IMPACT OF VIRTUAL LABORATORY ON SECONDARY SCHOOL BIOLOGY STUDENT'S ACHIEVEMENT AND RETENTION IN MINNA METROPOLIS, NIGER STATE

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BEING A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF EDUCATIONAL TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR IN TECHNOLOGY IN EDUCATION TECHNOLOGY (B. TECH) IN THE DEPARTMENT OF EDUCATIONAL TECHNOLOGY; SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA NIGERIA.

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ABSTRACT

The study investigated the of impact of virtual laboratory on secondary school biology student's achievement and retention in Minna metropolis, Niger state. The study employed a quasi-experimental design, specifically the pretest-posttest nonequivalent group design. Fifty (50) students from which comprised of male and female selected from senior secondary school students. The experts validated the instrument Biology Achievement Test (BAT). Four research questions were answered and four hypotheses were tested. The data were analyzed using mean, standard deviation. The results revealed that students taught using virtual laboratory performed better than students taught using conventional material; male students did not perform better than their female counterparts in Biology, students taught using virtual laboratory retained better than students taught using conventional material; male students retained better than their female counterparts in Biology. The mean scores were higher for student's taught with Virtual laboratory compared to those taught without it with lower mean scores; there was significant difference in the achievement mean score of students taught using students virtual laboratory and those taught without it; there was no significant difference in the mean achievement scores of male and female students in Biology; there was significant difference in the mean retention score of students taught using students virtual laboratory and those taught without it; there was a significant difference in the mean retention scores of male and female students in Biology. Based on the findings and implications, it was recommended amongst others teachers should enroll in educational technology where they can learn the process of producing virtual laboratory. It was suggested that there should in service training for teachers.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to The Study

Laboratory exercises provides effective skill acquisition and hands-on experience, we are now seeing new emerging technologies that can overcome some of the potential difficulties in this area (Potkonjak *et al*., 2016). These include: computer graphics, augmented reality, computational dynamics, and virtual worlds. Practical experience is an important component of the educational process. However, the time and economical resources often required for the setting up and construction of scientific laboratories is outside the scope of many institutions (Tatli & Ayas, 2010). A solution to this problem could be found in the adaptation of the Virtual Reality technology, which could allow the creation of Virtual Laboratories, which will simulate the processes and actions that could take place in real laboratories (Alexiou *et al*., 2004).

Muradova (2020) opined that virtual laboratories include software simulating laboratory experiments, and remote laboratories include a laboratory facility with remote access. One of the goals of creating virtual laboratories is the desire for a comprehensive visualization of the studied processes, tasks - providing students with the most complete perception, understanding of the studied processes. Virtual laboratories make it possible in real production conditions to observe processes that are difficult to distinguish due to the small size of devices or particles, not to depend on time and resources, to change the parameters of experiments without fear of violation of security measures, to form competencies outside of an educational organization. You can use laboratories both offline and online. Virtual experiments, namely interactive laboratory work, can be carried out in online resources, or can be through a series of specialized discs. Students' activities in a

virtual laboratory are useful for the formation of research competencies, an experiment is the result (automatic processing of the results).

Wuketits (2018) noted that Biology is a natural science, this is clear and trivial. But it has to answer questions and explain phenomena that go beyond physics and chemistry. Also, what should never be forgotten, it offers explanations of the origin and evolution of our own species, its particular evolutionary pathways and its present situation. Rogers (2019) defined Biology as the study of living things and their vital processes. The field deals with all the physicochemical aspects of life. is a science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy (Mouhammad, 2018).

Subramanian (2016) defined achievement as excellence in all academic disciplines, in the class as well as extracurricular activities. It includes excellence in sporting, behavior, confidence, communication skill, punctuality, assertiveness, art, culture and the like. Achievement generally refers to a child's performance in the academic areas (e.g., reading or language, art, math, science and history). The definition could vary depending on a child's circumstance or situation. Academic Achievement is the specified level of attainment or proficiency in academic work as evaluated by teachers or by standardized test or combination of both. Thus, achievement refers to what a person has acquired after specific training or instruction has been imparted/academic achievement can be assessed by tests, which are primarily designated to measure the effects of specific program of instruction or training. Tuyuz (2010) revealed that virtual laboratory applications made positive effects on students' achievements. Tatli and Ayas (2011) concluded that virtual laboratory software is effective as the real laboratory, in terms of student achievement. Virtual laboratory provides considerable support for students and helped to improve their conceptual understanding in science and science process skills, and in elevating learning outcomes (El-Sabagh, 2010)

Abuodha (2019) defined retention as a process by which both working memory and long-term memory preserves knowledge so that it can locate, identify and retrieve it in the future. Retention is simply the ability of students to recall what has been learnt over a period of time (Nweke *et al*. 2019). Hussaini *et al*. (2021) revealed that virtual laboratory enhanced student's retention. This is in line with the findings of Gambari *et al*. (2013) who revealed that students taught using virtual learning package had better retention than those without it.

Gambari *et al*. (2010) reported that gender had no influence on academic performance of students. Therefore, part of this study examined the influence of female and male students exposed to the same amount and types of experiences in physics practical using virtual lab package in order to determine whether gender have any influence on students' performance. Gambari (2013) also revealed that there is no gender effect on the achievement of male and female students taught physics practical with virtual learning package.

1.2 Statement of The Research Problem

In the case of traditional methods in Biology teaching, it is obvious that Biology concepts are usually being taught by using abstract examples and words. This way of teaching, which needs highly cognitive skills to assimilate the taught subjects, creates a high pressure on the students leading them to lose their self-confidence and lower their use of capacities. Lecturing and questioning are the most common teaching methods in most of the traditional Biology classrooms in Nigeria (Achuonye, 2015). Students are exposed mainly to subject matters and they generally cannot understand why they learn those subjects, when they are not interested in them, or when they know that this knowledge will never be of any use to them throughout their life. Scheidies (2018) stated that the school system has become so much more subject matter centered than experience centered. In this transition from experience based to symbol-based education, students

have been facing the problem of formal education that is ‘abstract’, ‘artificial’, and ‘bookish’. Teaching Biology concepts especially its practical aspects is daunting due to the unavailability of laboratories.

Learning by doing is one of the proposed teaching models to teaching Biology, in this way of learning students engage in experiences and experiments from which they derive their own knowledge and meaning. Constructivist models of instruction propose to create environments in which learners actively construct their own knowledge, rather than receiving the teacher’s explanation of the world (Shah, 2019). Increasing technological developments highly influence educational activities such as cognitive tools, teaching machines, computers, and calculators. The constructive learning environments can be created with the help of some cognitive computer-based tools such as databases, spreadsheets, and multimedia construction software where learners can participate in active, mindful, and purposeful interpretation and the reflection of the external world.

Virtual Laboratory provide learning environments that engage students in creative tasks and problem solving mostly reflects the real-world assumptions (Aljuhani, 2018). Besides, Virtual Laboratory could be used as a supplemental to traditional instruction or as replacement for traditional instruction. With the powerful growth of the computer technology in the recent years, most of the biological concepts can be redefined and simulated by means of software use (McHaney, 2012). In this way, many Biology concepts, electronically, can become concrete, clear, and encouraging for the primary education students. The evolution of the information technologies causes the rapid changes in societies. As we consider the inadequacy of conventional teaching methods to overwhelm the obstructions in the instruction process, one of the best solutions is the use of information technology. Integration of computers in Biology classrooms can provide an effective learning environment for students to enhance their mathematical skills by engaging them

with “real world” conditions to make the abstract concepts concrete and clear. In this way, students can have a meaningful and retentive learning and they will be ready for their future education life such as university education or even their professional life. This study intends to determine the impact of virtual laboratory on secondary school Biology achievement and retention in Minna Metropolis, Niger State.

1.3 Aim and Objectives of the Study

This study aims to investigate the impact of virtual laboratory on secondary school Biology achievement and retention in Minna Metropolis, Niger State. Specifically, the study will achieve the following objectives;

1. Determine the mean achievement score of Biology students taught using Virtual laboratory and those taught without using virtual laboratory
2. Determine the mean retention score of Biology students taught using Virtual laboratory and those taught without using virtual laboratory
3. Determine male and female Biology students mean achievement score taught using Virtual laboratory
4. Find out male and female Biology students mean retention score taught using Virtual laboratory

1.4 Research Questions

The following research question were formulated to guide this study:

1. What is the mean achievement score of Biology students taught using Virtual laboratory and those taught without using virtual laboratory?

2. What is the mean retention score of Biology students taught using Virtual laboratory and those taught without using virtual laboratory?
3. What is the male and female Biology students mean achievement score taught using Virtual laboratory?
4. What is the male and female Biology students mean retention score taught using Virtual laboratory?

