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Relative Effectiveness of E-Laboratory and Real Laboratory in Improving Students' Performance in Secondary School Practical Biology in Ondo State

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Abstract **– The study examined the relative effectiveness of e-laboratory and real laboratory in improving performance of students in practical Biology in Ondo State. Also, it compared the attitudes of Biology students towards Biology practical when they are taught using e-laboratory and real laboratory. These were with a view to determining a suitable Laboratory activity for students' learning in practical Biology.**

The study adopted the non-equivalent pretest, posttest control group research design. The population for the study comprised of senior secondary school science students in Ondo State. One senatorial district was selected from the three senatorial districts of Ondo State, using simple random sampling technique. One Local Government Area (LGA) in the senatorial district was selected using simple random sampling technique. The sample for the study comprised of 72 Biology students in two intact classes from two Senior Secondary Schools one (SSS 1). The schools were randomly assigned to treatments and one intact class was used in each school. The sample was purposively selected from two senior secondary schools in one LGA based on availability of well-equipped laboratory and internet facilities. There were two groups: one group contained 35 students for e-Laboratory (eL) and the other 37 students for real laboratory (RL). Two instruments were used to collect data for the study namely: Achievement Test on Biology Practical (ATBP) and Questionnaire on Attitude of Student towards Biology Practical (QASBP). Data obtained were analysed using t-test.

The results indicated that there was no significant difference in the students' academic achievement when exposed to e-Laboratory (eL) and Real Laboratory (RL) ($t=0.72$; $p>0.05$). The findings also showed that there was no significant difference in the improvement in attitude of students under the two forms of Laboratory activities ($t=0.69$; $p>0.05$). The study concluded that students learnt better when taught with e-laboratory.

Keywords **– Achievement, Attitude, E-Laboratory, Real Laboratory.**

I. INTRODUCTION

Biology is a standard subject of instruction at all levels of our education, from primary to tertiary levels. It is one of the core subjects at Secondary School Certificate Examination (SSCE) whose study is very relevant to man's successful living [4]. Biological knowledge plays a fundamental role in most aspects of human life. It's applications in genetic engineering has resulted in the production of high yielding plant and animal species. This has made a tremendous contribution towards meeting the demand of food requirements for the ever growing human population.

Biology is a prerequisite subject for many fields of learning that contributes immensely to the technological growth of the nation and because of its importance, more students enrolled for Biology in the Senior Secondary School Certificate Examination (SSCE) than for physics and chemistry (West African Examination Council, 2011). In spite of the importance and popularity of Biology among Nigerian students, performance at senior secondary school level has been poor [3]. However, studies have been conducted to identify some of the more specific factors contributing to the poor performance of students in Biology, the results of which have been linked to poor quality of teachers, inadequate science teachers, inadequate science equipment and poor teaching methods [14]. Educational researches opined that poor teaching methods adopted by teachers at senior secondary school level in Nigeria have been identified as one of the major factors contributing to poor performance of students in Biology [11]; [4]; [20].

Biology in secondary schools is composed of practical activities. Ahmed (2008) stated that Biology as one of the science subjects in all field of studies develops human thinking faculty to accurate observation, he also stated that practical's are very necessary in teaching of Biology. Practical Biology is the scientific study of life and structure of plants and animals and their relative environments in real or experimental set-up rather than dwelling in the theory and ideas. Practical work is any teaching and learning activity which involves students working individually or in small groups, manipulating, observing real objects and materials, as opposed to the virtual world (Science Community Representing Education, SCORE, (2008). Practical work stimulates learner interest when they are made to personally engage in useful activities and the knowledge obtained through practical work and experience promote long term memory that theory alone cannot do and this can only be achieved when accorded with well-equipped laboratory and a qualified teacher.

The neglect of the practical aspect of Biology in schools has been blamed on such factors as the inability of the school authorities to provide materials and equipment for practical work, teachers' failure to recognize the importance of practical work in science teaching, failure to apply the teaching method that will aid better performance and negative attitudes of students' towards Biology practical. Educational researches have called upon Government to improve on science education funding and it seems they would respond while waiting for a good response, steps should be taken to reduce the rate of failure in Biology examination. This lead teachers in an attempt to

find alternative ways of teaching Biology practical using real laboratory which result to the use of alternative to practical Biology method, e-Laboratory packages among others.

