtual laboratories) have been made.
2. Students' achievement can be improved when physical and virtual laboratories are used in teaching and learning of senior secondary school geography concepts
3. Gender gap between the performance of male and female student can be bridged through the use of physical and virtual laboratories
4. The research work has pushed the frontier of knowledge by serving as reference point and a basis for further research by students, teachers, curriculum planners, policy makers, government, researchers among others.

5.1 Conclusion

Based on the findings of this study, it can be deduced that the use of physical laboratory for teaching and learning of secondary schools' geography is more effective than virtual laboratory and lecture method though both physical and virtual laboratory have positive effect on students' academic achievement, retention and attitude towards geography. Difficult physical geography concepts can be easily delivered to learners through the use of these strategies in teaching secondary school students. This will undoubtedly positively improve students' achievement, retention and attitude towards geography. If these strategies are adopted by teachers and students, virtual laboratory can therefore be used to complement classroom instruction in geography. Consequently, the use of physical and virtual laboratory could be regarded as one of the best strategies for enhancing achievement, retention and attitude of geography students in North Central Nigeria.

5.2 Recommendations

Based on the major findings of this study, the following recommendations are proffered as follows:

1. Physical and virtual laboratories should be embraced as teaching strategies for teaching geography concepts in our senior secondary schools because it has been proven to improve students' achievement in physical geography.
2. Awareness should be created in order for Geography teachers and students to be expose to physical and virtual laboratory environments as this will help to improve students' achievement and encourage social interaction, active learning, motivation, learning by doing and learning by experience.
3. Virtual laboratory should be used to complement physical laboratory as a mutually beneficial interface between both (laboratories) could impact positively on the learners. The use of the package will help students to develop students' positive attitude and retention towards geography irrespective of their gender.
4. Students should be encouraged to work together as they perform task while working in laboratory, this will improve on their retentive abilities and social interaction in physical activities.
5. Government through Nigeria Education and Research Development Council should ensure that the use of both physical and virtual laboratories is incorporated into the senior secondary school syllabus as these one of current innovation trending in the global world which Nigeria cannot be exception.
6. Workshops and training should frequently be organized on the use of laboratories by state ministry of education and its agencies, this will increased

both the teachers and students attitude towards laboratories and enhance better performance of both teachers and students.

7. Teachers should be encouraged by the school management through training and workshops to be familiar with the use of current approaches in the use of modern laboratories. This will enable them to appreciate the use of recent innovative strategies in teaching and learning in the laboratory environment and further improve the attitude of students towards geography. To achieve this, the Federal, State, Local Government, Private, voluntary organizations and alumni associations should endeavour, as a matter of commitment to provide schools with needed well equipped geography laboratories, manpower and routine maintenance.
8. Text-book writers for senior secondary school class in physical geography, should shift emphasis from teachers-centered to learners-centered activities that will promote learning by doing, social interaction, group activity based learning.
9. Curriculum developers should embrace and consider laboratory method model to learners, this will bring about improvement in learning, acquisition of critical thinking, social interaction, problem solving and performance skills in students.
10. Efforts should be made by government to post and provide skilled laboratory technicians to each school so as to carry out geography practical and ensure safety in the laboratory.

5.3 Limitations of the Studies

The following limitations were observed in the course of the study:

1. The curriculum contents contained in the developed product was limited to three SSII geography content thus, there could be other contents in the subject this learning package could be developed upon,
2. The nature of the schools sample for the study were privileged schools that are equipped with adequate computer facilities and manpower, thus, the generalization of the findings of this study to other schools that have no such privileges may not be possible
3. The discoveries of the present study on the efficiency of both physical and virtual laboratories might not be generalized beyond North Central on the grounds that the platform was just tried on seven hundred and sixty-eight geography students.

5.4 Suggestions for Further Studies

Based on the experience gathered during the course of this study, the following suggestions are made for future research on the effects of Physical and Virtual Laboratories on learning outcomes in Geography among senior secondary school students:

1. This study should be replicated in other geopolitical zones of Nigeria to find the effects of Physical and Virtual Laboratories on learning outcomes in Geography among senior secondary school students.
2. Senior secondary school students form the sample of this study; for future research, higher institutions of learning like universities and colleges of education may be used as research sample. In addition, similar study be conducted in other levels of education such as primary and junior secondary

schools. In this case, the result can be generalized to not only O'level but other educational levels.

3. Since the aim of this study is geared towards overall improvement of the learners, therefore, other prototypes or teaching approaches like the use of libraries for teaching and learning Geography could be employed to compare their effects on students' achievement.
4. Research could be conducted on gender alone, using other learning strategies at primary and junior secondary schools.

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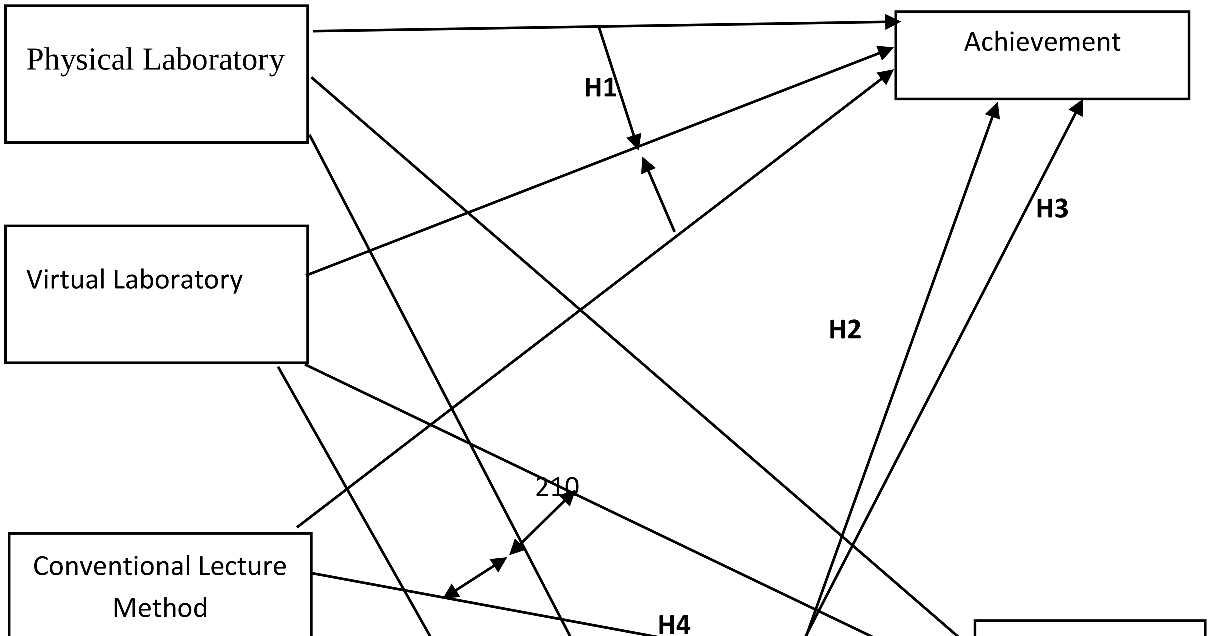
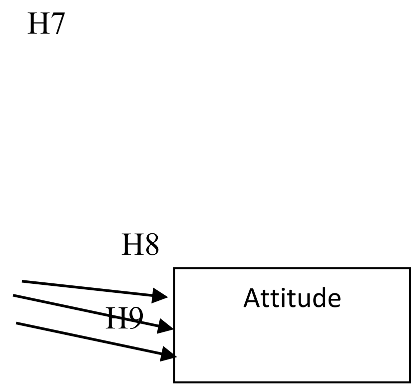
APPENDIX A

The diagram below explains the interaction of all the hypotheses raised in the study based on the various variables as central to achievement, retention, attitude and gender as a moderating variable of the study.





Design Model of the Study

Source (Ismail, 2015)

APPENDIX B

CHIEF EXAMINER REPORT FOR 2005 - 2014

The tables below illustrate WAEC and NECO Chief Examiner's Reports Depicting Candidate's area of weakness in Geography examination.

	NECO 2005-2014
2005	Poor understanding of map and sketches and Interpretation of maps.
2006	Poor sketches and map skills by candidates, probably due to inadequate emphasis during teaching and learning process.
2008	Inability to draw sketch maps with correct insertion and Legend.
2009	Candidates generally have phobia for question Required diagrams, sketches and maps to buttress argument

2010	Poor understanding of Map features and interpretation

WAEC 2008-2018		
Students Weakness	**May/June reported years**	**Nov./Dec. reported years**
Inadequate explanation of points.	2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018	2008, 2009, 2011, 2014, 2017, 2018
Inadequate preparation	2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018	2008, 2009, 2011, 2012
Poor, presentation, of geographic features and their inability to represent some geographical features on the sketches.	2008, 2009, 2010, 2011, 2013, 2014.	2008, 2011, 2012, 2015,

APPENDIX C

Analysis of result

National Examinations Council

Analysis of Performance of Candidates in Selected Subjects

SSCE 2003 -2013 (Jun/Jul)

10/29/14

Geography

Exam Year	No of Candidates Registered	No of Candidates Sat	Distinction	Credit	Pass	Fail
2003	547,785	506,228	38,981 7.70%	261,788 51.71%	78,034 15.41%	114,514 22.62%
2004	561,402	520,812	8,181 1.57%	80,560 15.46%	251,218 48.23%	158,091 30.35%
2005	553,606	509,321	22,805 4.47%	118,800 23.32%	201,223 39.50%	140,651 27.61%
2006	582,846	548,761	1,800 0.32%	277,282 50.52%	173,771 31.66%	62,085 11.31%
2007	657,944	621,907	514 0.08%	279,851 44.99%	216,904 34.87%	100,276 16.12%
2008	748,713	694,753	17,733 2.55%	485,181 69.83%	106,234 15.29%	59,036 8.49%
2009	760,171	721,453	1,389 0.19%	176,896 24.51%	304,166 42.16%	164,942 22.86%

2010	743,132	711,689	709 0.09%	162,729 22.86%	361,620 50.81%	149,877 21.05%
2011	772,797	674,686	2,601 0.38%	151,012 22.38%	460,333 68.22%	32,401 4.80%
2012	747,782	703,316	4,715 0.67%	341,206 48.51%	317,648 45.16%	33,027 4.69%
2013	703,490	671,991	7,931 1.18%	424,308 63.14%	206,905 30.78%	28,010 4.16%

APPENDIX D

Demographic Distribution of Samples for the Research Study

Groups	**Total**	**Male**	**Female**
Experimental Group I	242	147	95
Experimental Group II	269	159	110
Control Group	257	185	72
Total	**768**	**491**	**277**

APPENDIX E

GEOGRAPHY ACHIEVEMENT TEST

Instruction: Tick the Best Answer from the Listed A – D

Instruction: Respond by ticking the appropriate answer to the question

Section A

Personal Data:

School……………………………………………………………………………….

Class…………………………………………………………………………………

Gender: Male ☐ Female ☐

Age: 11-15 ☐ 16-20 ☐ 20-25 ☐

Study the map of SERA DISTRICT below and use it to answer questions 1-10.