1.5 Research Hypotheses

The following null hypotheses are formulated to guide this study

Ho_1: There is no significant difference between the mean achievement scores of Biology students taught using virtual laboratory package and those taught without using virtual laboratory.

Ho_2: There is no significant difference between the mean retention scores of Biology students taught using virtual laboratory package and those taught without using virtual laboratory.

Ho_3: There is no significant gender difference in the mean achievement scores of Biology students taught using virtual laboratory package.

Ho_4: There is no significant gender difference in the mean retention scores of Biology students taught using virtual laboratory package

1.6 Significance of The Study

Findings from this research work would be extremely beneficial to students, classroom teachers, school administrators, curriculum developers, and Ministry of Education.

The findings of this study will of great benefits to students, as they will be able to grasp biology concepts with the use of virtual laboratory for teaching and learning, it will also enhance their achievement and retention levels

This research will assist the teacher in making improvements and will also lead the students in making proper use of technology in the classroom. These findings will also assist the teacher in being resourceful and developing problem-solving skills in the use of technology. Because technology is beneficial and brings innovation and development to the teaching and learning process, the study will also help students to be effective and proficient in their mastery of the subject matter. It will also help them discover their full potentials.

The findings will continue to raise awareness and enlighten school administrators about the value of technology in the classroom for teaching and learning.

The findings of this study would also assist curriculum developers in understanding the importance of technology adoption and its usefulness in teaching and learning in primary and secondary schools, which should be included when developing curricula.

Furthermore, the findings of this study will be important to the ministry of education at all levels in Nigeria, since they will provide the government with valuable information about the status of education in Nigeria. The evaluation of technological integration would act as a foundation for improving technological usage in the country as a whole.

1.7 Scope of The Study

This study assesses the effects of virtual lab on the achievement and retention of biology students in senior secondary schools in Minna, metropolis, Niger state. This study will be carried out at

FUT Model Secondary School due to the availability of resources such as stable power supply and computers to install the virtual lab. This study will be carried out among SSI Biology students, the students will be taught life cycle of frog. This study will last for six (6) weeks.

1.8 Operational Definition of Terms

Achievement: this is excellence in all academic disciplines, in the class as well as extracurricular activities

Biology: is the study of living things and their vital processes

Retention is simply the ability of students to recall what has been learnt over a period of time

Virtual Laboratory: an educational environment that uses virtual technology and provides tools and visualizations that motivate the students to participate and collaborate within the class

CHAPTER TWO

2.0 LITERATURE REVIEW

The major areas reviewed under this project work have been classified under; conceptual framework, Theoretical framework and Empirical studies

2.1 Conceptual Framework

2.1.1 Concept of Biology

It is a well-known issue today that science influences man in all aspects of life including feeding, clothing, shelter, health care, communication, transportation, space exploration, as well as leisure. Elechi, (2010) inferred that the most obvious effect of science has been its medical and technological applications, with the accompanying effects on health care, lifestyles, and social structures. Science also influences culture in many modern societies by playing a major role in shaping cultural world views, concepts, and thinking patterns (Mberekpe, 2013). It is important to note that science is useful in the world today. Almost all aspects of man's life are influenced by science either directly or indirectly (Clement, 2018). Man needs to be scientifically literate to exist comfortably in his environment. This informs the need for inclusion of scientific literacy in the goals of education in Nigeria (FME, 2008). The relevance of science in development of the nation cannot be over emphasized. Scholars (Muhammad *et al*., 2013), agreed that the growth of any nation to the standard of the 21st century technology should be anchored on the scientific based knowledge of her subjects. The growth of any nation is a measure of its advancement in science. Science is a major subject taught in schools all over Nigeria, and any nation that hopes to develop must not neglect the teaching of science in its schools (Badmus & Omosewo, 2018). One of such science subjects is Biology.

Biology can be defined as the science of life (Singh *et al*., 2021). It is a science subject offered in all the senior secondary schools in Nigeria, which is compulsory for both the science, and Arts oriented students. Adeleye (2020) pointed out that, the teaching of biology is important because, it equips the students to comprehend the world around them and equips them with necessary skills to build a progressive society. Similarly, Hussaini (2014) observed that, biology provides a platform for teaching students the ability to apply learning of science concepts and principles in solving every day's problems.

Biology remains one of the basic sciences whose teaching and learning is universally known to be efficient and successful, if only undertaken simultaneously with the help of adequate instructional resources and facilities. Biology plays a vital role in the field of biochemistry, medicine, physiology, ecology, genetics, and molecular biology and as such, biology has been made a central focus in most human activities including being a solution to the problem of food scarcity, health, hygiene, family life, poverty eradication, management and conservation of natural resources, biotechnology, ethics, various social vices and as well lack of appropriate infrastructural materials.

Biology is one of the science subjects that senior secondary students offer in senior secondary certificate examinations in Nigeria (FRN, 2004). Interestingly, it is a popular subject among students and its popular nature among other science subjects has made it distinct choice for all students (Lawal, 2011). Biology is a very important science subject and a requirement for further studies of other science related professional courses such as medicine, agriculture, pharmacy, biotechnology, genetic engineering, etc. Biology is the key to economic, intellectual, sociological, human resource development and wellbeing of any society. It is of importance in many ways for both individual and societal development as seen in biotechnology and genetic engineering

(Britannica, 2019). Based on these assertions on the importance of biology, there is need for it to be properly taught in the secondary schools to improve students' achievement in the subject.

2.1.2 Biology Curriculum in Nigeria

Egbodo (2016) regards curriculum as a process of determining and pursuing set societal objectives through the instrumentality of the school. Curriculum is the totality of the environment in which education takes place. Biology curriculum is the totality of learning experiences, practices and intended learning outcomes to which the Biology students are exposed to, throughout the period of their senior secondary school. It is often consisted of general learning objectives and a list of courses and resources. The National Policy on Education (FRN, 2013), noted that learning of Biology will provide the students with suitable laboratory and field skills in biology, meaningful and relevant knowledge in Biology, scientific knowledge that is applicable, in health, agriculture, personal and community daily life matters and development of functional scientific attitudes.

To make objectives of teaching and learning of Biology achievable, emphasize should be placed on field studies, guided discovery, laboratory techniques and skills along with conceptual thinking in the curriculum. In pursuance of the stated objectives, the (2009) edition of the Biology curriculum (NERDC, 2009) has organization of; life, work, environment and continuity of life as its themes. To achieve this, education must be made functional. Functional education is determined by the quality of the curriculum content and its implementation. Functional curriculum content must be valid, significant, learnable and consistent with social realities, useful and reflects the interest of the learner (Chikwenze & Chukwuneke, 2012). Also, valid curriculum content must be related to the philosophy and objective of education. Curriculum planners and developers attempted to take care of the mentioned issues but there are still some

barriers to the attainment of goals of education in Nigeria. Some of these set-backs are curriculum overload, overcrowded classrooms, poor method of instruction, lack of adequate laboratories, lack of computers, slow or total absence of internet connectivity, and equipment, etc. (Chukwuneke & Chikwenze, 2012). Students are seldom confronted with first-hand and concrete experience which could allow them perceive relationship, predict events and draw conclusions. This is as a result of lack of adequate laboratories and equipment, lack of computers, overcrowded classrooms, inappropriate teaching methods, etc.

The problem of Biology may be solved or at least minimized significantly by changing the method of teaching the subject. Though the curriculum specifies hands on process and skill acquisition, most children are not exposed to these real situations in the schools (Fatima & Alhaji, 2011). This means that scientific, vocational and technological aspects of education are not effectively implemented. Hence, curriculum should be reviewed to make it relevant to national development in line with the global and national demand of this era. Curriculum review became imperative as a result of Federal Government of Nigeria decision to attain the Millennium Development Goals (MDGs) by the year 2015 together with the need to meet the critical targets of the National Economic Empowerment and Development Strategies (NEEDS) summarized as Value re-orientation; Poverty eradication; Job creation; Wealth generation; and using education to empower the people. It became evident that the existing curriculum for secondary schools should be reviewed, restructured and realigned to fit into a 3-year of Biology Education. The knowledge of Biology provides explanations for anatomical and physiological changes per age, sex and time in an individual. If the knowledge is restricted to science students that offer Biology only, there will be no medium to provide the needed explanations for the non- sciences students. National Examinations Council (NECO) Curriculum (2004-2006) aims at achieving the following: Mastery

of the structures and functions of living things, appreciation of nature and the needs to conserve it, acquisition of an adequate laboratory and field skills of Biology necessary to carryout and evaluate experiments and projects in Biology, Ability to observe, group, and interpret data that are related to Biology, acquisition of meaningful and relevant knowledge in Biology as a pre- requisite for pursuit of careers in Biological science and related discipline, acquisition of acceptable scientific attitudes for solving problems; and ability to apply knowledge of biology to everyday life in matters of personal, social, economic, environmental and community health. This implies that when an individual successfully acquired the objectives stated in WAEC and NECO curriculum, would facilitate such to be scientific literate with particular reference to Biology.