According to [6], the introduction of e-Laboratory provides remote control of real Biology experiments over the internet or through electronic media as it occurs in the real laboratory had contributed greatly to the performance of students in practical Biology. Its main purposes are to provide e-learning of science (24 hours per day and 7 days a week), providing real scientific experiments (remotely controlled) which cannot be acquired by a school and this has made e-Laboratory a free, accessible, remotely controlled laboratory and can be accessed by everyone whose computer or phone has access to internet. Today majority of students in senior secondary school have phones that have access to internet, rather than using it for educational purpose, they are either on *Facebook, twitter, WhatsApp, Messenger or 2go* among others and there are numerous packages online that could bring about meaningful learning, arouse their interest, and bring about better performance. E-learning refers to the use of information and communication technology (ICT) to enhance and/or support learning in education. However this encompasses an ample array of systems from students using e-mail and accessing course materials online. E-learning is an education via the internet, network or standalone computer. E-learning is basically the network — enabled convey of skills and knowledge. E-learning refers to using electronic applications and processes to learn. E-learning applications and processes include web-based learning, computer — based learning, virtual classrooms and digital collaboration. E-learning is when content is delivered or the internet, intranet/extranet, audio or videotape, satellite TV and CD-ROM. E-learning was first called "internet-based training" then "web-based training. E-learning is not only about training and instruction but also about learning that is tailored to individual.

Technology is a tool used to remove geographical barriers and facilitate everybody to learn anytime and anywhere without the presence of an instructor. Bubble and Linn (1991) cited in [7], argued that the traditional science classroom provides an inaccurate representation of the nature of science and how scientific understanding is generated. They maintained that "a traditional science course makes students think that science is a collection of abstract facts to be memorized rather than set of principles that are warranted by evidence, and studies have reported that real laboratory have been successfully used to achieve the development of practical skills in Biology practical.

Ref [22], in physics found out that the effectiveness and impact of the e-laboratory is comparable (or better) than the real laboratory. The e-laboratory has effectively tested the students' conceptual knowledge, allowed them to work collaboratively on the problem, interact with the equipment, learn by trial and error and allowed the students to perform analysis on real experimental data, and this is supported by [9] that e-laboratories have provided increased access to equipment for students. With e-laboratories students can perform and repeat the experiment at any time and any place conveniently. Students have also gained the experience of controlling equipment remotely and with this, attention is being shifted from real laboratory to the use of e-Laboratory in teaching and learning of science practical. However, no sufficient studies exist on the relative effectiveness of these two types of laboratories in Biology practical and this study intends to fill this gap.

The teaching of Biology at the Senior Secondary School level in Nigeria as tended to be rooted in the conventional teaching method. The fundamental challenge of this method is that they tend to limit the interests of the learner rather than stimulating them. Studies have shown that both real laboratory and e-Laboratory have been successfully used to achieve development of practical skills in practical Biology among secondary school students, though real laboratory is more commonly used in secondary schools. Given the observed deficiencies that still exist in the acquisition and application of these necessary practical skills, however, few studies existed on the comparative effectiveness of these two types of laboratories and hence this study.

Therefore the specific objectives of the research are to:

a. Examine the relative effectiveness of e-laboratory and real laboratory in improving performance of students in practical Biology in Ondo State;
b. Compare the attitudes of Biology students towards Biology practical when they are taught using e-laboratory and real laboratory.

II. Research Hypotheses

From the objectives mentioned above, the following research hypotheses were generated:

Ho_1: There is no significant difference between the performance in practical Biology of students taught with e-laboratory and those taught with real laboratory.

Ho_2: There is no significant difference between the attitude in practical Biology of students taught with e-laboratory and those taught with real laboratory.

Significance of the Study

In the 21st century, technology, teaching and learning have been changing rapidly. Emphasis is now being placed on student-centered learning which requires adoption of strategies that could arouse students' interest, stimulate their thinking and arouse their learning outcomes. Generally, the result of this study should uplift the standard of Biology practical teaching in secondary schools.