1. The feature marked G on the map stands for

   A. a cuesta

   B. a mountain

   C. a slope

   D. a saddle.

2. The feature marked Y —Z is regarded as

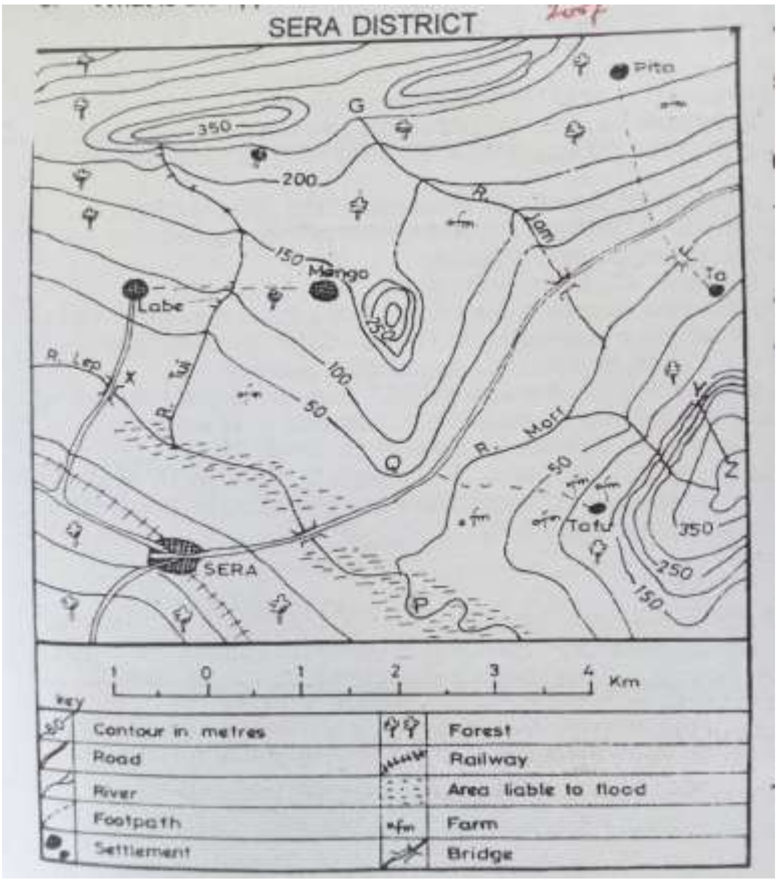
   A. plateau

   B. haning valley

   C. convex slope

   D. dip slope

SERA DISTRICT



3. The highest point on the map is a little above

A. 250 m

B. 300 m

C. 400m

D. 500 m.

4. SERA may be described as a

A. fishing town
B. coastal town
C. nodal town
D. gap town

5. Which of the following towns is not intervisible?

A. Labe and Mongo

B. Sera and Tafu

C. Sera and Pita

D. Ta and Pita

6. The feature marked Q represents a

A. conical hill

B. cliff

C. knoll

D. spur

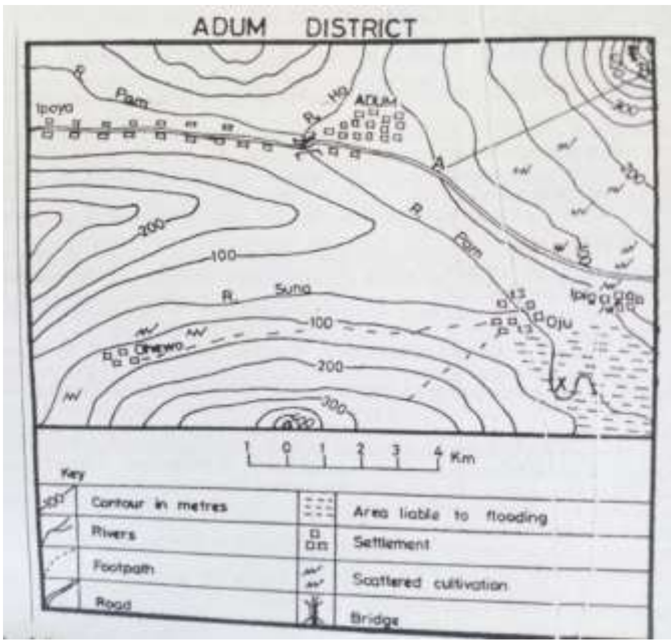
7. The relief feature marked P stands for a

A. meander

B. Cliff

C. confluence

D. broad valley.



8. The feature marked X can be described as

A. an ox-bow lake

B. a meander

C. a spur

D. a col

9. The direction of flow of River Pam as indicated in the map is

A. North-West

B. North-East

C. South-West

D. South-East

10. The likely occupation of the people in Ipiga as shown in the map is

A. fishing

B. clusterefarmin

C. mining

D. lumbering

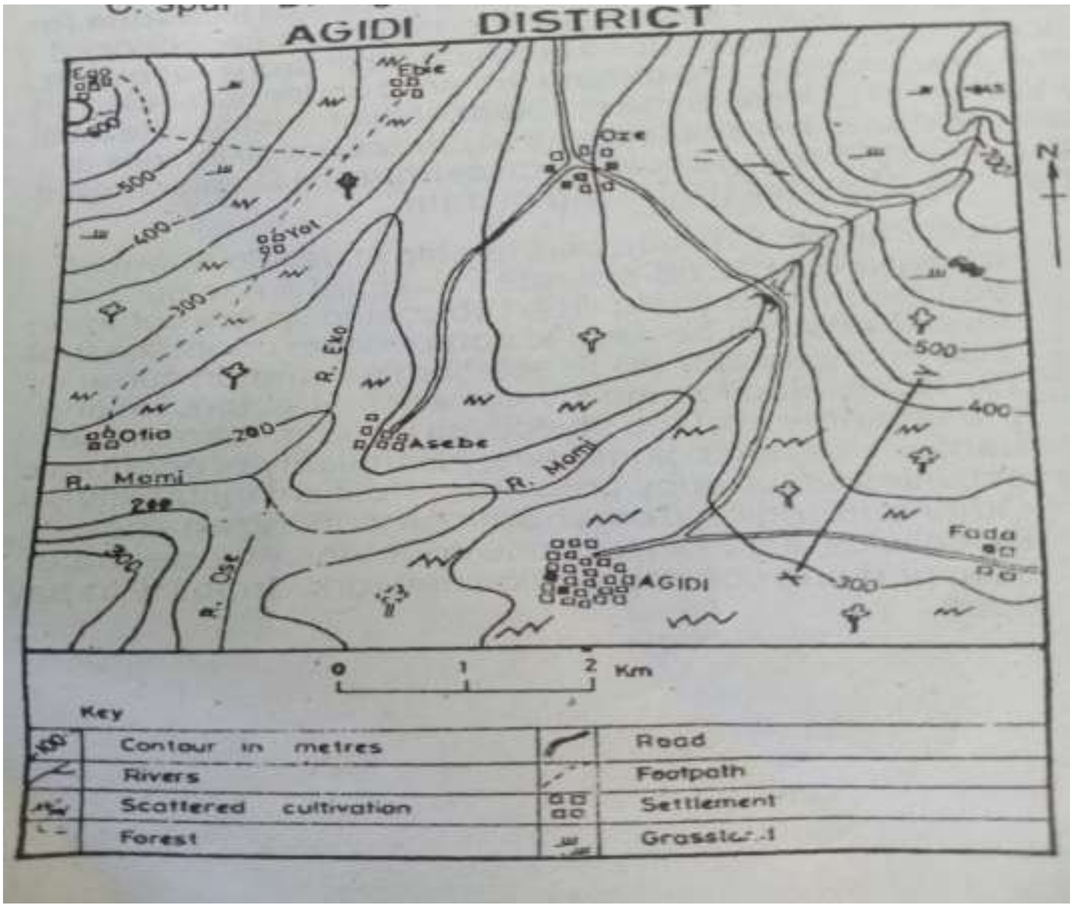
11. The feature marked A-B can best be described as

A. concave slope

B. scarp slope

C. dip slope

D. convex slope



12. The feature marked X-Y is a

   A. cuesta

   B. Cliff

   C. Spur

   D. Ridge

13. From the map, how many tributaries has river momi

   A. 1

   B. 2

   C. 5

   D. 6

14. What is the likely occupation of the people of agid district

A. Mining

B. Trading

C. Agriculture

D. Boat building

15. The highest contour line on the map is

A. 850m

B. 800m

C. 600m

D. 500m

16. As shown on the map, the actual distance from ofia to yot as the ‘crow flies’ is

A. 15km

B. 12km

C. 7km

D. 3km

17. The second largest settlement on the map is

A. Oze

B. Agidi

C. Asebe

D. Fada

18. As indicated on the map, which of the following towns is not intervisible

A. Agidi and fada

B. Oze and Asebe

C. Abie and yot

D. Ofia and Ego

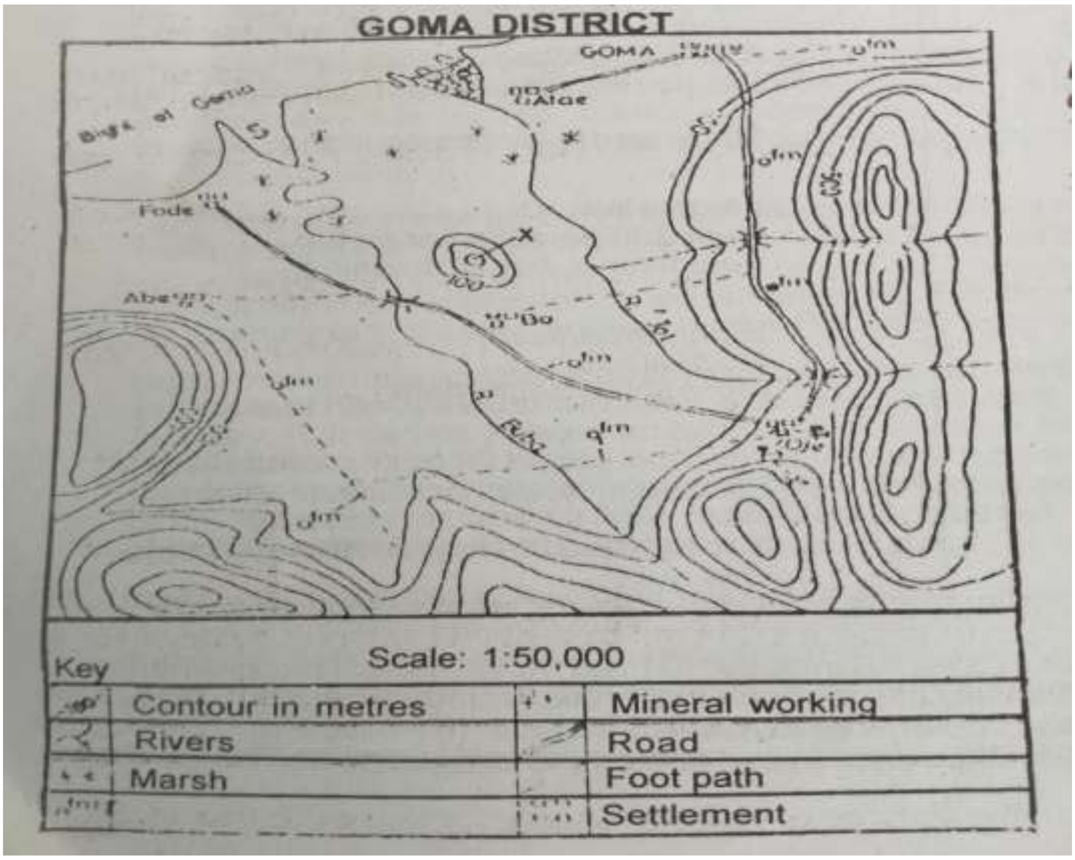
19. The symbol .845 in the North Eastern part of the map is known as

A. Trigonometrical station

B. Contour line

C. Spot height

D. Hachures.



20. The gradient of the river ohun between point X and Y is approximately

A. 1:10

B. 1:12

C. 1:16

D. 1:40

21. The highest point above sea level on the map is over

A. 1,000mm

B. 900m

C. 800m

D. 700m

22. Which of the following is not true of the drainage network on the map

A. River ohun is a hand tributary of river oyi

B. The drainage pattern in the central part is radial

C. River oyi is flowing north- eastward

D. Most of the rivers are seasonal

23. Orile on the map is located on a

A. Valley

B. Spur

C. Headland

D. Flood plain

E. Scarp

24. The feature marked Z can best be described as

A. an island

B. a depression

C. an-ox-bow lake

D. a knoll

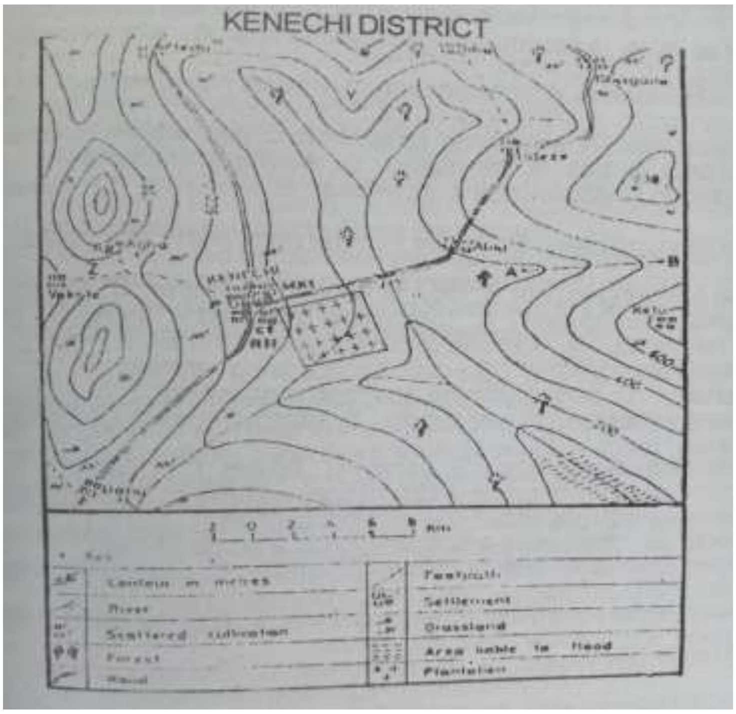
25. A plateau has all the following characteristics except that

