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## Effective School Laboratory Practice for Science Teaching: An Overview

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### ABSTRACT

*This paper titled “effective laboratory practice for science teaching: an overview” examine the role of physical laboratory and virtual laboratory in science teaching in Nigeria schools. It also examined the role of blending the two types of laboratory in science teaching, the challenges facing the use of virtual and physical laboratory were also discussed. It was suggest among others that school authority should provide alternative power supply in case there is power outage and for some part of the country where there is no power supply; Internet supporting devices and facility should be made available to all secondary schools in the country. The paper therefore concluded that blending of virtual and physical laboratory in science teaching will go a long way in achieving if not all, some of the sustainable goals of the 21<sup>st</sup> century.*

**Keywords:** Physical laboratory, Virtual laboratory, Science teaching, and Senior Schools.

### INTRODUCTION

Science education has continued to play a key role in the development of any nation. In fact science education is a basic tool in realizing the nation’s scientific and technological aspiration. Science is the foundation of technology and technology is the bedrock of modern development. The importance of science (Biology, Chemistry and Physics) can also be seen by the status conferred on the subject as one of the core subjects in secondary school curriculum (NPE, 2004). Science has been defined by many scholars based on the dimension they sees it. According to Abimbola, (2013) science is defined as a body of knowledge, a way of investigation or method, and a way of thinking in the pursuit of an understanding of nature.

Science refers to the knowledge about the structure and behavior of the natural and physical world based on facts that can be proved through experiments (The Oxford Advanced Learner Dictionary, 2006; 6<sup>th</sup> Ed.). It can be deduced from the above definitions that science teaching requires practical application of the theoretical knowledge that students’ acquires in a classroom setting. Thus this place a great demand on laboratory space and/or equipment for carrying out such exercises.

“To many students, a ‘lab’ means manipulating equipment but not manipulating ideas.” (Lunetta, 1998). “Laboratory” may refer to a room equipped with benches and student workstations, or it may refer to various types of indoor or outdoor science activities. Laboratory experiments play a critical role in furthering scientists’ understandings of how the universe works,

and in light of this importance, it is no wonder that educators have historically placed high value on laboratory experiences in science classrooms. To this effect there exist two types of Laboratory namely: “Physical or Real Laboratory and Virtual Laboratory”.

### PHYSICAL LABORATORY

Physical laboratory experimentation involves teaching scientific concepts using the physical or real laboratory equipment. That is, experimental activities are actually carried out in the laboratory environment using the real scientific equipment. Scientific equipment/facilities help to promote greater acquisition and higher retention of skills and as well contribute to the development of students’ attitude and behavior (Agboola and Haruna, 2017). The use of laboratory equipment in teaching and learning processes makes learning effective and help to sustain students’ attention throughout the lesson.

Bandele (2003) noted that the importance of physical facilities cannot be relegated. Facilities like modern laboratories, libraries and classrooms are to be put in place in all our schools. The usefulness and effectiveness of the science laboratory have been bones of contention in science teaching as far as one cares to go back in the literature. Laboratory instruction is costly, and, since its effectiveness has been difficult to substantiate compellingly, some responsible administrators have viewed it is a luxury we cannot afford. Yet most scientists and science educator have a deeply rooted, intuitive feeling that laboratory experience is essential to learning and understanding of science, and they fight hard for maintaining such instruction in the face of frequently expressed doubts and occasionally formidable opposition (Arons, 1993)

Nevertheless virtually all science teachers recognize that empirical enquiry is the hallmark of the natural sciences. It is hard to imagine learning to do science, or learning about science, without doing laboratory or fieldwork. Experimentation substantiates all scientific knowledge and understanding. Laboratories are wonderful venues for teaching and learning science. It offers students’ opportunities to think about, discuss, and solve real problems.

**Table 1:** Some Equipment found in Science Laboratory

Item No.	Biology Equipment	Chemistry Equipment	Physics Equipment
1.	Beakers	Beakers	Spring balance
2.	Bunsen burners	Bell jar	Trolley
3.	Boiling tube	Boss heads	Beakers
4.	Crucibles	Burettes	Pendulum bulbs
5.	Conical flasks	Burette brushes	Stop watches/clock
6.	Measuring Cylinders	Bunsen burners	Metre rule
7.	Chemical balance	Carbon rods	Pulley
8.	Dissecting sets	Calorimeters with stirrers	Drawing board
9.	Dissecting boards	Combustion tubes	Hydrometers
10.	Dropping pipettes	Liebig condenser	U-tube manometer
11.	Evaporating dishes	Copper plate	Spiral spring
12.	Flasks (round & flat	Cotton wool	Pair of Vernier calipers