The finding of this study is expected to create awareness for the teachers about different mode of online practical packages and how this new innovation would help to enhance their job performance. Biology teachers might appreciate the value of using e-laboratory in enhancing academic achievement of students and reduce the stress of limited facilities. The study would uncover the effectiveness of e-laboratory and real laboratory in practical Biology to the students, teachers, government and the entire society. The study will also improve the attitude of students when exposed to e-laboratory and real laboratory which could aid better performance in practical Biology.

Scope of the Study

This study was limited to senior secondary school one (SSI) students in two intact classes from two secondary schools which were purposively sampled based on well-equipped laboratory and access to internet facilities from one Local Government Area in Ondo State. The students were taught with practical e-laboratory and real laboratory on two topics: Food test and Osmosis.

This study is based on the concept of constructivism which has been strongly promoted by Brunner, Vygotsky and Piaget. Constructivism is a psychological theory of knowledge which argues that humans construct knowledge and meaning from their experiences. Constructivism is a set of beliefs about knowledge that begins with the assumption that reality exists but cannot be known as a set of truth [19]. Constructivism is not accepting what you are told but your prior knowledge about what you are taught and your perceptions about it. Active involvement of students is emphasized in constructivism, hence knowledge gained last long in their memory.

Through constructivism approach in classroom, students will actively involve in educational process and they have the chance to create their own based on their background. The role of the teacher is to organize information around conceptual clusters of problems, questions and discrepant situations in order to engage the student's interest. Teachers assist the students in developing new insights and connecting them with their previous learning. Ideas are presented holistically as broad concepts and then broken down into parts. The activities are student-centered and students are encouraged to ask their own questions, carry out their own experiments, make their own analogies and come to their own conclusions. However, with e-laboratory and effective teaching of real laboratory this can be easily achieved. Cognitive theorists believe the role of the teacher is to provide learners with opportunities and incentives to learn. The primary message of constructivism is that students who engage in active learning are making their own meaning and constructing their own knowledge in the process.

The e-Laboratory is expected to provide learners with appropriate method of learning Biology practical through their own experience by complementing teacher skills and experience to enable them attain instructional goals since i-Learning is interactive, imaginative, innovative, inspiring, ingenious i.e. it combines the best learning theory and practice with the best technologies to produce the best learning experience possible as it occurs in the Real Laboratory.

III. Research Methodology

The study adopted the non-equivalent pre-test, post-test control group design. There were two groups. One group was assigned to experimental group which was taught with e-Laboratory and the other was taught with real laboratory apparatus as the control group. The design for the study is represented below:

(Experimental group)	O_1	X_1	O_2
(Control group)	O_4	X_2	O_5

Where $O_1$and O_4 represent the pre-test
$O_2$and O_5 represent the post-test
X_1 represents treatment using e-laboratory (eL) package
X_2 represents treatment using Real Laboratory (RL)

The population for the study comprised of Senior Secondary (SSI) School students in Ondo State. One Senatorial District was randomly selected from the three Senatorial district of Ondo State. One Local Government Area in the Senatorial District was selected using simple random sampling technique. The study sample was made up of 72 senior secondary school one (SS1) Biology students from two intact classes in the two purposively selected senior secondary schools in the Local Government Area of Ondo State based on well-equipped laboratories and internet facilities. The schools selected were Temidire College, Ondo and Lassalle College, Ondo. The schools were randomly assigned into two groups and students were used in their intact classes.

The following two instruments were used for data collection: "Achievement Test on Biology Practical" (ATBP) and "Questionnaire on Attitudes of Student towards Biology Practical" (QASBP). The research instrument was validated by giving the ATBP which contains 40 questions before the trial testing to the researcher supervisor, two experiences Senior Secondary School Biology teachers for vetting and corrections. Trial testing of the instruments was carried out by administering the instruments on SS1 students in intact class of one of the schools that met the criteria for sampling but was not used for the main study. The validated items were administered on the students, the data obtained from the trial testing were analysed to determine the level of difficulty and discriminating index of each test item. After subjecting the scores to discriminating indices and difficulty indices, questions whose difficulty and discriminating index were within the range of 0.25 and 0.75 were selected because they were considered moderate while those with difficult indices below 0.25 were rejected because they are too difficult and those above 0.75 were also rejected because they are too simple. This led to reduction of the item to 25 objective questions. The scores of the students were subjected to Kuder Richardson formula 21 (KR-21) which yielded reliability coefficient of 0.78. Based on the validation process out of 40 questions that were initially set, 15 out of the questions were dropped, at the end of which a total of 25 questions were considered to be valid for the study. The value obtained was adjudged good for the study.