A. it sometimes serve as a watershed

B. it is higher than the surrounding areas

C. it is an elevated stretch of land

D. it has a uniformly flat unbroken surface



26. The feature marked **Y** near the northern border of the map is called a

A. spur

B. headland

C. pass

D. gap

27. The feature marked Z on the western part of the map near vokote is called a

A. ridge

B. scarp

C. pass

D. Gap

28. The feature marked A and B on the map represents a

A. dry valley

B. inselberg

C. knoll

D. watershed

29. Which of the following pairs of towns on the map are intervisible

A. vokote and Dabu

B. kenechi and udeze

C. Gbagada and ketu

D. medu and tiba

30. The highest point above sea level on the map is over

A. 1,000 m

B. B 900m

C. C 800m

D. D 700m

ANSWER

1. **D**
2. **C**
3. **C**
4. **C**
5. **C**
6. **D**
7. **A**
8. **B**
9. **D**
10. **B**
11. **A**
12. **C**

13. D

14. C

15. B

16. D

17. A

18. D

19. C

20. D

21. B

22. D

23. B

24. D

25. D

26. A

27. C

28. A

29. D

30. B

APPENDIX F

QUESTIONNAIRE ON ATTITUDE OF STUDENTS TOWARDS GEOGRAPHY

Instruction: What in your own opinion is the best answer considering the items listed A – D.

Instruction: Respond by ticking the

appropriate answer that describes your opinion in the question?

Section A

Personal Data:

Name of the Sc-hool:…………………………………………………………………….

Class:……………………………………………………………………………………..

Gender: Male ☐ Female ☐

Age: 11-15 ☐ 16-20 ☐ 2☐

Section B

		SA	A	D	SD
1.	Virtual laboratory develops the attitude of geography students to technological world.				
2.	Geography enables students to link up with the important information experiences in the global world.				
3.	Geography enables students develop self-concept, self-actualization and self-reliance.				
4.	Teaching of the concept (contour representation of land forms) increases students' punctuality in the class.				
5.	Teaching and learning of concepts (contour representation of land forms) through virtual lab is easily understood by geography students.				
6.	Effective manipulation of materials is developed				

	when learning through physical and virtual laboratories				
7.	Learning of physical geography Create student/ teacher rapport.				
8.	Students respond vividly to questions in physical geography.				
9.	Learning through physical and virtual laboratories does not help teacher to control large classes.				
10.	It increases student punctuality and participation in the classroom				
11.	Interaction between students, teachers and materials during teaching and learning of physical geography is enhanced.				
12.	Development of team work and knowledge seeking is increased.				
13.	It is time consuming.				
14.	They do like using computer manipulation more than practical lesson in the laboratories.				
15.	Physical geography develops creative thinking and desire for project work.				
16.	Interaction with virtual world during teaching physical geography brings about friendship among students.				
17.	Relationship between previous knowledge and the new knowledge is enhanced in physical and virtual class.				
18.	Students develop skills in learning, observation, asking questions thinking and analyzing results.				
19.	It encourages students to work on their own and creates in them the mastery of the subject matter.				
20.	Difficult concepts in physical geography should be stimulated for easy and fast understanding.				

APPENDIX G

Lesson plan for conventional teaching strategy

LESSON ONE
Institution: B
Subject: Geography
Topic: Cross section
Class: SS II
Date:-
Time/Duration:- 40 minutes
Behavioural objectives:
By the end of the lesson, students should be able to:

i. Identify the procedure for cross section drawing.
ii. Show a nature of relief that is represented by a contour line at a glance.
iii. Construct topographical map using the method (contour lines) to represent physical features in their discrete form

Previous Knowledge:-
Students are conversant with the basic concepts of map reading.
Instructional material:-
by Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is a cross time tasection? How do we re represent relief features using contours?	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing.	Teacher start by explaining and listing what is meant by cross section drawing through the use of a chart	The students listen attentively, discuss, take down the	Demonstration, illustration and explanation.

± (3 minutes)		teacher's note and sketch the diagram/figure.	
Presentation Step 2 ± (5 minutes) procedures for cross section drawing	Teacher list and explain the procedures for cross section drawing	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to draw a straight line to join the two point X and Y on a map .	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Identification of point of intersection	Teacher lead students to mark point of intersection of lines or the point opposite the base of the figure using a graph.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.

Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Shading of the relief profile to bring out the rel feature of the relief	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for conventional teaching strategy

LESSON 2
Institution: B
Subject: Geography
Topic contou representation of land forms

Class :SS II
Time/Duration:-2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

i. Describe methods of representing these features (relief) on maps
ii. Arrange fraction of mountain on their contour

Previous Knowledge:-
Students are conversant with the concepts , cross section
Instructional material: - Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is contour? How do we represent relief features using contours	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note b-ooks/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 ± (3 minutes) The definition of cross section drawing.	The teacher define and explain the term contour as the line drawn join places of equal height	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.

Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use diagram on the chart to give detail explanation of contour.	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to draw diagram of contour lines and give brief description of the diagram	The students pay attention to the teacher's instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Following the earliar explanation, the teacher lead students to indicate the contour interval as shown in the diagram	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation **Step 5** ± (8 minutes) Application of the topic to problem	Student were instructed to use the example provided to draw similar contour line with different contour interval	Students perform the exercise in their note books individually taking not of the example	Use of example and the explanation.

solving.		illustrated for them within a given time frame.	

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for conventional teaching strategy

LESSON 3
Subject: Geography
Topic: Relief features
Class :SS II
Time/Duration:-2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

i. Mention physical features on topographical maps.
ii. Describe various relief features
iii. Show the method of representing relief on the map.

Previous Knowledge: -
Students are conversant with the concepts, contour line
Instructional material: - Chalk board, clay, charts, models, thread

Content development	Teacher's performance activities	Students' performance activities	Skills emphasised
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is relief?	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing' ± (3 minutes)	The teacher defines and explain the term relief as the position and character of the highlands and lowlands.	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.
Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use diagram on the chart to give detail explanation of relief features.	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention

Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to identify methods of representing relief on the map.	The students pay attention to the teacher's instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Resulting from the earlier explanation, the teacher lead students to draw the diagram of various relief features.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Student were instructed to use the example draw similar relief features.	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions

Students ask questions on the area of the lesson that are not clear to them

Evaluation

± (2 minutes)

Teacher evaluates the lesson by asking questions based on the topic taught.

Conclusion

± (1 minutes)

Teacher conclude the lesson summarizing the topic of the lesson

EXPERIMENTAL

LESSON ONE

Institution: B

Subject: Geography

Topic: Cross section

Class: SS II

Time/Duration: -2 hours

Behavioural objectives:

By the end of the lesson, students should be able to:

iv. Identify the procedure for cross section drawing.

v. Show a nature of relief that is represented by a contour line at a glance.

vi. Construct topographical map using the method (contour lines) to represent physical features in their discrete form

Previous Knowledge: -

Students are conversant with the basic concepts of map reading.

Instructional material: -Virtual Geography Laboratory Package

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses and captivate the attention of students by describing how new technologies can simplify abstract concepts in geography.	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing. ± (3 minutes)	The virtual geography laboratory package installed on individual student's computer list the procedures involved for cross section drawing.	The students listen attentively, discuss, take down note.	Demonstration, illustration and explanation.
Presentation Step 2 ± (8 minutes) procedures for cross section drawing	Using audio, the computer describe the procedures for cross section drawing	The students listen attentively, discuss, take down note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	The computer lead students by various clicking options on the platform to draw a straight line to join the two point X and Y on a map .	The students pay attention and perform task on the	Illustration with explanations.

		computer, ask questions if any.	
Presentation Step 4 ± (8 minutes) Identification of point of intersection	The computer lead students to mark point of intersection of lines or the point opposite the base of the figure using a graph by clicking an option.	The students perform task on computer Ask questions if any	Illustration with explanations.
Presentation Step 5 ± (8 minutes) Application of the topic to problem solving.	The students use the computer to shade the relief profile drawn on the platform.	Students perform task on computer.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for conventional teaching strategy

LESSON 2
Institution: B
Subject: Geography
Topic contour representation of land forms
Class: SS II

Time/Duration: -2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

iii. Describe methods of representing these features (relief) on maps
iv. Arrange fraction of mountain on their contour

Previous Knowledge: -
Students are conversant with the concepts, cross section
Instructional material: - Chalk board, clay, charts, models, thread

Content development	Teacher's performance activities	Students' performance activities	Skills emphasised
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses and captivate the attention of students by describing how new technologies can simplify abstract concepts in geography	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 ± (3 minutes) The definition of cross section drawing	The teacher define and explain the term contour as the line drawn join places of equal height	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.

Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The virtual geography laboratory package installed on individual student's computer was used to describe contours. .	The students listen attentively, and perform task.	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	The platform lead students to draw diagram of contour lines and give brief description of the diagram	The students pay attention and perform. Ask questions if any and note	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Following the earliar diagram drawn, the package lead students to indicate the contour interval as shown in the diagram	The students pay attention and perform Ask questions if any and note	Illustration with explanations.
Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Student were instructed to use the example provided to draw similar contour line with different contour interval	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion

± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

LESSON 3
Subject: Geography
Topic: Relief features
Class: SS II
Date: -
Time/Duration: -2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

i. Mention physical features on topographical maps.
ii. Describe various relief features
iii. Show the method of representing relief on the map.

Previous Knowledge: -
Students are conversant with the concepts, contour line
Instructional material: - Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses and captivate the attention of students by describing how new technologies can simplify abstract concepts in geography	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 ± (3 minutes) The definition of cross section drawing	Various relief feature was described and displayed on computer for students to see by clicking an option.	The students listen attentively, and perform task.	Demonstration, illustration and explanation.
Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The diagrams was described using an audio by clicking an option.	The students listen attentively, discuss, take down note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	The computer students to identify methods of representing relief on the map by clicking an option.	The students pay attention and perform task. Ask questions if any and note down the example in their note books	Illustration with explanations.

Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Resulting from the earlier explanation, the platform lead students to draw the diagram of various relief features.	The students pay attention and perform task, ask questions if any.	Illustration with explanations.
Presentation Step 5 ± (8 minutes) Application of the topic to problem solving.	Student were instructed to use the example draw similar relief features.	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion

APPENDIX H

Lesson plan for Physical laboratory lesson

LESSON ONE
Institution: B
Subject: Geography
Topic: Cross section
Class: SS II
Date:-
Time/Duration:- 40 minutes
Behavioural objectives:

By the end of the lesson, students should be able to:

vii. Identify the procedure for cross section drawing.
viii. Show a nature of relief that is represented by a contour line at a glance.
ix. Construct topographical map using the method (contour lines) to represent physical features in their discrete form

Previous Knowledge:-

Students are conversant with the basic concepts of map reading.

Instructional material:-

by Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is a cross time tasection? How do we re represent relief features using contours?	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing. ± (3 minutes)	Teacher start by explaining and listing what is meant by cross section drawing through the use of a chart	The students listen attentively, discuss, take down the teacher's note and sketch the	Demonstration, illustration and explanation.

		diagram/figure.	
Presentation Step 2 ± (5 minutes) procedures for cross section drawing	Teacher list and explain the procedures for cross section drawing	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to draw a straight line to join the two point X and Y on a map using models.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Identification of point of intersection	Teacher lead students to mark point of intersection of lines or the point opposite the base of the figure using a graph.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.

Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Shading of the relief profile to bring out the rel feature of the relief	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions

Students ask questions on the area of the lesson that are not clear to them

Evaluation

± (2 minutes)

Teacher evaluates the lesson by asking questions based on the topic taught.

Conclusion

± (1 minutes)

Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for Physical laboratory lesson

LESSON 2
Institution: B
Subject: Geography
Topic contou representation of land forms
Class :SS II
Time/Duration:-2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

v. Describe methods of representing these features (relief) on maps
vi. Arrange fraction of mountain on their contour

Previous Knowledge:-
Students are conversant with the concepts , cross section
Instructional material: - Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is contour? How do we represent relief features using contours	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note b-ooks/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 ± (3 minutes) The definition of cross section drawing.	The teacher define and explain the term contour as the line drawn join places of equal height	The students listen attentively, discuss, take down the teacher's note and	Demonstration, illustration and explanation.

		sketch the diagram/figure.	
Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use diagram on the chart to give detail explanation of contour.	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to draw diagram of contour lines and give brief description of the diagram	The students pay attention to the teacher's instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Following the earliar explanation, the teacher lead students to indicate the contour interval as shown in the diagram	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.

Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Student were instructed to use the example provided to draw similar contour line with different contour interval	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for Physical laboratory lesson

LESSON 3
Subject: Geography
Topic: Relief features
Class :SS II
Time/Duration:-2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

iv. Mention physical features on topographical maps.
v. Describe various relief features
vi. Show the method of representing relief on the map.

Previous Knowledge: -
Students are conversant with the concepts, contour line
Instructional material: - Chalk board, clay, charts, models, thread

Content development	Teacher's performance activities	Students' performance activities	Skills emphasised
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is relief?	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing' ± (3 minutes)	The teacher defines and explain the term relief as the position and character of the highlands and lowlands.	The students listen attentively, discuss, take down the teacher's note and	Demonstration, illustration and explanation.

		sketch the diagram/figure.	
Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use diagram on the chart to give detail explanation of relief features.	The students listen attentively, discuss, take down the teacher’s note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to identify methods of representing relief on the map.	The students pay attention to the teacher’s instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Resulting from the earlier explanation, the teacher lead students to draw the diagram of various relief features.	The students pay attention to the teacher’s explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.

Presentation **Step 5** ± (8 minutes) Application of the topic to problem solving.	Student were instructed to use the example draw similar relief features.	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for Physical laboratory lesson

LESSON ONE
Institution: B
Subject: Geography
Topic: Cross section
Class: SS II
Date:-
Time/Duration:- 40 minutes
Behavioural objectives:

By the end of the lesson, students should be able to:

x. Identify the procedure for cross section drawing.
xi. Show a nature of relief that is represented by a contour line at a glance.
xii. Construct topographical map using the method (contour lines) to represent physical features in their discrete form

Previous Knowledge:-

Students are conversant with the basic concepts of map reading.

Instructional material:-

by Chalk board, clay, charts, models, thread

Content development	Teacher's performance activities	Students' performance activities	Skills emphasised
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is a cross time tasection? How do we re represent relief features using contours?	Students listen attentively to the teacher's questions and respond to the questions accordingly.They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing. ± (3 minutes)	Teacher start by explaining and listing what is meant by cross section drawing through the use of a models in the lab	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.
Presentation Step 2 ± (5 minutes) procedures for cross section drawing	Teacher list and explain the procedures for cross section drawing using models in the lab	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention

Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to construct a straight line to join the two point X and Y on a map using models.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Identification of point of intersection	Teacher lead students to mark point of intersection of lines or the point opposite the base of the figure using a graph.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 5 ± (8 minutes) Application of the topic to problem solving.	Shading of the relief profile to bring out the rel feature of the relief	Students perform the exercise in their note books individually taking not of the example illustrated for them within a given time frame.	Use of example and the explanation.

Questions

Students ask questions on the area of the lesson that are not clear to them

Evaluation

± (2 minutes)

Teacher evaluates the lesson by asking questions based on the topic taught.

Conclusion

± (1 minutes)

Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for Physical Laboratory
LESSON 2
Institution: C
Subject: Geography
Topic contou representation of land forms
Class :SS II
Time/Duration:-2 hours

Behavioural objectives:

By the end of the lesson, students should be able to:

vii. Describe methods of representing these features (relief) on maps

viii. Arrange fraction of mountain on their contour

Previous Knowledge:-

Students are conversant with the concepts , cross section

Instructional material: - Chalk board, clay, charts, models, thread

Content development	Teacher's performance activities	Students' performance activities	Skills emphasised
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is contour? How do we represent relief features using contours	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note b-ooks/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 ± (3 minutes) The definition of cross section drawing.	The teacher define and explain the term contour as the line drawn join places of equal height	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.

Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use models on the to give detail explanation of contour.	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to construct models to bring out contour lines and give brief description of the models	The students pay attention to the teacher's instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Following the earliar explanation, the teacher lead students to indicate the contour interval as shown in the models	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation **Step 5** ± (8 minutes) Application of the topic to problem	Student were instructed to use the example provided to draw similar contour line with different contour interval	Students perform the exercise in their note books individually taking not of the example	Use of example and the explanation.

solving.		illustrated for them within a given time frame.	

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

Lesson plan for Physical laboratory lesson

LESSON 3
Subject: Geography
Topic: Relief features
Class :SS II
Time/Duration:-2 hours
Behavioural objectives:

By the end of the lesson, students should be able to:

vii. Mention physical features on topographical maps.
viii. Describe various relief features
ix. Show the method of representing relief on the map.

Previous Knowledge: -
Students are conversant with the concepts, contour line
Instructional material: - Chalk board, clay, charts, models, thread

Content development	**Teacher's performance activities**	**Students' performance activities**	**Skills emphasised**
Introduction of the lesson ± (2 minutes) Assessment of extent of mastery of pre-requisite knowledge	Teacher arouses the attention of students by asking question on the topic of the lesson as: What is relief?	Students listen attentively to the teacher's questions and respond to the questions accordingly. They note down the correct responses in their note books/minds.	Explanations and use of diagrams and examples.
Presentation Step 1 The definition of cross section drawing' ± (3 minutes)	The teacher defines and explain the term relief as the position and character of the highlands and lowlands.	The students listen attentively, discuss, take down the teacher's note and sketch the diagram/figure.	Demonstration, illustration and explanation.

Presentation Step 2 ± (8 minutes) procedures for cross section drawing	The teacher use diagram on the chart to give detail explanation of relief features.	The students listen attentively, discuss, take down the teacher's note	Make sure students are paying attention
Presentation Step 3 ± (8 minutes) Line drawing.	Teacher lead students to identify methods of representing relief on the map.	The students pay attention to the teacher's instructions. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation Step 4 ± (8 minutes) Contour interval as shown in the diagram	Resulting from the earlier explanation, the teacher lead students to draw the diagram of various relief features.	The students pay attention to the teacher's explanation. Ask questions if any and note down the example in their note books	Illustration with explanations.
Presentation **Step 5** ± (8 minutes) Application of the topic to problem	Student were instructed to use the example draw similar relief features.	Students perform the exercise in their note books individually taking not of the example	Use of example and the explanation.

solving.		illustrated for them within a given time frame.	

Questions
Students ask questions on the area of the lesson that are not clear to them
Evaluation
± (2 minutes)
Teacher evaluates the lesson by asking questions based on the topic taught.
Conclusion
± (1 minutes)
Teacher conclude the lesson summarizing the topic of the lesson