2.1.3 Brief History of Computers in Education

Computers and related technologies are now in most of the schools in all around the world. Advancements in technology are inevitably reflected in educational systems. In most of the developed countries education has been penetrated by information technologies (IT); schools have computers, a large number of teachers use computers and new technologies while teaching, and more over textbooks have some parts devoted to new technologies. New technologies are integrated into disciplines and more disciplines are being influenced by the new technologies in an integrated way. Most of the educators and researchers try to use technologies in various subject matters, and this integration changes the nature, concepts and methods of work in each subject. For example, in mathematics education, the way of teaching and learning, the roles and functions of the most concepts have changed with the use of technology. 19 Although the wide-spread interest in computers as an instructional tool did not occur until the 1980s, computers were first used in education and training at a much earlier date. Much of the early work which computers introduced in education was done in the 1950s by researchers at IBM, who developed the first

Computer Assisted Instruction (CAI) author language and designed one of the first CAI programs to be used in public schools. Students followed the commands on the computer screen receiving rewards for correct answers within the framework of behaviorist approaches. In 1959, PLATO, the first large-scale project for the use of computers in education was implemented by Donald Bitier at the University of Illinois (Carter, 2003). Atkinson and Suppes' (1959) work led to some earliest applications of computers at both the public school and university levels during the 1960s. By the early 1980s many educators were attracted to microcomputers because they were relatively inexpensive, compact enough for desktop use, and could perform many of the functions performed by the large computers that had preceded them. The dominant use of computer-based instruction in the 1980s was typified by the employ of "behavioral-based branching" software that based greatly on drill-and practice to teach programmed content and/or skills. The educational software that ran on the computers of the early 1980s were at first based on Skinner's "methods of branching": first separating into small sections, rewarding combined responses, and teaching disconnected facts. Although the learning is passive where learners do not work together with problems and content, research studies indicate that learner did advantage from the technology when the learning objectives were behavioral. During the 1990s, computers eventually started to have a major impact on instructional practices in schools. With the help of advances in technology and learning, science researchers consider learning with technology as means for construction problem-solving skills and for achieving learner independence. The cognitive approach to instructional technology emphasized "looking at how we know rather than how we respond, and analyzing how we plan and strategize our thinking, remembering, understanding, and communicating" (Saettler, 2003). Besides, students would also to learn through playing games and simple simulations with the help of cognitive 20 school of thought. The worth of using a word

processor has been discovered by writing teachers and almost immediately students were using the advantages of word processor by writing, deleting, formatting and revising with effortlessness. Other subject matter teachers perceived the importance of the computer in creating a rich learning environment by using databases, spreadsheets, presentation, and research tools. Since 1995, rapid advances in computer and other digital technology, as well as the Internet, have led to a rapidly increasing interest in and use of these media for instructional purposes (Reiser, 2001). Swiftly there was a volume of information obtainable to students with a network of people all through the world that improved communication and the exchange of thoughts. Additionally, distance education courses are offered and in this way students in geographically isolated schools have extended learning opportunities in a diversity of subject areas. For example, in United Nations, Kalu (2006) states "the proportion of instructional rooms with Internet access increased from 51 percent in 1998 to 93 percent in 2003". Theoretical explanations could now be demonstrated and manipulated with the help of technology innovations. A complete innovative learning environment became possible. Since the advent of the personal computers in the mid-1980s, computers have rapidly become one of the key instructional technologies used in both formal and informal education. The computer's role has changed because of two factors: first, it can provide rich learning experiences for students and secondly, computer giving students the power to manipulate depth and way of their learning. Furthermore, teachers can use the computer as an aid to manage classroom activities; it has a multitude of roles to play in the curriculum which can range from tutor to student tools.

2.1.4 Roles of Computers in Education

At this point, I thought that it would be helpful to offer some descriptions of learning activities involving computers. In the domain of instruction there are four broad classes of computer

applications: as an object of instruction, as a tool, as an instructional device, as a means of teaching logical thinking. The computer may itself be the object of instruction such as in computer literacy course students can learn about how computers are used in society and in computer programming course they can learn how to construct a program by using programming languages. In its role as a tool, the computer assists both teachers and students, such as calculator, typewriter, and presentation aid. Students can use computers to solve complex mathematical calculations as a pocket calculator or students can use word processing programs to complete term papers and assignments. Both teachers and students can use data presentation software which incorporates with computers to present the content of the subject-matters. In addition to this, students can use a database for inquiry of specific information. Virtual laboratory is the representative application of computers as an instructional device in instruction. For example, Math Blaster assists students in learning math facts (addition, subtraction, multiplication, and division) through drill and-practice using an arcade game format. Finally, computers can be used as a means of teaching tool. For example, in his book, The Children's Machine, Seymour Paper (1993) offered that, the computer should be an "object to think with" not a dispenser of information. **Jebusimiham** (2014) defined the terminologies used by educators and researchers "computer-assisted instruction, computer-based education, computer-based instruction, computer-enriched instruction, computer-managed instruction" that can easily become puzzled by educators. The following definitions are a combination of those offered by the literature represent commonly accepted (although surely not the only) definitions of these terms: Computer-based education (CBE) and computer-based instruction (CBI) are the broadest terms and can refer to virtually any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing 22 using word processors,

and other applications. These terms may refer either to standalone computer learning activities or to computer activities which reinforce material introduced and taught by teachers. Larbi-Apau (2020) opined that a virtual laboratory is an interactive environment for creating and conducting simulated experiments. It involves the conduct of experiments with domain-dependent simulation programs. Indeed, a virtual reality technology can be adapted to create a virtual laboratory to simulate the processes and actions in physical laboratories. This is capable due to the utilization of computer in education.

2.1.5 Virtual Laboratory

Tatli and Ayas noted that an alternative learning environment, called a virtual laboratory, can help to make this crucial educational application available to students. Virtual laboratories simulate a real laboratory environment and processes, and are defined as learning environments in which students convert their theoretical knowledge into practical knowledge by conducting experiments (Woodfield, 2005). Virtual laboratories provide students with meaningful virtual experiences and present important concepts, principles, and processes. By means of virtual laboratories, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences. Moreover, the interactive nature of such teaching methods offers a clear and enjoyable learning environment (Jeschke *et al*., 2010).

A virtual laboratory may sometimes be a preferable alternative, or simply a supportive learning environment, to real laboratories. A virtual laboratory provides students with opportunities such as enriching their learning experiences; conducting experiments as if they were in real laboratories; and improving their experiment related skills such as manipulating materials and equipment, collecting data, completing experiment process in an interactive way (with boundless supplies), and preparing experiment reports (Subramanian & Marsic, 2001). Researchers have determined

that instructions carried out with virtual laboratories significantly increase student achievement levels. Virtual environments let students observe the process in more detail, compared to board and chalk activities of the traditional classroom or partially completed experiments of the real laboratory environment. In addition, virtual environments foster attention and motivation towards the course by supporting a discussion platform among partners, peers, and among students and teacher.

Tüysüz (2010) emphasized on learning by doing which is supported by the constructivism theory of learning, he noted that laboratory application in students' learning has a very important place in science education and observed that laboratory activities are expensive, time consuming, overcrowded and insufficient laboratory equipment's has prompted the need for the virtual laboratory. Therefore, use of virtual laboratory or simulation programs, overcomes some of the problems faced in traditional laboratory applications and make positive contributions in reaching the objectives of an educational system. It is not always possible to see the results of students' studies in a real laboratory application, especially in inadequate laboratory conditions.

Use of simulation programs can overcome that mistakes occur as a result of such laboratory conditions or misuse of the laboratory. Moreover, they also overcome the possible dangers that can be seen in the real laboratory conditions (Ramadhan & Irwanto, 2017). For example, a dangerous experiment for human health is prepared in computer as simulations, so that students can see the experiments design and perform the experiment in computer and observe the result. Other than performing dangerous, difficult or impossible experiments, simulations have advantages from the time, security, cost and motivation point of view (Veksler *et al*., 2018).