The purpose of the questionnaire was to elicit information on the students' attitude to learning of Biology practical before and after the treatments. The researcher initially produced a draft of 25 items. The item was based on four-point Likert Scale and the ordering of the scale ranged from Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The face and content validity of the 25 items on QASBP were determined through the project supervisor and two other experts in the Department of Science and Technology Education. They all reviewed the items in terms of relevance, sentence structure and adequacy of the instruments. Based on their recommendations, 5 out of the items were dropped. Their

corrections and suggestions were made to determine which of the items were valid enough for the study and to produce the final draft. The reliability of the questionnaire was determined by using Cronbach Alpha. A reliability coefficient of 0.82 was established. The value obtained was adjudged as good enough for the instrument

The researcher visited the two schools selected for the study. Permission was sought from the relevant authorities of the school as well as from the Biology teacher to allow the use of their schools. They were briefed about the purpose of the study and they in turn gave their full cooperation and assigned Biology teachers for assistance. The pretest ofAchievement Test on Biology Practical (ATBP) and Questionnaire on Attitudes of Students towards Biology Practical (QASBP) was administered personally by the researcher in the first week to all the students before the experimental group was subjected to treatment. This is to ascertain the academic equivalence and the attitude of the students before treatments. A week after the pre-test, the researcher introduced the e-Laboratory packages which contained the food test and osmosis practical experiments. The downloaded online instructional packages were projected on the screen via LCD projector. Students read, listened and watched the video of the lesson based on the mode of multimedia instructional package. After the class presentation, students had opportunities of interacting with the e-laboratory by clicking on Next, Previous, Pause and Stop button at their convenience using computer. Likewise the real laboratory group were exposed to the real experiment using the real apparatus on two Biology practical concepts which are osmosis and food test practical with the help of Biology teacher assistant.

The students were exposed to two contacts lessons (double period) one per week for two weeks. At the end of the two weeks intervention by the researcher which was two contacts with each of the selected schools, a post-test was administered on the students for their achievements in food test and osmosis and questionnaire on attitude of students was also administered to determine their attitudes after being exposed to the treatments. The post-test was 100 points scores.

Data Analysis

The data collected were analyzed based on the stated hypotheses using Descriptive statistics and t-test. Descriptive statistics were used to analysed the estimated marginal means, standard deviation and standard error estimates and t-test was applied to examine whether any significant differences existed between the two groups. All the analyses were carried out at 5% level of significance.

Hypotheses Testing

The testing of the two hypotheses for the study stated earlier was undertaken to decide whether they should be rejected or not. The interpretation of the results is given, and after which discussions of the findings which emanated from the study are presented.

Hypothesis 1:

There is no significant difference between the performance in practical Biology of students taught with e-laboratory (eL) and those taught with real laboratory (RL).

In testing this hypothesis, the post-test scores of students who were taught under e-Laboratory were compared to the post-test scores of students who were taught under real laboratory using t-test statistics and the results are presented in the Table below.

Table A. T-test Analysis of the Performance of Students' taught using e-Laboratory and those taught using Real Laboratory

Groups	N	$\bar{X}$	SD	Df	T	p-value
eL	35	62.69	14.32	70	0.72	0.29
RL	37	59.89	18.19			

P<0.05

Table shows that there was no significant difference in the mean scores of the two groups in the ATBP (t = 0.72, P>0.05). Thus, the null hypothesis is not rejected. This implies that there is no significant difference in the performance of students in practical Biology of taught with e-laboratory (eL) and those taught with real laboratory (RL). The mean scores revealed that e-laboratory group ($\bar{X}$ = 62.69) performed better than the real laboratory group ($\bar{X}$ = 59.89) but not significantly.