APPENDIX I

```
CORRELATIONS
  /VARIABLES=GROUP1 GROUP2
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

PPMC CORRELATION

CORRELATIONS

Correlations

		GROUP1	GROUP2
GROUP1	Pearson Correlation	1	.765**
	Sig. (2-tailed)		.000
	N	30	30
GROUP2	Pearson Correlation	.765**	1
	Sig. (2-tailed)	.000	
	N	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.705	2

APPENDIX J
VALIDATION FORM

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF EDUCATIONAL TECHNOLOGY

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. She/he is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument

Thanks for your anticipated assistance.

Dr ALABI, Thomas O. 4/3/19

H. O. D.
Dept of Educational Technology
Fed. University of Technology
MAR 2019
Minna, Niger State

Head of Department (Signature, Date & Official Stamp)

Student's Surname: USMAN

Registration Number: Ph.D/SSTE/2017/991 Other Names: HUSSAINI

Programme: Ph.D

Title of the Instrument: VIRTUAL GEOGRAPHY LABORATORY PACKAGE

ATTESTATION SECTION

Summary of the Remark on the Instrument: THE INSTRUMENT IS GENERAL WITHIN THE REACH OF THE STUDENTS.

I hereby attest that the above named student brought his instrument for validation

Name of Attester: Dr. ADAMU ZUBAIRU GANA [handwriting partly illegible]

Designation: LECTURER

Name and Address of Institution: FUT, MINNA

Phone Number: 08036328687 E-Mail: adamu2ubairu@futminna.edu.ng

Please comment on the following

1. Appropriateness of the Instrument for the purpose it's design for. THE INSTRUMENT IS VERY APPROPRIATE
2. Clarity and simplicity for the level of the language used. CLEARED
3. Suability for the level of the targeted audience. VERY SUITABLE
4. The extent in which the items cover the topic it meant to cover. THE ITEMS COVERED THE SCOPE
5. The structuring of the Questionnaire. STANDARD
6. Others (grammatical errors, spelling errors and others. MINOR
7. General overview of the Instrument. STANDARD

Suggestions for improving the quality of the Instrument

1. THE INSTRUMENT CAN BE REVIEWED
2.
3.
4.
5.

Name of Validator. DR. ADAMU ZUBAIRU EVUTI

Area of Specialization. EDUCATIONAL TECHNOLOGY

Name of Institution. FUT, MINNA Designation. LECTURER

Signature. [signature] Date. 18-03-2019

Thank You

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF EDUCATIONAL TECHNOLOGY

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. She/he is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument

Thanks for your anticipated assistance.

Dr ALABI Thomas Omotayo 4/3/19
Head of Department (Signature, Date & Official Stamp)

H. O. D. Dept of Educational Technology, Fed. University of Technology, Minna, Niger State

Student's Surname: USMAN
Registration Number: PhD/SSTE/2017/991 Programme: Ph.D Other Names: HUSSAINI
Title of the Instrument: VIRTUAL GEOGRAPHY LABORATORY PACKAGE

ATTESTATION SECTION

Summary of the Remark on the Instrument……………………………………

……………………………………………………………………………

……………………………………………………………………………

I hereby attest that the above named student brought his instrument for validation

Name of Attester: Dr. M. A. EMIGILATI
Designation: SENIOR LECTURE
Name and Address of Institution: DEPT. OF GEOGRAPHY S-PS FUT MX
Phone Number: 07039950192 E.-Mail: Mr.emigilati@futminna.edu.ng

Please comment on the following

1. Appropriateness of the instrument for the purpose it's design for... Adequately prepared
2. Clarity and simplicity for the level of the language used... Satisfactory
3. Suability for the level of the targeted audience ... Accurately
4. The extent in which the items cover the topic it meant to cover... adequately
5. The structuring of the Questionnaire...
6. Others (grammatical errors, spelling errors and others... Well taken of