2.1.6 Virtual Labs and Achievement

The widespread usage of computers by educators to support teaching has been dramatic over the last thirty years. A lot of research has been conducted on the effects of computer use on student achievement, attitude, and other variables. However, many educational stakeholders still continue to search the evidence on the positive effects of virtual laboratory on student learning before implementing the computer technologies into educational settings. In the case of virtual laboratory, the researcher of this study believed to examine the available literature on the effectiveness of virtual laboratory which is an area that needs a concrete evidence to show the effectiveness of computers in education. Thus, the following serves to represent a sample of the studies on the impacts of computer-assisted instruction on achievement and learning. There is a large enough data to show the usefulness of educational technologies that they are capable to improve the students' achievement. Most of the studies of computer use in Biology education have largely examined clearly pioneering situations, usually linked to development projects of same type. Equally, the focus of these studies has been mainly on student cognition and computer interaction. Ramadhan and Irwanto (2017) revealed that the use of virtual laboratory is able to enhance students' problem solving, critical thinking, creativity, conceptual understanding, science process skills, lab skills, motivation, interest, perception, and learning outcomes. Similarly, Tatli and Ayas (2011) provides the results the effects of a virtual chemistry laboratory on student's achievement by comparing the mean scores of students taught Chemistry with the virtual laboratory and those taught without it. Results showed that the students taught with the virtual laboratory achieved significantly higher than those taught without the virtual laboratory. Likewise, Tuyuz (2010) who observed that virtual experiments prepared by using flash program and used in the experimental group. Result of this study showed that virtual laboratory applications made positive effects on

students' achievements and attitudes when compared to traditional teaching methods. Terhemen *et al*. (2019) investigated the effect of virtual mathematics laboratory on student's achievement in secondary school Geometry in North Central geopolitical zone of Nigeria, results revealed that students taught geometry using the virtual mathematics laboratory achieved significantly higher than students taught using traditional mathematics laboratory. Gambari *et al*. (2016) investigated the efficacy of virtual laboratory on the achievement of secondary school students in Physics in Minna, Niger State Nigeria. The result of the study showed that the application of the virtual laboratory had positive effects on student's achievement when compared to physical laboratory method. The author added that the findings of the study revealed that virtual laboratories is beneficial for the students.

2.1.7 Virtual Labs and Retention

Duration of active learning and distributed practice of academic content has influenced the level of academic retention (Freeman *et al*., 2014). The level of retention of Biological knowledge also depends on the type of teaching method. Instructional methods that allow students to participate actively to learning process are the only significant variables which has an impact on the long-term retention. Lecture continues to be the most prevalent teaching mode in secondary and higher education; despite overwhelming evidence that it produces the lowest degree of retention for most learners. According to "Dale's cone of experiences" the highest retention rates are devoted to discussion, practicing by doing, and teach others with the respective percentages 50%, 75% and 90% (Kelly, 2012). Gambari *et al*. (2013) investigated the Efficacy of virtual laboratory on the achievement and attitude of secondary school students in physics practical. The results revealed that virtual laboratory had a significant effect on the retention of secondary school students. ELANGOVAN and Ismail (2014) investigated the effect of 3D computer simulation on Biology

student's achievement and retention, the study revealed that simulation improved retention of students.

2.1.8 Virtual Labs and Gender

Gender is a socio-cultural phenomenon that divides humans into feminine and masculine. Gender issues have been linked with students' achievement and retention in academic tasks in several studies but without any definite conclusion. But there is general conclusion that there is little or no gender imbalance exist in computer use, access, career and attitude. This may be the reason why Davies, *et al*. (n.d.) suggested that gender imbalance in technology and the role that technology will play in the future should be a concern for men and women, practitioners, policy makers and parents. Gender and computer illiterate teachers have been identified as hindering factors to the use of computer in schools. Time to learn computer and available information in a discipline are also factors influencing computer use. Keziah (2011) found that there is no 38 statistically significance validating gender differences in pattern of online interaction between male and female students. Gambari *et al*. (2017), in a study on the effects of virtual laboratory on achievement levels and gender on secondary school Chemistry students individualized and collaborative settings in Minna, Nigeria, found that there was no significant difference in the mean achievement scores of male and female students taught chemistry using virtual laboratory in collaborative learning setting. Yusuf and Afolabi (2010) opined that gender has no influence in the academic performance of male and female students exposed to CAI either individually or cooperatively. This study therefore investigated not only the effect of computer use on students' academic achievement and retention but also the effect of gender on the use of computer. Gunawan *et al*. (2017) investigated students creativity based on gender by applying virtual laboratory to Physics instruction, the study revealed that females performed better than their male counterparts.

2.2 Theoretical Framework

Two major theories were found to support the use of virtual laboratory for teaching and learning, they include; The Behavioural Theory of Learning and the constructivism learning theory.

2.2.1 Behavioral Learning Theory

Behavioural Theory of Learning The primary focus of the behavioural perspective is the influence of the external environment on behaviour. One of the processes by which behaviour is shaped is called conditioning. The two main branches of behavioural system of thought are classical conditioning and operant conditioning. Classical conditioning is based on the scientific work of Pavlov (1927) and has to do with associational learning in which conditioned responses may be achieved by pairing selected stimulus with the desired behaviour. Eventually, the desired behaviour can be elicited by the presentation of the conditioned stimuli. Operant conditioning, the basis of most learning theory, was originally developed by Skinner (1938). Operant conditioning is affected by introducing punishment or reinforcement after a behaviour has been exhibited. In this way, the probability that a behaviour will be repeated is diminished or increased. This theory is made up of four behavioural learning principles. These learning principles suggest that student will learn better if they know exactly what they are expected to learn (i.e, what learning will be reinforced); students must master basic skills before they can master complex skills; all students do not learn at the same rate; and subject matter should be programmed into small bits, with immediate positive feedback. Based on Skinner's principles, computer-programmed instruction was developed. The drill and practice modus operandi of virtual learning are based on the principle of behaviourism. The computer provides immediate feedback to the learner during simulation activities thereby reinforcing respective responses. Learning is defined as the probability of a given behaviour occurring in a particular situation. The environment presents an antecedent (A) that

prompts a behaviour (B) that is 26 followed by some consequence (C) and then determines whether the behaviour will occur again. If the learner repeatedly behaves in the desired manner in response to the specific antecedent, then learning has occurred. In order to reinforce desired behaviours and eliminate undesired behaviours, instructions must guide the student's behaviour by providing clear and measurable objectives at each stage. Several educational practices can be traced to the behavioural type of learning. The systematic design of instruction, behavioural objectives, notions of the instructor's accountability, programmed instruction, computer-assisted instruction, and competency-based education are all solidly grounded in behavioural learning theory. This theory could be useful in basic science by designing instructional software to stimulate and condition the learning behaviour of the students as they are opportuned to replay the designed software at their own pace. Behavioural theory has a number of classroom implications for both science teachers and students for application of virtual laboratory in the classroom teaching and learning. The teacher should constantly offer good remarks and rewards when a student gives a correct answer to a question. Programmed learning such as designed educational software can be used in the teaching of science especially at the senior levels of secondary school. Virtual laboratory can be used in teaching science subjects where students have to learn some concepts such as dissection, cells, culture staining etc. Virtual laboratory allows students to proceed at their own pace, with the brighter ones moving at faster rate than the slower students

2.2.2 Constructivism Learning Theory

Bada (2015) noted that constructivist conceptions of learning have their historical roots in the work of Dewey in 1929. Constructivism is an approach to teaching and learning based on the premise that cognition (learning) is the result of "mental construction." In other words, students learn by fitting new information together with what they already know. Constructivists believe that learning

is affected by the context in which an idea is taught as well as by students' beliefs and attitudes. Constructivism is a learning theory found in psychology which explains how people might acquire knowledge and learn. The fundamental insight of constructivist theory is that knowledge is actively constructed and not simply acquired by the learner. The constructivist foundation is based on the principle of learning rooted in cognitive theories. The common trend among these theories is that learners construct knowledge themselves rather than simply receiving it from knowledgeable teachers. Interactive CAI programs such as virtual laboratories have been tied to constructivism in that students are at the center of the learning process rather than being passive recipients of instruction, they are actively involved in constructing knowledge. The term constructivism denotes a school of thought that proposes that an individual's knowledge is constructed from the building blocks of previously acquired knowledge of a subject. Virtual laboratories that are truly interactive and enable students to control the pace and sequence of their learning are tied to this approach. In mastery learning, as proposed by Benjamin Bloom, a student is presented with specific tasks and must master them before going to the next level. In the drill and practice modality of computer-based instruction, the pace and number of trials to reach mastery varies from student to student. The curriculum for both constructivism and mastery learning types of computer-based instruction is designed by experts in a given subject area, and the traditional role of teachers is reduced to that of a monitor in a computer lab. The constructivist view does not accept the assumption that types of learning can be identified independent of the content and the context of learning. The constructivist view turns toward a consideration of what real people in a particular knowledge domain and real-life context typically do. The goal should be to portray tasks and not to define the structure of learning required for achieving a task. The constructivist theory requires that the attention of the teachers be turned to the learners to help each of them creates his or her own model

to explain what nature means to them. The constructivist teacher is required to follow a pedagogical strategy that must provide learners with the opportunity to interact with sensory data and construct their own world. The science teacher should give students activity that will lead to the creation of new knowledge. It is in light of this that the present study looks forward to present the learners with opportunity to observe, manipulate, think, ponder, consider and illustrate by synchronizing computer with education to learn the basic science content as the content is presented to them.