Hypothesis 2:

There is no significance difference in the attitude to Biology practical of students taught using e-laboratory and those taught using real laboratory.

In testing this hypothesis, the attitudes of the students were measured and analysed using mean and t-test statistics as shown in Table below.

Table A t-test Analysis of the Attitudes of Students' taught using e-Laboratory and those taught using Real Laboratory.

Groups	N	$\bar{X}$	SD	Df	t	p-value
eL	35	49.14	7.32	70	0.69	0.42
RL	37	48.00	5.99			

P<0.05

Table above revealed (t = 0.69, P>0.05) that there was no significant difference in the attitude of students exposed to e-laboratory and those exposed to real laboratory hence the null hypothesis is not rejected. The mean scores revealed that e-laboratory group ($\bar{X}$ = 49.14) have better positive attitude than real laboratory group ($\bar{X}$ = 48.00) but not statistically significant.

The results of the analysis of Hypothesis 1, showed that there was no significant difference in the performance of students taught using e-laboratory and those taught using real laboratory. It was found out that both e-laboratory and real laboratory had a comparable effectiveness on the performance of the students. The mean scores only showed that students taught under e-laboratory performed better than those taught under real laboratory but not statistically significant. This little mean difference might be as a result of environmental factor or because of the ability of the students in e-laboratory to be able to replay the video over and over again. This result was in support of findings of [22], [12]; [18]; [16]; [17]. The authors discovered that either e-laboratory or real laboratory was effective in

enhancing student's performance and that the effectiveness and impact of the e-laboratory was comparable to that of real laboratory. The authors affirmed that both types of laboratories teachings were effective because they had the advantage of allowing learners to use process skills to generate content information and also to understand more complex materials. The authors also affirmed that both types of laboratories help to aid conceptualization, memory and help to develop students in the understanding of science. These findings were in line with that of [5] who reported that there was no significant difference between performance of student taught using remote laboratory and those taught Biology practical using hands-on laboratory.

The results of this study was consistent with that of [10] who also found out in his study on the comparative study of hands-on and remote physics laboratory that there was no significance difference in the performance of students taught using hands-on laboratory and those taught using remote laboratory. The findings from this study were also supported by the findings of [1] who found out that the usual (traditional) laboratory teaching is comparable (or better) to video media instruction and affirmed that video media instruction could be used after classroom teaching or serves as tutorial materials. The results were also in line with that of [2]. They found out that the physical science considers the use of concrete visual devices like projectors, camera, video, laser video disc as aids to teaching.

The results of the findings showed that there was no significant difference (P>0.05) in the effectiveness of e-laboratory (eL) and real laboratory (RL) in improving positive attitude in students towards Biology practical. From the study, both e-laboratory group and real laboratory group showed positive attitude but with mean difference of 1.14 in the e-laboratory group showed more positive attitude, than the real laboratory. From the findings, it could be concluded that either of the two types of laboratories could be used to improve positive attitudes in Biology practical of students if they are used effectively. In support to the findings, [21] and [13] reported that students' attitude towards learning correlates highly with their achievement. [15] Reported that the correlation between high school students' achievement in Chemistry and their attitude towards Chemistry ranged from 0.24 to 0.41. [8] Also discovered that undergraduate student who had a less positive attitude to chemistry almost invariably obtained lowered examination marks.

Based on these findings, the study concluded that students learnt better when taught with both methods. From the results of these findings, it also shows that real laboratory improved students' performance going by real laboratory students posttest, which means if students could be properly taught and not waiting towards the commencement of external examination before conducting practical's for the students it would yield a better performance and in the absence of teachers, students need not to wait for teachers to learn since there are numerous practical online that students can learn from which would also yield a better result. Also, the study concluded that either e-laboratory or real laboratory were effective in promoting the students' attitudes to Biology practical.

RECOMMENDATIONS

1. As a result of this global technological development, teachers at secondary school level should be exposed to computer training and also the use of internet to facilitate their teaching and learning experiences.
2. All subject teachers at the secondary school level should be encouraged to download videos from the internet most especially those ones relevant to their subjects and then incorporate them in their teaching.

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