7. General overview of the Instrument... very much interested and adequately covere prop

Suggestions for improving the quality of the Instrument

1. ... Use good environment
2. ... Very good spoken English
3. ... manageable class
4. ... Instrument made it for to use
5. ... (standard) observe individual differe

Name of Validator... Dr. M. A. Emigilati

Area of Specialization... Geography

Name of Institution... Fut Minna Designation...

Signature... Date... 19/3/2019

Thank You

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF EDUCATIONAL TECHNOLOGY

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. She/he is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument

Thanks for your anticipated assistance.

Dr ALABI Thomas Omiwale [signature] ... 14 MAR 2019

Head of Department (Signature, Date & Official Stamp)

Fac. of Education, Fed. University of Techn., P.M.B. 65 Minna, Niger State

Student's Surname: USMAN

Registration Number: Ph.D/SSTE/2017/991 Other Names: [illegible]

Programme: Ph.D

Title of the Instrument: VIRTUAL GEOGRAPHY LABORATORY PACKAGE

ATTESTATION SECTION

Summary of the Remark on the Instrument: The package is well designed and programmed containing all the features of the subject matter

I hereby attest that the above named student brought his instrument for validation

Name of Attester: DR. IBRAHIM, I. KUTA

Designation: SL

Name and Address of Institution: FUT, Minna

Phone Number: 08035837865 E-Mail: ---

Please comment on the following

1. Appropriateness of the instrument for the purpose it's design for...The instrument is well designed based on the features of a package.....
2. Clarity and simplicity for the level of the language used.......................... The instrument is clear, vivid, audible and in simple terms
3. Suability for the level of the targeted audience... Very adequate for the intending audience.....................
4. The extent in which the items cover the topic it meant to cover......................... ....Maximally covers the topics on topographic maps and contour line
5. The structuring of the Questionnaire... Structure of the questionnaire very good.............
6. Others (grammatical errors, spelling errors and others.................................... .....Very minimal...
7. General overview of the Instrument.. ......The instrument (package) is good.........................

Suggestions for improving the quality of the Instrument

1. ......The instrument if well administered it will
2. ......
3. ......Yield a dependable result that would
4. ......Solve the problem of map sectioning and contouring
5. ......

Name of Validator...DR. I. I. KUTA...

Area of Specialization...Educational Technology (Bio)......................

Name of Institution...F.U.T, Minna..................Designation...SL..............

Signature.....[signature]..Date. 18/3/19.....

Thank You

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF EDUCATIONAL TECHNOLOGY

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. She/he is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument

Thanks for your anticipated assistance.

Dr Alabi 29/1/20[illegible]

Head of Department (Signature, Date & Official Stamp)

Student's Surname: USMAN Other Names: HUSSAINI

Registration Number: PhD/SSTE/2017/1991 Programme: PhD

Title of the Instrument: QUESTIONNAIRE ON THE ATTITUDE OF STUDENTS TOWARDS GEOGRAPHY

ATTESTATION SECTION

Summary of the Remark on the Instrument: THE INSTRUMENT IS SUITABLE FOR PURPOSE ITS MEANT FOR

I hereby attest that the above named student brought his instrument for validation

Name of Attester: HAAIZA M. MUHAMMAD (Ph.D)