2.3 Empirical Studies

Solikhin (2019) developed a virtual laboratory for teaching chemistry. The characteristic of this virtual chemistry laboratory associated with the effect on students' achievement was analyzed. Thus, this type of research was research and development by using ADDIE development model. In the implementation, the phase of the product was the quasi experimental method with a post-test only design. Classes used for this study were 3 classes, first-class using traditional laboratory, a second class using only virtual laboratory, and the third class using traditional laboratory and virtual laboratory as a supplement. All three classes were performed by the same teacher and the learning time. The instrument used to see the effect of the virtual laboratory was a test instrument. While the instrument used to assess the quality of the media was a questionnaire assessment. The results of this study were a developed virtual laboratory that can be operated via the web on smartphones and computers. In addition, the results of the assessment by the chemistry teachers stated that the virtual laboratory was in good quality and in classroom studies, the third and first classes showed significant differences. In the future research virtual laboratory as a supplement in other subject, matters can be developed.

Gambari *et al*. (2017) investigated the effects of virtual laboratory on the achievement levels and gender of secondary school chemistry students in individualized and collaborative settings in Minna, Nigeria. Five hypotheses were formulated and tested at 0.05 level of significance. 120 Senior Secondary Class Two (SS II) chemistry Students were stratified along gender and achievement levels. Sixty students (male, n = 30 & female, n = 30) were randomly selected from each school. The study employed a quasi-experimental involving pretest, posttest, and control group design. A validated Chemistry Achievement Test (CAT) made-up of twenty multiple-choice items was used for data collection. A reliability coefficient of 0.91 was obtained from the pilot test using Kuder Richardson (KR-20). Mean and ANCOVA were employed in analyzing the data. The results showed that: (i) Students exposed to chemistry virtual laboratory package in collaborative learning setting outperformed their counterparts in individualized setting; (ii) there was significant difference in the mean achievement scores of male and female students taught using Chemistry using Virtual Laboratory in Individualized Setting; (iii) There was no significant difference in the mean achievement scores of male and female students taught chemistry using virtual laboratory in collaborative learning setting; (iv) there was no significant difference in the mean achievement scores of high, medium and low students taught using chemistry virtual laboratory in collaborative, and individualized settings respectively. Based on these findings, it was recommended that the use of virtual laboratory instruction in collaborative setting should be encouraged in teaching chemistry at senior secondary schools in Nigeria.

Kamtor (2016) investigated the impact of virtual laboratories (VLabs) on academic achievement and Learning Motivation in the Students of Sudanese Secondary School in the subject of chemistry. The study followed a quasi-experimental method. The population consisted of second-grade students of Almutamaar school boys in Omdurman, the study sample was selected randomly

totaling 54 students were divided randomly into two groups: 27 for experimental group and 27 for control group. The study used achievement pre-& posttests, and Learning Motivation scale as tools for data collection. The result showed that there were statistically significant differences at the level (0.05) between the mean scores of students of the experimental group (a group is taught by VLabs) and control group (a group is taught by conventional method) in the post test in favor of the experimental group, and there were statistically significant differences at the level (0.05) between the mean scores of pretest and posttest for the students of the experimental group in favor of the post test, and there were statistically significant differences at the level (0.05) in the Learning Motivation scale between the experimental group(taught by VLabs) and control group (taught by conventional method) for the favor of the experimental group too.

Gambari *et al*. (2018) investigated the impact of virtual laboratory on the achievements of secondary school chemistry students in homogeneous and heterogeneous collaborative settings in Minna, Niger state, Nigeria. Three hypotheses were formulated, analyzed and tested at 0.05 alpha level. Stratified sampling technique was used to select 60 Senior Secondary Class Two (SS II) Chemistry Students. The subjects were stratified along gender and ability levels. Sixty students were randomly selected from two secondary schools in Minna, Nigeria. Thirty students (male, n = 15; female, n = 15) were selected from each school. Pretest, posttest, and experimental group design was employed. Experts validated 20-item multiple-choice Chemistry Achievement Test (CAT) was used for data collection. A reliability coefficient of 0.91 was obtained from the pilot testing using Kuder Richardson (KR-20). ANCOVA and Sidak post-hoc statistics were used for testing the hypotheses at 0.05 level of significance. The results showed that: (a) students in homogeneous ability grouping taught Chemistry using virtual laboratory instruction in collaborative setting performed better than their counterpart taught Chemistry in heterogeneous

grouping composition; (b) female students in homogeneous group performed better than their counterparts in heterogeneous groups; (c) the higher achiever students in homogeneous groups outperformed those in heterogeneous groups. Based on these findings, it was recommended that the use of virtual laboratory instruction in homogeneous gender and ability level grouping in collaborative setting should be encouraged in teaching practical chemistry at senior secondary schools in Nigeria.

Gambari *et al*. (2013) investigated the efficacy of virtual laboratory (VL) on the achievement of secondary students in physics practical in Minna, Niger State, Nigeria. It also examined the influence of gender, retention and attitude on the use of VL. The efficacy of authors developed virtual laboratory package (VLP) for teaching physics practical was determined using Pretest – Posttest Experimental group design. 56, SSII students (28 males and 28 females) were from two secondary schools in Minna Metropolis made-up the sample. The schools were randomly assigned to experimental and control groups (EG & CG). The EG (n =28) was exposed to VLP while the CG (n = 28) was exposed to physical laboratory method (PLM). Three research instruments were used in this study: (i) Physics Practical Achievement Test (PPAT) used as a testing instrument, comprised of 40-item multiple-choices physics achievement test; (ii) Virtual Laboratory Package (VLP) used as a treatment instrument, was made up of three components (text, video and simulated experiment); and (iii Physics Attitude Scale (PAS) comprised of 20, four point Likert type items used to elicit response from the two groups before and after the treatments. The instruments were validated by experts. The Kudar-Richardson (KR=21) formula yielded 0.92 reliability coefficient for PPAT and 0.89 for PAS. t-test statistics was used to test the hypotheses at 0.05 levels of significance. Results of this study showed that the application of the virtual laboratory had positive effects on students' achievements, retention and attitudes when compared to PLM. Gender had no

influence on the students exposed to VLP during posttest and retention test. Recommendations were made based on the findings.

2.4 Summary of the Literature Reviewed

The above is a part of broad literature that is thought to be necessary to have a general theoretical and conceptual background on the computer usage and effectiveness in the field of education particularly in the mathematics teaching and learning activities. Technology has great impact on every dimension of our daily life. Education is just one of these areas where computers were introduced as a teaching tool for the enrichment and support of subject matters. With the help of computers, students are expected to improve their understanding, creativity, problem solving skills, and retention. The theoretical framework; the behavioral and constructivism learning theories helped to explain learning as process of doing rather than students been passive listeners, the use of virtual laboratory allows for engagement, interactions and stimulation. Thus, they will have a chance to be more active learner. Literature provides considerably much empirical findings about the effectiveness of virtual laboratories against conventional style of teaching in the classrooms all over the world. Studies strongly suggest that the positive relationship between the use of virtual laboratories, student achievement, retention and gender (Kamtor, 2019; Solikhin, 2019; Gambari *et al*. 2018; Gambari, 2017; and Gambari *et al*. 2013). Based on the works of a number of studies in the world, it was hypothesized that the introduction of virtual laboratory in Biology concepts will provide viable alternative for enhancing learning in Biology. In this way it is assumed to prevent the possible educational problems and to enhance the students' achievement and retention in senior secondary school Biology.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Research Design

In this study quasi-experimental research design was used in order to investigate the impacts of virtual laboratory on secondary school Biology student's achievement and retention in Minna Metropolis Niger State. A quasi-experimental research design was utilized because random assignment of subjects to the experimental and control groups was not possible in the current study so as to prevent the interruption of normal classroom activities.

3.2 Population of the Study

The population for this study consists of all the second-year secondary school (SSI) students in Minna Metropolis, Niger state with a total population of (2170) students which constitute the population of the study (Niger State Educational Data, Senior Secondary Education Board (NSSEB) while the target population comprises students who offered Biology in the two selected secondary schools (FUT Model secondary school, Minna and Ahmadu Bahago secondary school, Bosso) in Niger State.

3.3 Sample and Sampling Technique

A sample refers to a small group of elements drawn through a definite produce from a specific population. A sample size of 50 students was drawn from the two schools. To produce the sample, intact classes was employed as the students were sampled as they were sampled as they were in their classes meanwhile two classes; SSI A from the two purposively selected schools, balloting was used to represent the experimental and control groups. The sample for the experimental group of one of the selected schools was used as experimental group and the other as the control group.

SSI A of FUT Model secondary school, Bosso with a class population size of twenty-one (21) students which formed the experimental group while SSI A of Ahmadu Bahago secondary school, Minna with a class population of twenty-nine (29) students formed the control group.