Designation: LECTURER II

Name and Address of Institution: IBB U LAPAI

Phone Number: 08069647527 E-Mail: haaizamachins01@gmail.com

Scanned with CamScanner

Please comment on the following

1. Appropriateness of the instrument for the purpose it's design for. THE INSTRUMENT IS APPROPRIATE AND SUITABLE FOR USE
2. Clarity and simplicity for the level of the language used. THE WORDINGS ARE SIMPLE TO THE UNDERSTANDING OF THE STUDENTS
3. Suability for the level of the targeted audience. THE INSTRUMENT IS SUITABLE FOR THEIR LEVEL
4. The extent in which the items cover the topic it meant to cover. IT COVERED ALMOST 80%
5. The structuring of the Questionnaire. WELL STRUCTURED
6. Others (grammatical errors, spelling errors and others. MINOR ERRORS
7. General overview of the Instrument. HAD EFFECT THE CORRECTIONS

Suggestions for improving the quality of the Instrument

1. ……………………
2. ……………………
3. ……………………
4. ……………………
5. ……………………

Name of Validator. HADIZA M. MUHAMMAD (Ph.D)

Area of Specialization. GUIDANCE AND COUNSELLING

Name of Institution. I.B.B.U. LAPAI

Signature. Hamuhammad ……… Designation. LECT II

……………………… Date. 09/3/2019

Thank You

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF EDUCATIONAL TECHNOLOGY

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. She/he is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument

Thanks for your anticipated assistance.

Dr ALABI Thomas (signature)

H.O.D. Dept of Educational ... Fed. University of Tech. ... 14 MAR 2019 ... Minna, Niger State

Head of Department (Signature, Date & Official Stamp)

Student's Surname: Usman

Registration Number: Ph.D/SSTE/2017/991 Other Names: Hussaini

Programme: Ph.D.

Title of the Instrument: Achievement Test

ATTESTATION SECTION

Summary of the Remark on the Instrument: The research instrument is valid and carefully designed/developed in order to achieve the purpose for which it is meant.

I hereby attest that the above named student brought his instrument for validation

Name of Attester: Isah Jibrin Masha

Designation: Chief Education Officer

Name and Address of Institution: Niger State Teacher professional Development Centre, Maitumbi Bandawu

Phone Number: 09037733 7742 E.- Mail

Please comment on the following

1. Appropriateness of the instrument for the purpose it's design for… The instrument is aptly appropriate for the level it is designed for.
2. Clarity and simplicity for the level of the language used… Thoroughly simple and learner friendly.
3. Suability for the level of the targeted audience … Suitable and adequate for the target level.
4. The extent in which the items cover the topic it meant to cover… The items have been able to cover well enough
5. The structuring of the Questionnaire… The questions are well set and standard.
6. Others (grammatical errors, spelling errors and others… Very minimal.
7. General overview of the instrument… It can measure what it is intended/designed to measure.

Suggestions for improving the quality of the Instrument

1. NIL
2. …
3. …
4. …
5. …

Name of Validator… ISAH JIBRIN MASHA

Area of Specialization… Environmental Management

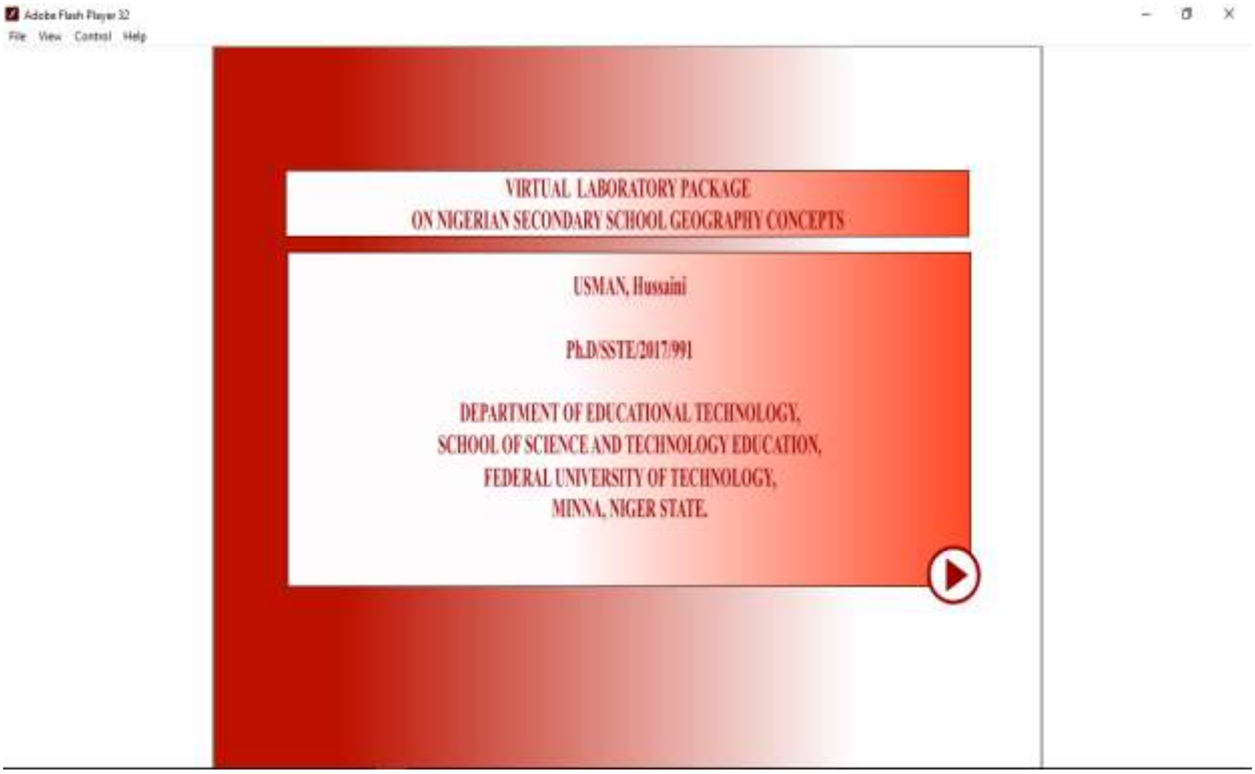
Name of Institution… NSTPDC/MA … Designation… CHIEF S/O

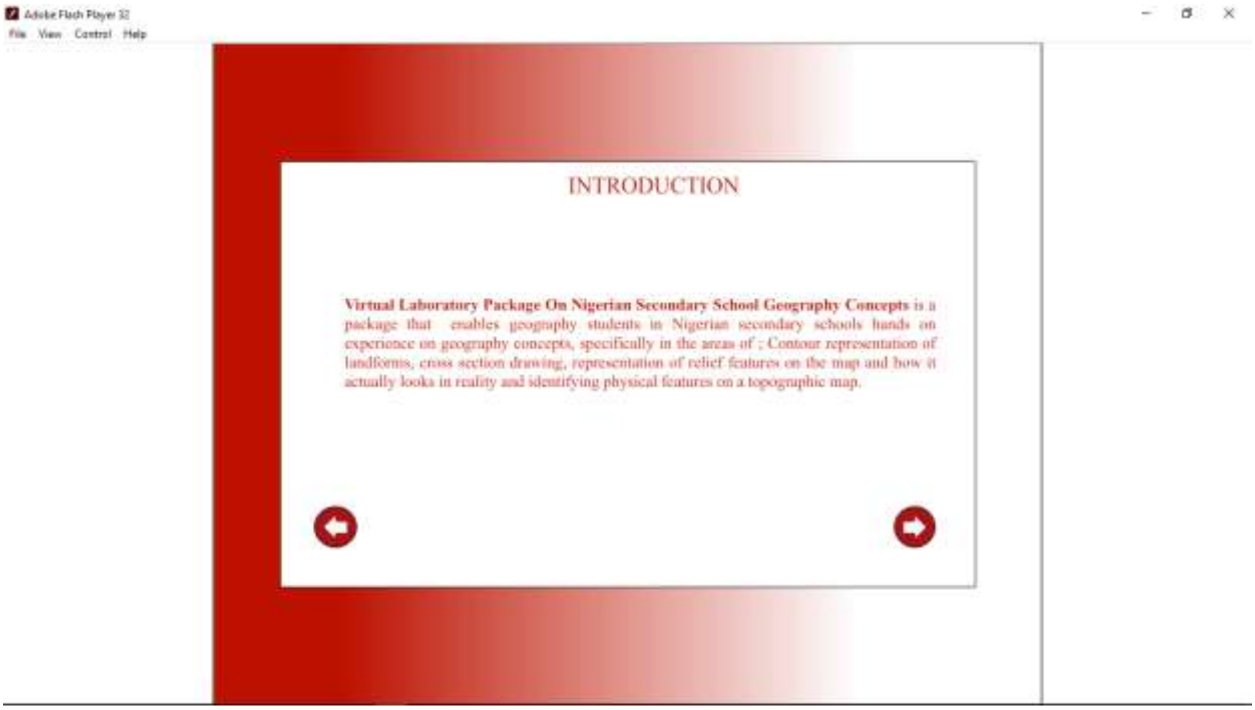
Signature… Date…

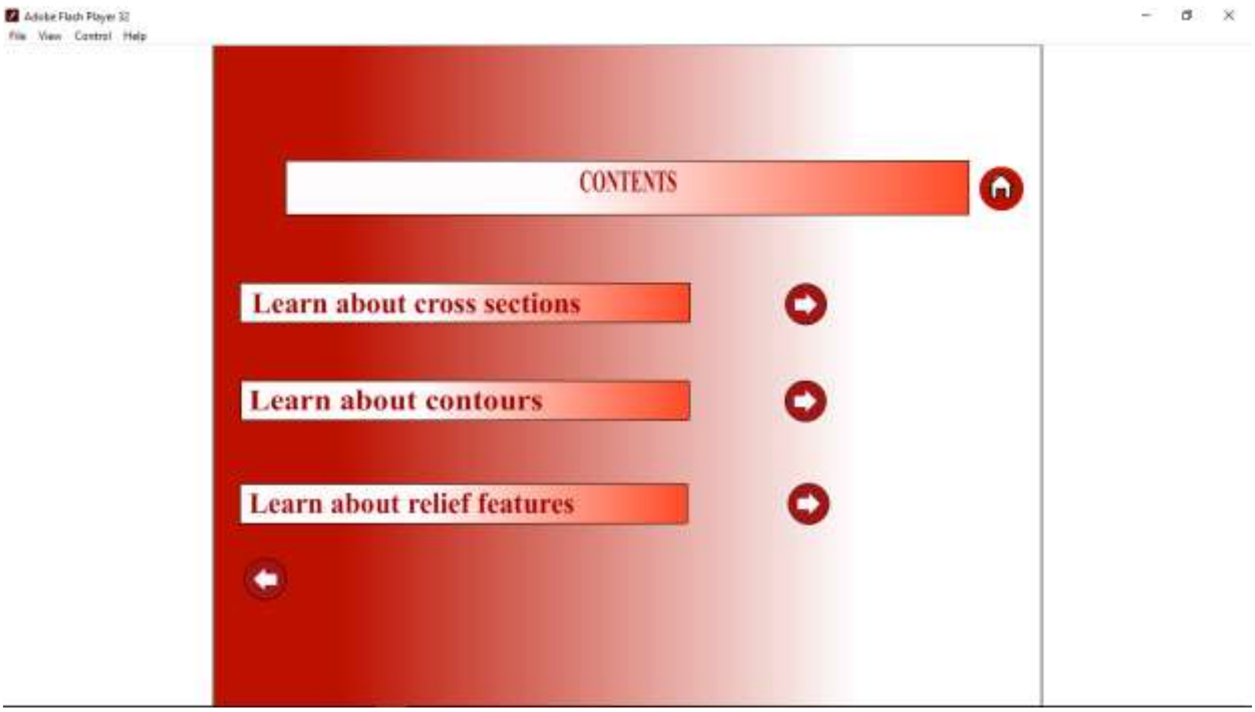
Thank You

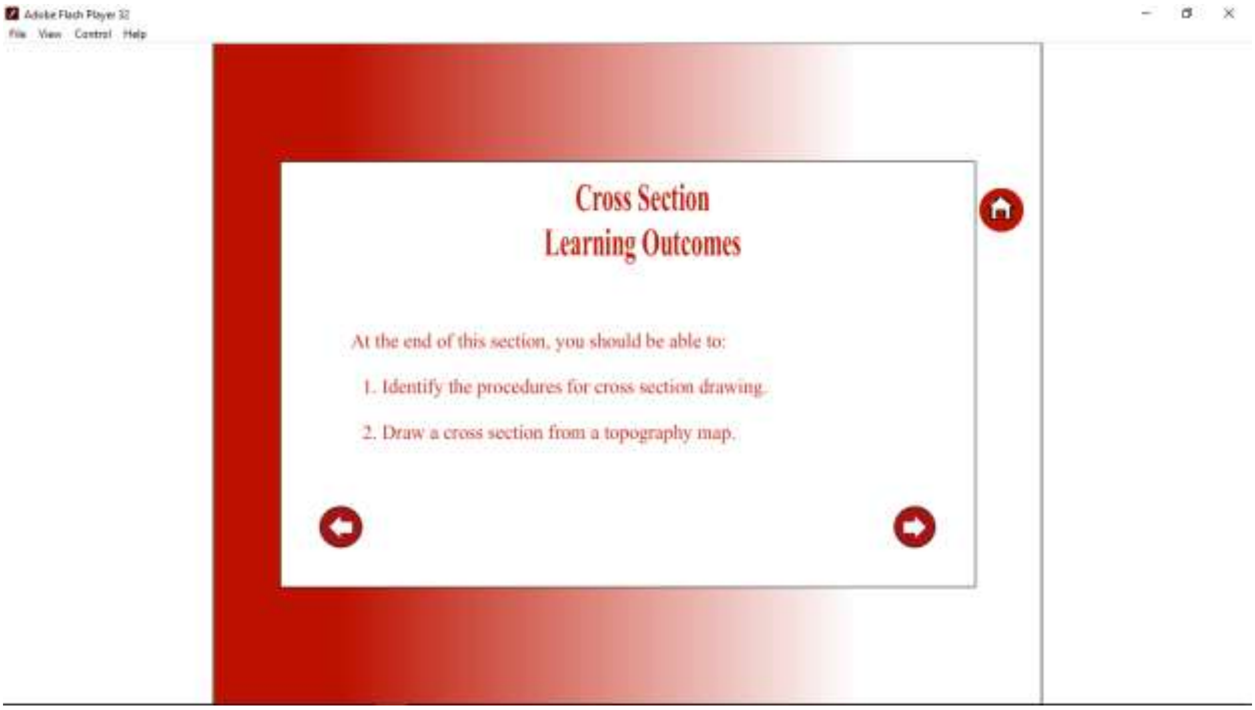
APPENDIX K

VIRTUAL LABORATORY PACKAGE




Adobe Flash Player 32
File View Control Help
INTRODUCTION