Table 3.1: Sample Size

S/N	Name of School	Population	Male	Female	Total
1	FUT Model Secondary School, Bosso	21	10	11	**21**
2	Ahmadu Bahago Secondary school, Minna	29	16	13	**29**
Total		**50**	**26**	**24**	**50**

The experimental group were taught using the virtual Laboratory package and the control group were taught using conventional method.

3.4 Research Instrument

The virtual laboratory package was used at the treatment instrument, while the researcher constructed a test instrument; Biology Achievement Test (BAT) and the Biology Retention Test (BRT) used for data collection. The instrument was constructed by the researcher and it consists of Twenty (20) questions on life of a frog. The achievement test and retention test consist of multiple-choice questions with four (4) options (A-D) out of which one serves as the correct answer based on the topic taught (life cycle of a frog). However, at the second face (posttest) the options were interchanged likewise the numbering method (reshuffled). Each score per correct answer is one (1) mark. The objective of the topic in Senior secondary school biology curriculum served as a guide for developing the questions. The items in the BAT and BRT were constructed and tested by the researcher to ensure the inclusion of all the contents of the lessons covered in the

topic. The Biology Achievement Test will be used to assess the students' achievement in Biology while the Biology Retention Test (BRT) will be used to assess the students' retention in Biology.

3.5 Validity of Instrument

The Biology Achievement Test (BAT) and the Biology Retention Test (BRT), which consists of twenty (20) multiple choice questions was face and content validated by two experts, one (1) expert from the Department of Educational Technology, School of Science and Technology Education (SSTE), Federal University of Technology Minna and a subject expert from FUT Model secondary school. Meanwhile, the virtual laboratory package was validated by two experts in the department of Educational Technology. These experts scrutinized the instruments and made necessary corrections and modification to the subject, proper wording of the items, appropriateness and adequacy of the items for the study, structure and adequate timing. The comments and recommendations of these experts helped to identify and correct the items in the instruments.

3.6 Reliability of the Instrument

The reliability of Biology Achievement Test (BAT) and the Biology Retention Test (BRT) was determined through pilot test by administering the instrument to 20 senior secondary school Biology students after instruction with virtual laboratory package in Government Day secondary school, Bosso, Niger State which is not among the sampled schools for the study, a reliability coefficient of 0.89 was determined from the data using Kuder Richardson 21.

3.7 Method of Data Collection

The school selected was visited by the researcher. Permission was taken from the Principal of the school which was given. The researcher was introduced to the Biology teacher of SSI students. The aim and mode of research was explained to both the teachers and the students for their

maximum cooperation. Thereafter, the students were sampled; the students were sampled from the two (2) schools; pretest was administered to the students in order to assess their entry behavior. The test was administered to the two schools used for experimental and control groups in the first week of the visit to the schools. The Biology Achievement Test (BAT) consists of 20 test questions which were drawn from the "Life cycle of a frog" in accordance with SSI Biology curriculum. Each question is followed by four multiple-choice optional answers (A-D) and students were expected to choose the correct answer. Each correct answer chosen earn one mark, zero awarded to any wrong answer chosen and overall score is then converted to percentage. The test lasted for thirty (30) minutes, the lesson commenced in all groups in the second week of experiment which was conducted using the regular period allocated to Biology during class hours. The experiment continued for two (2) weeks followed by revision. The two (2) schools were taught life cycle of a frog for this period of two weeks. The experimental group was taught with the virtual laboratory package while the control group was taught without the virtual laboratory package. On the fourth week, posttest was administered to the two schools to test the achievement of the students for both experimental and control groups. The same items contained in the pre-test were used but this time around the questions numbering were reshuffled as well as the options. Each correct answer chosen earn one mark, zero was awarded to any wrong answer chosen and the overall score is then converted to percentage and after two weeks another post-test was administered to the same group of students to determine their retention ability in both the experimental and control group respectively. The test lasted for 30 minutes and scripts were collected immediately for scoring.

3.8 Method of Data Analysis

Mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses at 0.05 level of significance. This level of significance formed the basis for

rejecting or accepting each of the hypotheses, from which findings, discussions and summary will be arrived at. Computer software Statistical Package for Social Science (SPSS) version 23.00 was used for the analysis.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Result

In this chapter, data for the study were analyzed and presented based on the research questions and hypotheses that guided the study. The research questions were answered using mean and standard deviation while independent statistics was used to test the research hypotheses. All the hypotheses were tested at $P < 0.05$ level of significance.

Research Question One: What is the mean achievement score of Biology students taught using virtual laboratory and those taught without using virtual laboratory? The answer is shown below on table 4.1

Table 4.1 Mean and Standard Deviation of posttest scores of students in the experimental and control group

Group	N	Pretest		Posttest	
		$\bar{x}$	SD	$\bar{x}$	SD
Experimental	20	12.80	2.30	17.30	1.30
Control	30	11.80	1.74	13.93	1.36

Table 4.1 indicates that students taught Biology using Virtual laboratory package has a mean achievement score of 17.30 with a standard deviation of 1.30 at the posttest while those taught using without the virtual laboratory package had a mean achievement score of 13.93 and a standard deviation of 1.36. from the posttest mean scores, it is revealed that the students that were taught with the virtual laboratory package scored higher than those taught without the virtual laboratory package. The level of significance was presented in table 4.5

Research Question 2: What is the mean retention score of Biology students taught using Virtual laboratory and those taught without using virtual laboratory? The answer is revealed in Table 4.2

Table 4.2 Mean and Standard Deviation of retention test scores of students in the experimental and control group

Group	N	Posttest		Retention	
		$\bar{x}$	SD	$\bar{x}$	SD
Experimental	20	17.30	1.30	18.15	0.87
Control	30	13.93	1.36	14.10	1.74

From Table 4.3, reveals that students taught Biology using the Virtual laboratory package had a higher posttest score with a computed mean of 17.30 and standard deviation of 1.30 while the retention score had a mean of 18.15 and standard deviation of 0.87. The control group had a posttest mean of 13.93 and standard deviation of 1.36 while the retention mean score was 14.10 and standard deviation of 1.74. The table indicates that students taught Biology using the Virtual laboratory package retained higher than the students taught using conventional method. Table 4.6 reveals the significant difference in retention scores of the experimental and control group.

Research Question 3: What is the male and female Biology students mean achievement score taught using virtual laboratory? The answer is revealed in Table 4.3

Table 4.3 Mean and Standard Deviation of male and female achievement scores of students in the experimental group

Group	N	Pretest		Posttest	
		$\bar{x}$	SD	$\bar{x}$	SD
Male	13	12.84	2.64	17.53	1.39
Female	7	12.71	1.70	16.85	1.06

Table 4.4 reveals the influence of gender on the mean achievement scores of students taught using the Virtual laboratory package. The male students had a mean achievement score of 17.53 and a standard deviation of 1.39 at the posttest, the female students had a mean achievement score of 16.85 and a standard deviation of 1.06. This indicates that males achieved higher than their female counterparts, although the difference in the mean achievement score is shown in table 4.7

Research Question 4: What is the male and female Biology students mean retention score taught using Virtual laboratory? The answer is revealed in Table 4.4

Table 4.4 Mean and Standard Deviation of male and female retention scores of students in the experimental group

Group	N	Posttest		Retention	
		$\bar{x}$	SD	$\bar{x}$	SD
Male	13	17.53	1.39	18.30	0.85
Female	7	16.85	1.06	17.85	0.89

Table 4.5 presents the influence of gender on the mean achievement scores of students taught using Virtual laboratory package. The male students had mean retention score of 18.30 and a standard deviation of 0.85 while the females had a mean of 17.85 and a standard deviation of 0.89. This indicated that the male students retained higher than the females.

4.2 Hypothesis Testing

Ho_1: There is no significant difference between the mean achievement scores of Biology students taught using virtual laboratory package and those taught without using virtual laboratory.

Table 4.5 t-test statistics for the posttest achievement scores of the experimental and control groups

Group	N	df	$\bar{x}$	SD	t-value	p-value
Experimental group	20		17.30	1.30		
		48			8.71	0.00
Control group	30		13.93	1.36		

Significant at $p < 0.05$

The t-test for table 4.6 shows the mean achievement scores of students taught Biology using the Virtual laboratory package and those taught using convention method. There was a significant difference between the mean achievement scores of students taught Biology using Virtual laboratory package and those taught using conventional teaching methods as determined by the t-test analysis with a t-value at 8.71 and a p-value of $0.00 < 0.05$. students taught using Virtual laboratory package (M=17.30, S.D=1.30) scoring higher than students taught using the conventional method (M=13.93, SD=1.36). Therefore, the null hypothesis was rejected which indicates that there was a significant difference between the mean achievement scores of students taught Biology using virtual laboratory package.

Ho_2: There is no significant difference between the mean retention scores of Biology students taught using virtual laboratory package and those taught without using virtual laboratory.

Table 4.6 T-test for the posttest retention scores of the experimental and control groups

Group	N	Df	$\bar{x}$	SD	t-value	p-value
Experimental group	20		18.15	0.87		
		48			9.56	0.00
Control group	30		14.10	1.74		

Significant at $p < 0.05$ level

The t-test for table 4.7 shows the mean retention scores of students taught Biology using the Virtual laboratory package and those taught using convention method. There was a significant difference between the mean retention scores of students taught Biology using virtual laboratory package and those taught using conventional teaching methods as determined by the t-test analysis with a t-value at 9.56 and a p-value of $0.00 < 0.05$. students taught using virtual laboratory package (M=18.15, S.D=0.87) scoring higher than students taught using the conventional method (M=14.10, SD=1.74). Therefore, the null hypothesis was rejected which implies that there was a significant difference between the mean retention scores of students taught Biology using virtual laboratory package

Ho_3: There is no significant gender difference in the mean achievement scores of Biology students taught using virtual laboratory package.

Table 4.7 T-test analysis of male and female students taught Biology using Virtual laboratory package

Gender	N	Df	$\bar{x}$	SD	t-value	p-value	Decision
Male	13		17.53	1.39			
		18			1.12	0.27	NS
Female	7		16.85	1.06			

NS= Not Significant at $p > 0.05$ level

The t-test for table 4.7 shows the mean achievement scores of male and female students taught Biology using the Virtual laboratory package. There was no significant difference between the mean achievement scores of male and female students taught Biology using Virtual laboratory package as determined by the t-test analysis with a t-value at 1.12 and a p-value of $0.27 > 0.05$.

Male students (M=17.53, S.D=1.39) while the female students (M=16.85, SD=1.06). Therefore, the null hypothesis was accepted, which indicates there was no significant difference between the mean achievement scores of male and female students taught Biology using Virtual laboratory package

Ho_4: There is no significant gender difference in the mean retention scores of Biology students taught using virtual laboratory package

Table 4.8 Retention t-test analysis of male and female students taught Biology using Virtual laboratory package

Group	N	Df	$\bar{x}$	SD	t-value	p-value	Decision
Male	13		18.30	0.85			
		18			1.10	0.28	NS
Female	7		17.85	0.89			

NS= Not Significant at $p > 0.05$ level

The t-test for table 4.8 shows the mean retention scores of male and female students taught Biology using the virtual laboratory package. There was no significant difference between the mean retention scores of male and female students taught Biology using virtual laboratory package as determined by the t-test analysis with a t-value at 1.10 and a p-value of $0.28 > 0.05$. Male students (M=18.30, S.D=0.85) while the female students (M=17.85, SD=0.89). Therefore, the null hypothesis was accepted, indicating that there was no significant difference between the mean retention scores of male and female students taught Biology using virtual laboratory package.

4.3 Discussion of Findings

The data analyzed in this chapter were interpreted and discussed on the results derived from four research questions and hypotheses. The main objective of the research is to determine the impact of virtual laboratory on secondary school Biology achievement and retention in Minna Metropolis, Niger State. The posttest scores in table 4.1 shows that the experimental group (M=17.30, S.D=1.30) had a higher achievement scores than the control group (M=13.93, S.D=1.36). Similarly, the p-value associated with the calculated value of t.val (8.71) in table 4.5 is 0.00 which is less than the level of significance, the null hypothesis was therefore rejected. Hence, there is significant difference in the mean achievement scores of students taught Biology with the use of Virtual laboratory package. The use of Virtual laboratory package therefore has a significant effect on student's achievement in Biology as compared to those taught with the use of the virtual laboratory package. This finding is in line with Kamtor (2016), Solikhin (2019) and Gambari *et al*. (2018) who revealed that virtual laboratory has an impact on students achievement.

The experimental retention group scores at the posttest level in table 4.2 shows that the experimental group (M=18.15, S.D=0.87) had a higher achievement scores than the control group (M=14.10, S.D=1.74). Similarly, the p-value associated with the calculated value of t.val. (9.56) in table 4.6 is 0.00 which is less than the level of significance, the null hypothesis was therefore rejected. Hence, there is significant difference in the mean retention scores of students taught Biology with the use of Virtual laboratory package. The use of Virtual laboratory package therefore has a significant effect on student's retention in Biology as compared to those taught with virtual laboratory. This is line with the findings of Gambari *et al*. (2013) who revealed that virtual laboratory has an impact on student's retention.

The male students at posttest level (M=17.53, S.D=1.39) achieved higher than the female Biology students (M=16.85, S.D=1.06). Although, the p-value revealed there was no significant difference

(p=0.27), in table 4.8 the p-value was greater than the 0.05 level of significance hence, the null hypothesis was accepted. This indicated that there is no significant difference in the mean achievement scores of male and female Biology students, this finding is in line with Gambari *et al* (2018) who observed that virtual laboratory had no significant difference on male and female students achievement levels.

The mean retention score of male students exposed to the Virtual laboratory package (M=18.30, S.D=0.85) while the mean scores of female students (M=17.85, SD=0.89). Similarly, the value associated with the value of t (t.val=1.10, df=18, p>0.28). In table 4.8, the p-value is greater than the level of significance (0.05), hence the null hypothesis was accepted. This indicates that there is no significant difference in the mean retention score between male and female students taught using Virtual laboratory package. This finding is in line with Gambari *et al*. 2013 who revealed that virtual laboratory has no influence on gender on retention.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The research determines the impact of virtual laboratory on secondary school Biology student's achievement and retention in Minna Metropolis, Niger State. This chapter contains the summary, conclusion, recommendation, major findings of the study, contribution to knowledge, implications of the findings and suggestions for further studies.

5.1.2 Conclusion

Based on the findings and discussion of the study, the following conclusion were drawn;

The effective and adequate use of virtual laboratory package improves the academic achievement and retention in Biology students. The evidence of the experimental group that used the virtual laboratory package in teaching enhances student's achievement more than those with the virtual laboratory. The use of virtual laboratory package has a great significant effect on student's retention level and also on gender achievement in Biology. Emphasis should be laid on the use of virtual laboratory package for teaching Biology in senior secondary schools.

5.2 Recommendation

In view of this project findings, the following recommendations was made;

1. There should be in-service training for teachers to enhance their knowledge and skills which will lead to the utilization of virtual laboratory in teaching and learning.

2. Seminars, conference and workshops should be organized and put in place for the teachers on the use of virtual laboratory package in order to carryout effective teaching.
3. There should be careful consideration concerning who will be hired to teach the virtual lab. The teacher should have up-to-date technological knowledge and skills, be a visionary, have passion for teaching in a virtual environment, have up-to-date knowledge and skills related to industry standards in a given field, be a person who can analyze a situation and come up with solutions for problems as they arise, and have a commitment for working with students.
4. Government, school administrators should show support and dedication to encourage creativity shown by co-science teachers by providing teaching materials which will promote science and technology in Nigeria.

5.3 Major Findings of the Study

The following findings have been made from the research work

1. There was significant difference between the mean achievement scores of students taught Biology using virtual laboratory package and those taught without virtual laboratory
2. There was significant difference between the mean retention scores of students taught Biology using Virtual laboratory package and those taught without virtual laboratory
3. There was no significant difference between the mean achievement scores of male and female students taught Biology using virtual laboratory package.
4. There was no significant difference between the mean retention scores of male and female students taught Biology using virtual laboratory package.

5.4 Contribution to Knowledge

The result of the study has contributed to knowledge in the following ways

1. Helping the teacher understand the use of instructional materials and Virtual laboratory package will reduce the abstract nature of Biology concepts thereby making learning interesting.
2. Adequate use of virtual laboratory package will help save the teacher's time and energy
3. Retention of students during learning activities can be enhanced through the use of virtual laboratory package
4. It helps to contribute to the existing literature and use to provide platform for further research.

5.5 Implications of the Findings

Various implications have been adopted but the most important is the use of virtual laboratory package in teaching Biology in senior secondary schools so as to improve student's achievement and retention level in Biology. Therefore, teachers should be encouraged and enlightened on the use of virtual laboratory package as it creates interaction between the teacher and the students. It can also be used to enhance the student knowledge and enables them to contribute their own quota on whatever they are been taught.