Virtual Laboratory Package On Nigerian Secondary School Geography Concepts is a package that enables geography students in Nigerian secondary schools hands on experience on geography concepts, specifically in the areas of ; Contour representation of landforms, cross section drawing, representation of relief features on the map and how it actually looks in reality and identifying physical features on a topographic map.


Adobe Flash Player 32
File View Control Help
CONTENTS
Learn about cross sections
Learn about contours
Learn about relief features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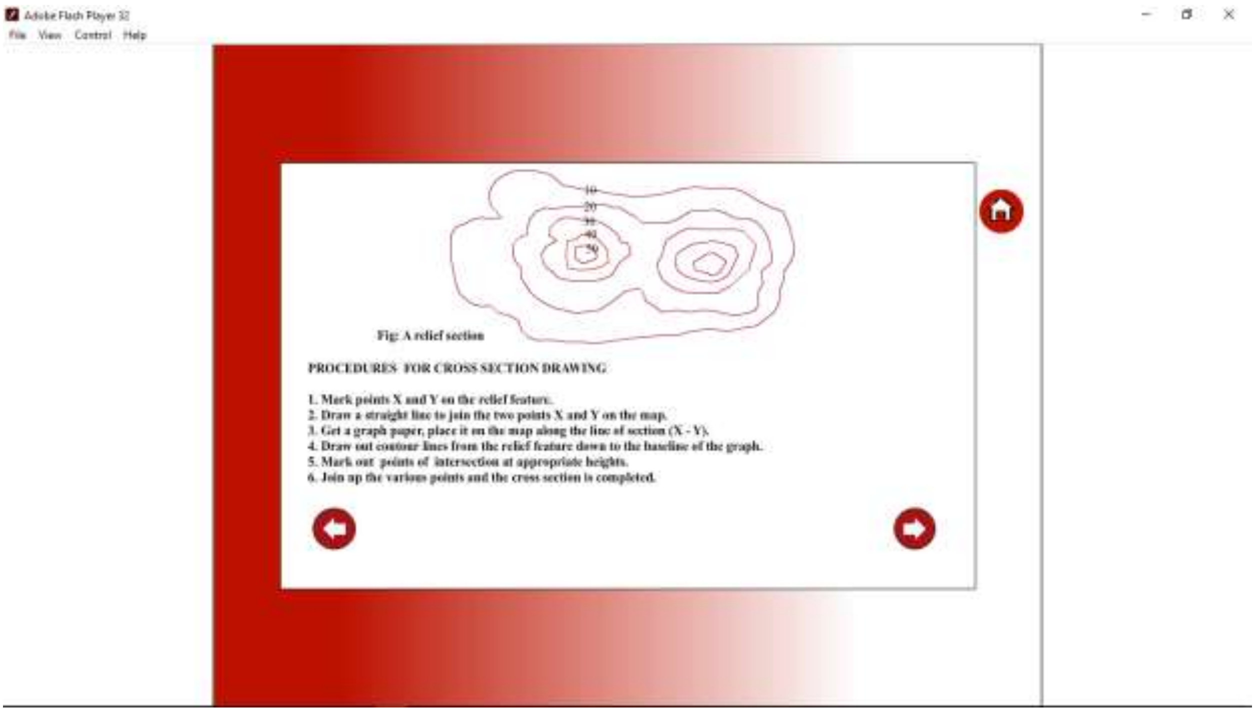
File View Control Help
Cross Section
Learning Outcomes
At the end of this section, you should be able to:
1. Identify the procedures for cross section drawing.
2. Draw a cross section from a topography map.


Adobe Flash Player 32
File View Control Help
10
20
30
40
50
Fig: A relief section
PROCEDURES FOR CROSS SECTION DRAWING
1. Mark points X and Y on the relief feature.
2. Draw a straight line to join the two points X and Y on the map.
3. Get a graph paper, place it on the map along the line of section (X - Y).
4. Draw out contour lines from the relief feature down to the baseline of the graph.
5. Mark out points of intersection at appropriate heights.
6. Join up the various points and the cross section is completed.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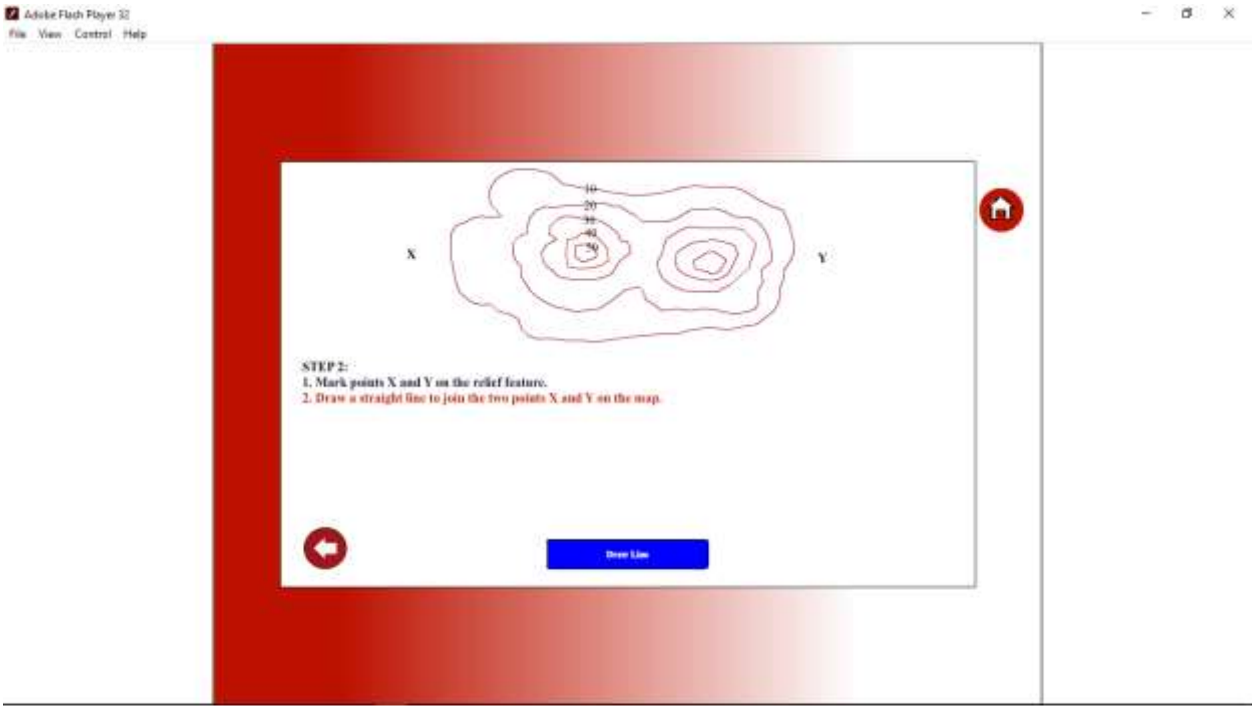
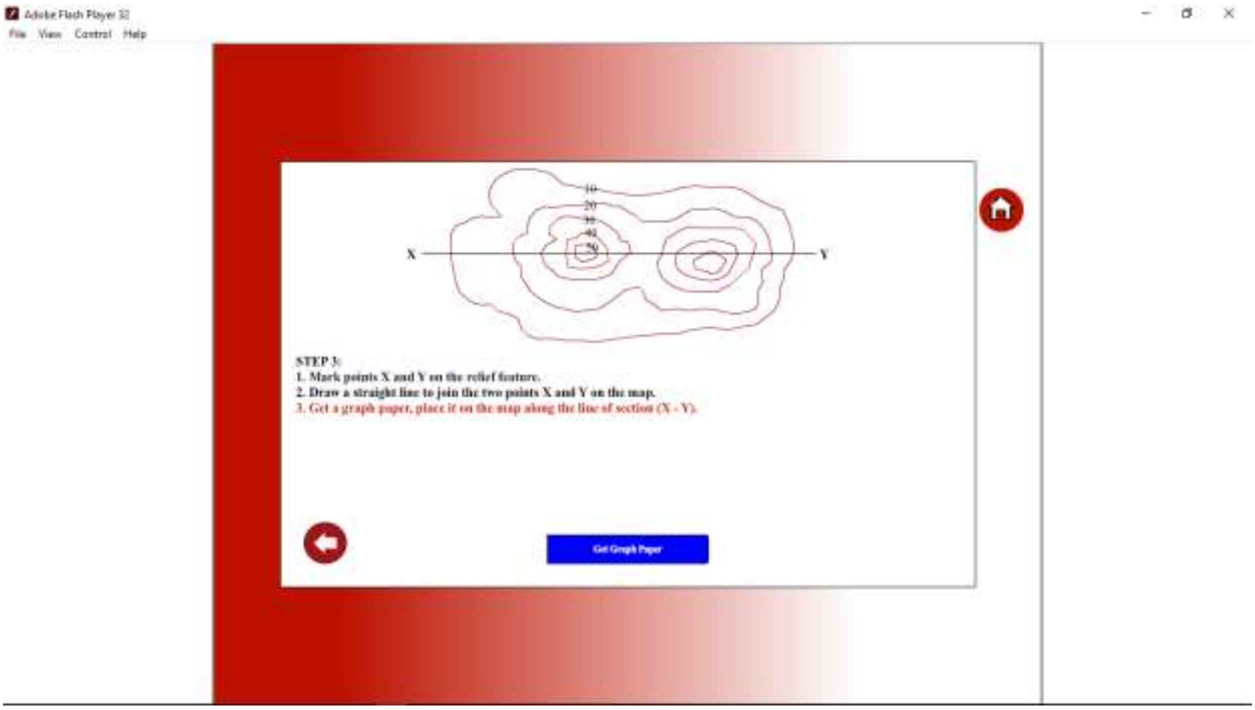
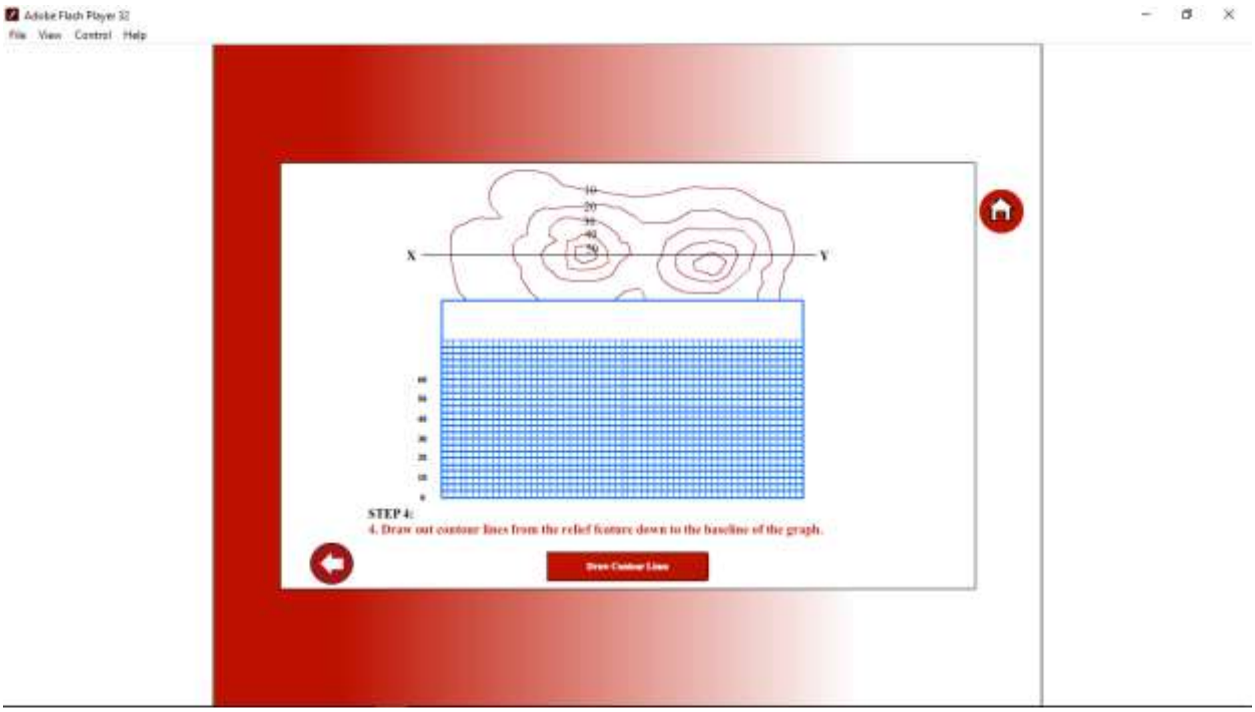
10
20
30
40
50
STEP 1:
1. Mark points X and Y on the relief feature.
Click to mark points


Adobe Flash Player 32
File View Control Help
10
20
30
40
50
X
Y
STEP 2:
1. Mark points X and Y on the relief feature.
2. Draw a straight line to join the two points X and Y on the map.
Draw Line


Adobe Flash Player 32
File View Control Help
X
Y
STEP 3:
1. Mark points X and Y on the relief feature.
2. Draw a straight line to join the two points X and Y on the map.
3. Get a graph paper, place it on the map along the line of section (X - Y).
Get Graph Paper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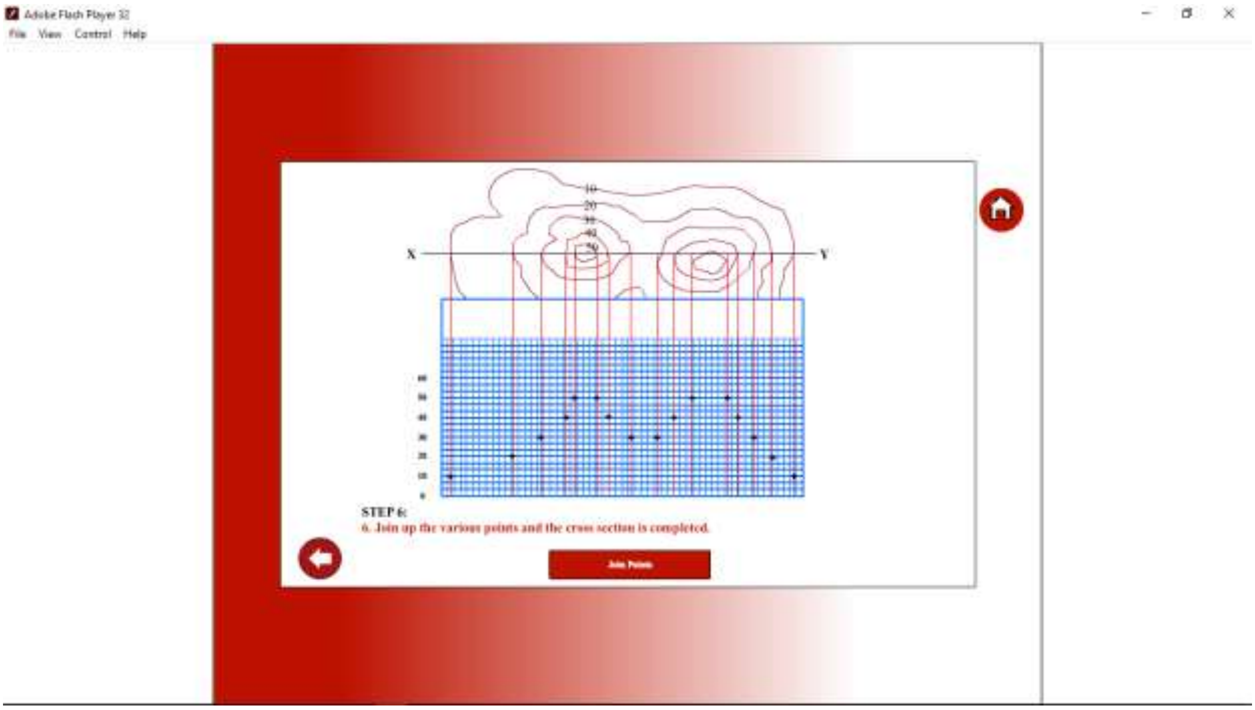
File View Control Help
X
Y
STEP 4:
4. Draw out contour lines from the relief feature down to the baseline of the graph.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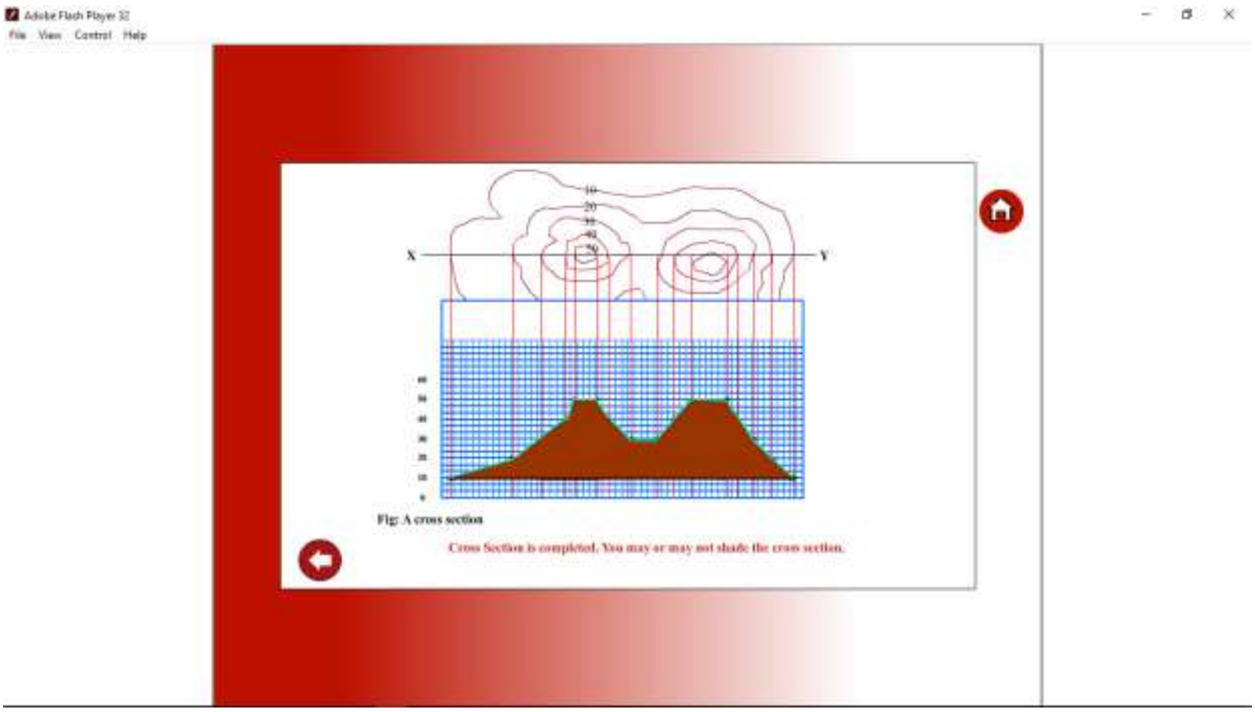
X
Y
STEP 6:
6. Join up the various points and the cross section is completed.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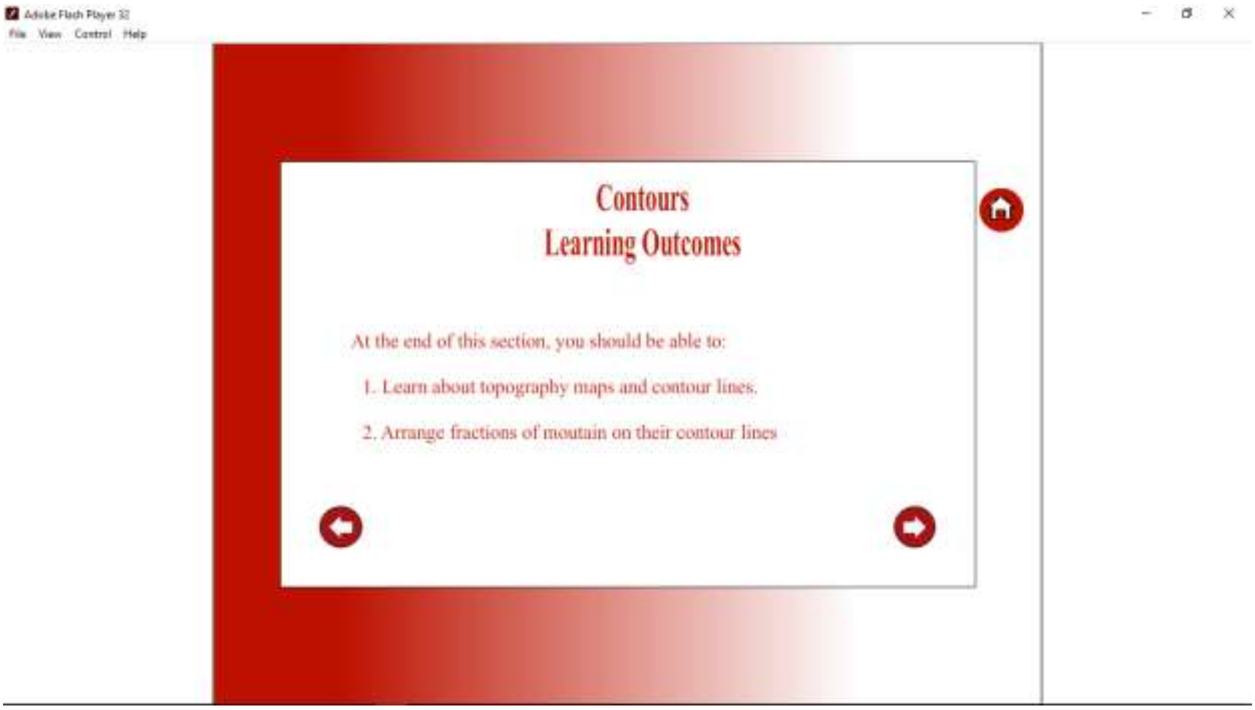
X
Y
Fig: A cross section
Cross Section is completed. You may or may not shade the cross section.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Contours
Learning Outcomes
At the end of this section, you should be able to:
1. Learn about topography maps and contour lines.
2. Arrange fractions of moutain on their contour lines


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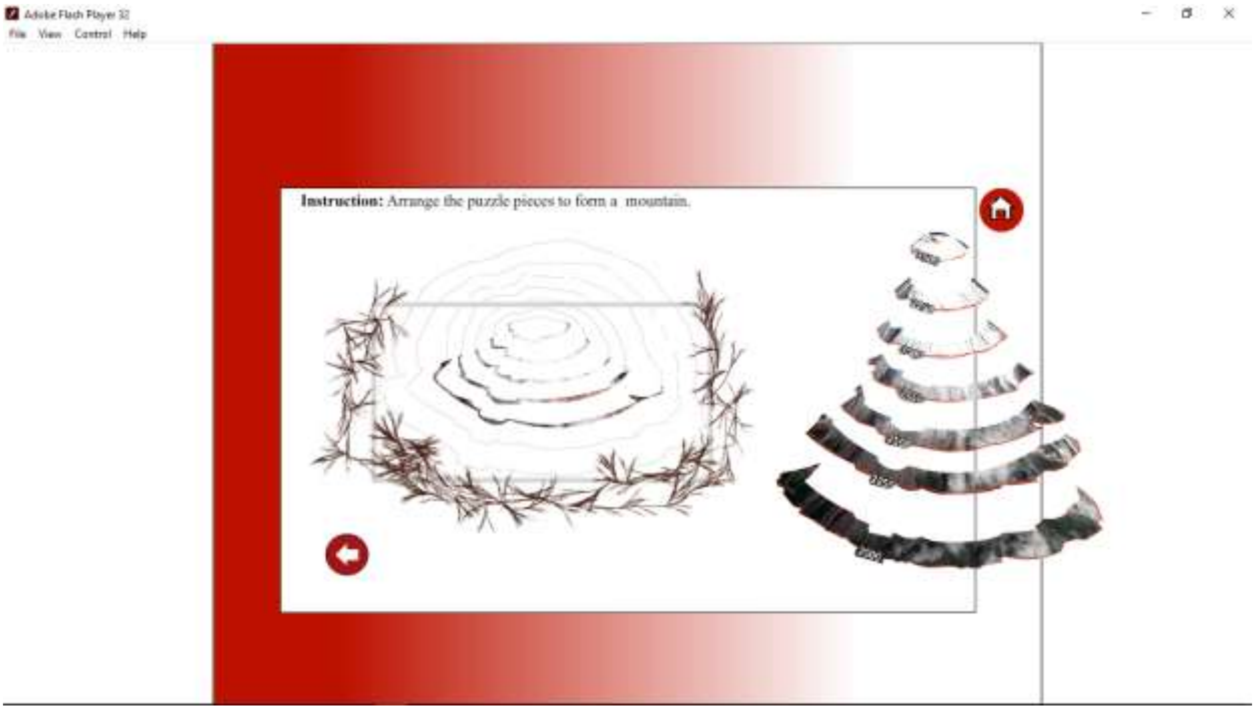
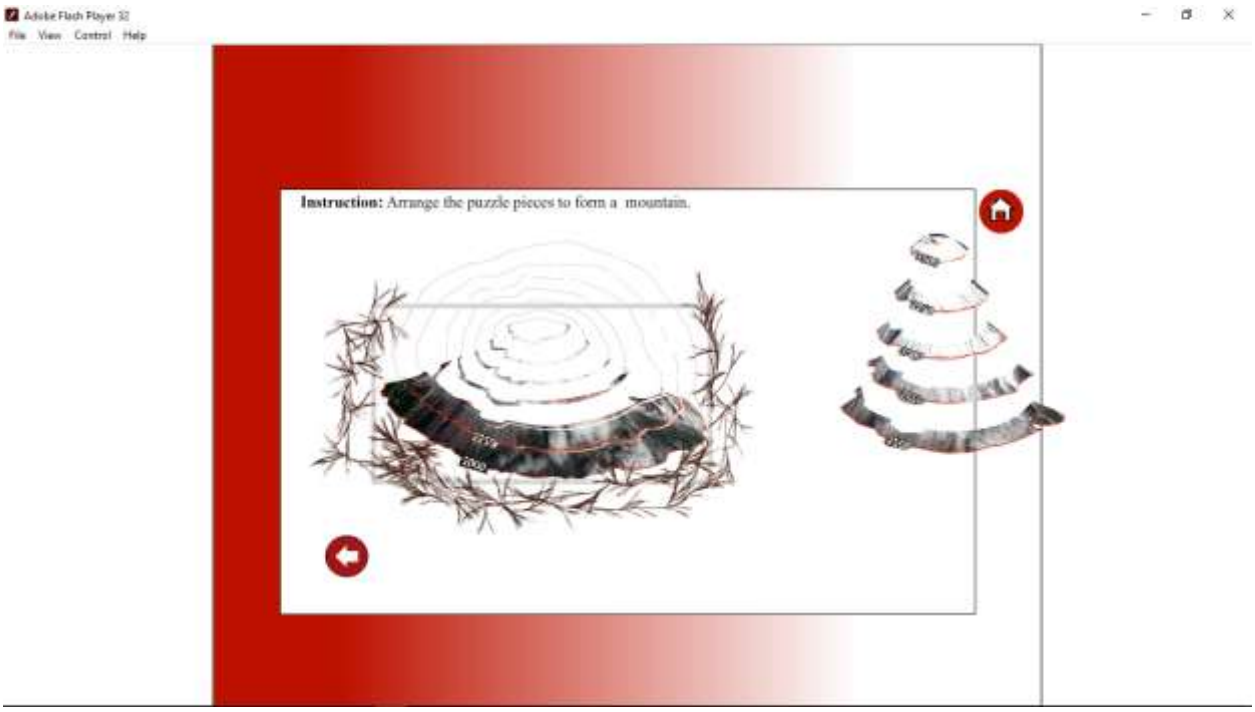
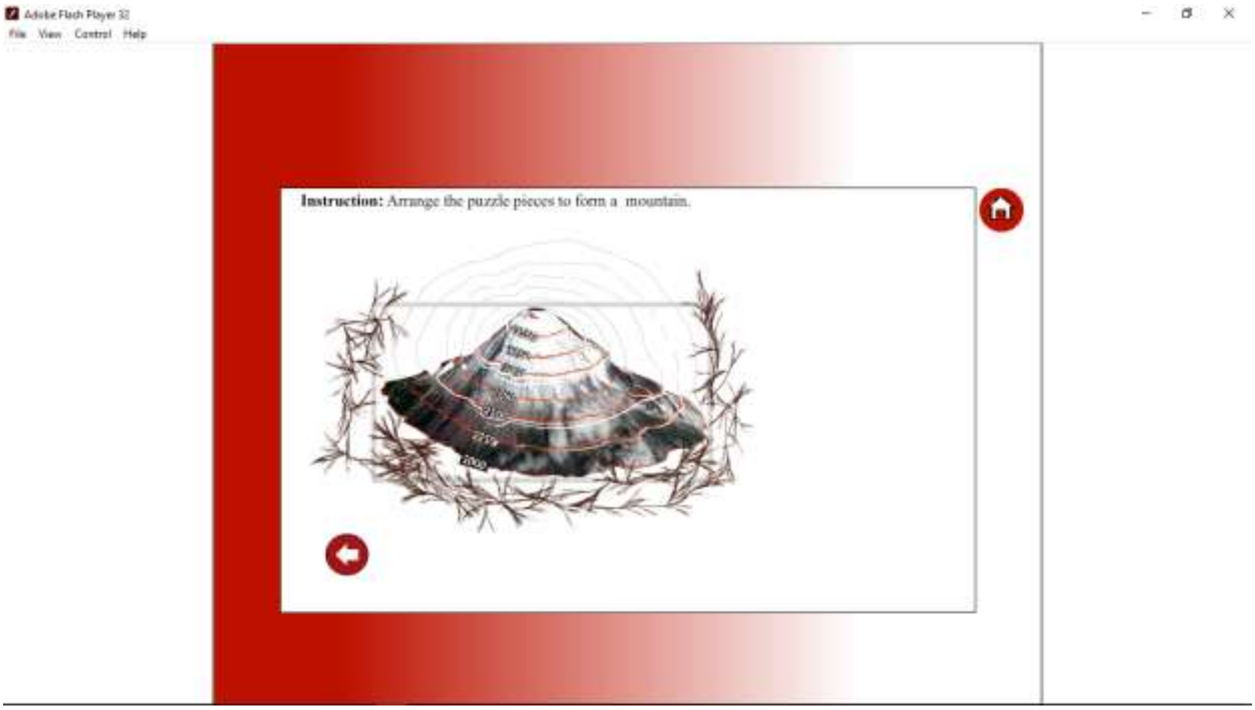
File View Control Help
Fig: A Relief Section.
UNDERSTANDING TOPOGRAPHY MAPS
The thin brown lines snaking around a topographic map are called contour lines. All points along the same contour lines are the same elevation above sea level, by following a contour line on the ground, you would travel neither uphill nor downhill, eventually ending up back at your starting point. A line marked "30", for example means that the point on the map is "30" feet above sea level.
Try Puzzle


Adobe Flash Player 32
File View Control Help
Instruction: Arrange the puzzle pieces to form a mountain.


Adobe Flash Player 32
File View Control Help
Instruction: Arrange the puzzle pieces to form a mountain.


Adobe Flash Player 32
File View Control Help
Instruction: Arrange the puzzle pieces to form a mountain.