5.6 Suggestions for further Research

Areas where further research could be done are as follows;

1. Further research should implement descriptive survey research to assess attitudes and interest towards virtual laboratories
2. Effect of virtual laboratory package on achievement, retention and interest on student's performance

3. Perception of virtual laboratory for teaching and learning for senior secondary schools in North-Central, Nigeria.

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APPENDIX A

BIOLOGY ACHIEVEMENT TEST (BAT) (Pre-Test)

1) The eggs of a frog are found in the _____?

a. isolated form on land

b. cluster form in water

c. isolated form in water

d. cluster form on land

2) Spawn is a _____

a. isolated form of frogs eggs on land

b. cluster form of frogs eggs in water

c. cluster form of frogs eggs on land

d. isolated form of frogs eggs in water

3) The egg cell of a frog, matures inside a shell to form a_____?

a. zygote

b. embryo

c. adult frog

d. tadpole

4) A tadpole can float in water with _____?

a. its tail

b. its fin

c. Supportive plant

d. None of the above

5) In tadpole, gills are located at its _____?

a. lateral sides

b. dorsal side

c. ventral side

d. None of the above

6) While tadpole matures, the first change in its body?

a. emergence of its hind legs

b. development of front legs

c. disappearance of external gills

d. disappearance of gill slits

7) The mature tadpole breathes through the _____?

a. gills

b. lungs

c. Both A and B

d. None of the above

8) While a tadpole matures, the last change seen in its body is _____?

a. disappearance of tail

b. development of front legs

c. disappearance of external gill

d. body B and C

9) A late frog with a small tail, is called a _____?

a. larva

b. tadpole

c. spawn

d. froglet

10) An adult frog has a _____?

a. small tail

b. big tail

c. no tail

d. none of the above

11) Identify the order of stages in the frog life cycle.

a. Egg, tadpole, froglet, frog

b. Tadpole, egg, froglet, frog

c. Froglet, tadpole, egg, frog

d. Frog, froglet, tadpole, egg

12) In which stage of the frog life cycle does it **NOT** eat?

a. Frog

b. Tadpole

c. Egg

d. Froglet

13) In what stage of a frogs life cycle does it live mostly on land?

a. Froglet

b. Egg

c. Tadpole

d. Frog

14) What does **NOT** happen as a tadpole changes into a froglet?

a. The tadpole grows lungs

b. The tadpole grows legs

c. The tadpoles tail begins to shrink

d. The tadpole begins to develop gills

True or False- Determine whether each statement is TRUE or FALSE. Circle your answer

15) Frogs start out as eggs.

True or **False**

16) Frogs are amphibians.

True or **False**

17) The difference between a bird and a frog is that a frog is warm-blooded.

True or **False**

18) A frog is a living thing because it reproduces and grows/develops.

True or **False**

19) A _____ is a small body of water that supports a lot of living things, including frogs.

a. Nose

b. Pond

c. River

d. sea

20) What organ does an adult frog use to breathe? _____

a. gills

b. skin

c. gills

d. liver

APPENDIX B

1. B

2. B

3. D

4. A

5. A

6. D

7. B

8. B

9. D

10. C

11. A

12. C

13. D

14. D

15. TURE

16. TRUE

17. FALSE

18.. TRUE

19. B

20. D

APPENDIX C

BIOLOGY ACHIEVEMENT TEST (BAT) (Post-Test)

1. The egg cell of a frog, matures inside a shell to form a_____?

a. Zygote b. embryo c. adult frog d. tadpole

2. The eggs of a frog are found in the _____?

a. isolated form on land b. cluster form in water c. isolated form in water

d. cluster form on land

3. Spawn is a _____

a. isolated form of frogs eggs on land b. cluster form of frogs eggs in water c. cluster form of frogs eggs on land d. isolated form of frogs eggs in water

4. The mature tadpole breathes through the _____?

a. gills b. lungs c. Both A and B d. None of the above

5. In tadpole, gills are located at its _____?

a. lateral sides b. dorsal side c. ventral side d. None of the above

6. A tadpole can float in water with _____?

a. its tail b. its fin c. Supportive plant d. None of the above

7. A late frog with a small tail, is called a _____?

a. Larva b. tadpole c. spawn d. froglet

8. While tadpole matures, the first change in its body?

a. emergence of its hind legs b.development of front legs c. disappearance of external gills d. disappearance of gill slits

9. While a tadpole matures, the last change seen in its body is _____?

a. disappearance of tail b.development of front legs c. disappearance of external gill

d. body B and C

10) An adult frog has a _____?

a. small tail b. big tail c. no tail d. none of the above

11) Identify the order of stages in the frog life cycle.

a. Egg, tadpole, froglet, frog b. Tadpole, egg, froglet, frog c. Froglet, tadpole, egg, frog

d. Frog, froglet, tadpole, egg

12 In which stage of the frog life cycle does it **NOT** eat?

a. Frog b. Tadpole c. Egg d. Froglet

13 In what stage of a frogs life cycle does it live mostly on land?

e. Froglet b. Egg c. Tadpole d. Frog

14 What does **NOT** happen as a tadpole changes into a froglet?

a. The tadpole grows lungs b. The tadpole grows legs c. The tadpoles tail begins to shrink

d. The tadpole begins to develop gills

True or False- Determine whether each statement is TRUE or FALSE. Circle your answer

15. The difference between a bird and a frog is that a frog is warm-blooded.

True or **False**

16. Frogs are amphibians.

True or **False**

17. Frogs start out as eggs.

True or **False**

18. A frog is a living thing because it reproduces and grows/develops.

True or **False**

19. A _____ is a small body of water that supports a lot of living things, including frogs.

a. Nose b. Pond c. River d. sea

20. What organ does an adult frog use to breathe? _____

a. Gills b. skin c. lungs d. liver

APPENDIX D

ANSWERS TO POSTTEST

1. D

2. B

3. B

4. B

5. A

6. A

7. A

8. D

9. B

10. C

11. A

12. C

13. D

14.D

15. FALSE

16. TRUE

17. TRUE

18. TRUE

19. B

20. C

APPENDIX E

LESSON PLAN FOR THE CONTROL GROUP

School	Ahmadu Bahago secondary school Minna
Date	20th May, 2021
Number in Class	29
Sex	Mixed class
Average age	14-17
Subject	Biology
Topic	Life cycle of a frog
Time	10:00 - 10:40
Duration	40mins
Period	1st

Method of Teaching	Discussion, Demonstration
Teaching Techniques	Set induction, Questioning
Instructional materials	Whiteboard
Specific Objective	At the end of the lesson students should be able to; a. Define life cycle b. List and draw the stages in the life cycle of a frog c. Explain in detail the stages in the life cycle of a frog d. Explain the differences between tadpole, forglet and frog
Introduction	Teacher introduce the lesson by asking the students the following questions: a. What is a life cycle b. Mention the stages in the life cycle of a frog
PRESENTATION	Teacher presents the lesson by the following steps
Step I	Teacher defined life cycle as the path which living things follow from birth to death, and the different changes that happen at a given stage or phase
Step II	Teacher lists the stages in the life cycle of a frog 1. Egg 2. Tadpole 3. Froglet 4. Adult frog
Step III	Teacher drew a well labelled diagram showing all the stages in the life cycle of a frog.
Step IV	Teacher explained in detail all the phases in the life cycle of a frog
EVALUATION	Teacher evaluates the lesson by asking the students the following questions. i. What is life cycle ii. Explain the difference between tadpole and frog iii. Draw and label the life cycle of a frog
Conclusion	The teacher concludes the lesson by summarizing the main point of the lesson
Assignment	Draw and label the diagram of an adult frog
Reference material	Modern Biology for Secondary schools.

APPENDIX F

LESSON PLAN FOR THE CONTROL GROUP

School	FUT Model secondary school Minna
Date	19th May, 2021
Number in Class	29
Sex	Mixed class
Average age	14-17
Subject	Biology
Topic	Life cycle of a frog
Time	10:00 - 10:40
Duration	40mins
Period	1st

Method of Teaching	Discussion, Demonstration
Teaching Techniques	Set induction, Questioning
Instructional materials	Whiteboard, Virtual laboratory package
Specific Objective	At the end of the lesson students should be able to; a. Define life cycle b. List and draw the stages in the life cycle of a frog c. Explain in detail the stages in the life cycle of a frog d. Explain the differences between tadpole, forglet and frog
Introduction	Teacher introduce the lesson by asking the students the following questions: a. What is a life cycle b. Mention the stages in the life cycle of a frog
PRESENTATION	Teacher presents the lesson by the following steps
Step I	Teacher defined life cycle as the path which living things follow from birth to death, and the different changes that happen at a given stage or phase
Step II	Teacher lists the stages in the life cycle of a frog 1. Egg 2. Tadpole 3. Froglet 4. Adult frog
Step III	Teacher drew a well labelled diagram showing all the stages in the life cycle of a frog.
Step IV	Teacher explained in detail all the phases in the life cycle of a frog
EVALUATION	Teacher evaluates the lesson by asking the students the following questions. i. What is life cycle ii. Explain the difference between tadpole and frog iii. Draw and label the life cycle of a frog
Conclusion	The teacher concludes the lesson by summarizing the main point of the lesson
Assignment	Draw and label the diagram of an adult frog
Reference material	Modern Biology for Secondary schools.