Item No.	Biology Equipment	Chemistry Equipment	Physics Equipment
	bottom)		
13.	Vacuum flasks	Crucibles, porcelain with lids	Micrometer screw gauges
14.	Filter paper	Petri dishes	Inclined planes
15.	Glass rods	Dropping pipettes	Tripod stand
16.	Glass sheets	Funnels, plain, polythene	Bunsen burner
17.	Graduated pipettes	Filter paper	Thermometer
18.	Hand lenses	Volumetric flask, Flat bottom flask, conical flask	Retort stand, boss & clamp
19.	Hygrometer	Fire extinguisher	Knife edges
20.	Insect nets	First aid box	Graduated cylinder
21.	Litmus paper	Gas jar	Barometer tube
22.	Microscopes	Glass Gas trough	Corks
23.	Petri dishes	Graduated cylinder	Mercury
24.	Photometers	Grease	Bicycle pump
25.	Plant pots	Indicator bottles	Ray boxes
26.	Plastic model (heart, eye, ear, etc)	Rubber stoppers, assorted, single and double holes	Lens holders
27.	Spatula/ Plastic spoons	Molecular model	Plane mirror
28.	Specimen bottles	Platinum electrodes	Rectangular blocks
29.	Separating funnels	Stop clocks	Triangular prisms
30.	Test tubes	Meter rule	Drawing pins
31.	Test tube holders	Sand buckets	Optical pins
32.	Test tube racks	Stand, burette, wooden, heavy base	Concave & convex mirrors
33.	Tripod stand	Test tube, test tube holders, test tube racks, borosilicates	Converging & diverging lenses
34.	Wire gauze	Thermometers	Sonometers
35.	Thermometer	Tongs, crucible	Turning fork
36.	Hydrochloric Acid	Tubing, rubber	Ripple tanks
37.	Nutric Acid	Tripod stands, Bunsen burner	Hand spectrosopes
38.	Sulphuric Acid	U-tubes	Bell jars
39.	Methylated spirit	Wash bottle, watch glasses	Set of weights
40.	Alum (iron) pure	Voltameter, voltmeter.	Bar magnet
41.	Ammonium Hydroxide	Methylated spirit	Crocodile clips
42.	Calcium Hydroxide	Water baths	Polythene rods
43.	Ethanol	Copper foil, copper turning	Acetate rods
44.	Pepsin powder	Barium chloride, calcium	Bulbs

Item No.	Biology Equipment	Chemistry Equipment	Physics Equipment
		chloride	
45.	Lead acetate pure		G-clamps
46.	Potassium chloride pellets	Ammonium chloride, aqueous ammonia,	Ammeters (d.c.)
47.	Zinc chloride	Litmus paper (blue & red)	Voltmeters (d.c.)
48.	Sodium hydroxides	Hydrochloric acid	Galvanometers
49.	Sucrose	Lead acetate	Connecting wires
50.	Sodium sulphate	Iron (II) sulphide, iron (II) chloride	Electric motor
51.	Fehling's solution	Iodine	Power units
52.	Skeleton of man	Liquid paraffin	Coil
53.	Brain chart	Manganese dioxide	Zinc & copper plates
54.	Lung chart	Litmus solution	Rheostats
55.	Human chart	Iron metal (filings)	Electric bells
56.	Ascaris	Lead paper	Resistors
57.	Tapeworm	Calorimeters with stirrers	Plug keys
58.	Fish	Fire blanket	Jockeys
59.	Human baby in uterus	Glass wool	Potentiometers
60.	Typical plant cell	Indicators bottles	Resistance boxes
61.	Typical animal cell	Drying tower	Gold-leaf electroscopes
62.	Spirogyra, Amoeba, paramecium, euglena.	Spatula, nickel	Chemical/scale balance
63.	Blood cells	Splints, wood	Battery charger
64.	Different types of mammalian bones	Resort rings	Constantin wire
65.	Parts of flowers	Porous pot	Daniel cells

**Source:** WAEC Laboratory Equipment Checklists (2015)

The table above shows a list of common Biology, Chemistry and Physics Laboratory equipment, reagents, chemicals, models, among other that are expected to be found in secondary school science laboratory in Nigeria schools. However, due to practical concerns of procuring laboratory equipment, safety concerns, and time constraints, computer simulated experiments are becoming an attractive alternative to laboratory experiments.

### VIRTUAL LABORATORY

Virtual laboratory can be seen as the use of animation to simulate the real laboratory experiment. In a virtual laboratory, computers are used to simulate or animate specific scientific phenomena. Students normally engage in hand-on activities which are directed towards increasing their understanding and insight of the principle involved. Edward and Harry, (2005) viewed virtual laboratory as laboratory experiment without real laboratory with its walls and doors. It enables the learner to link between the theoretical aspect and the practical aspects of

science. It is electronically programmed into a computer in order to simulate the real experiments.

Virtual laboratory is also defined as a virtual studying and learning environment aims at developing the laboratory skills of students (Agboola and Haruna, 2017). Students need practical experiences to enable them understand some abstracts concepts in science; therefore, effective use of laboratory will improve the mastery of scientific concepts. When taking this into consideration, looking for appropriate alternatives is inevitable, hence, the use of virtual laboratory in supporting the laboratory methods can be logical in this era of information technology or information economy.

### ***Blending Virtual Laboratory Experiment into Real Laboratory Experiment***

According to Al-baiati, (2006) the following should be taking into consideration in an attempt to integrate virtual laboratory into Science teaching.

1. **The Laboratory Set and Equipment:** The virtual laboratory is considered integral to the traditional laboratory but not an alternative to it. The existence of the traditional laboratory is very necessary, but in lower numbers and requirements, which help in the possibility of using it by several users outside the laboratory;
2. **Computer Devices:** They are represented in personal computers, which are linked to the local net or to the international net so that the students can work directly in the laboratory, or distantly at anywhere and anytime;
3. **Communication Network and the Related Hardware:** In case of performing experiments electronically, all the sets should be linked to the computer, because the link between the users with laboratory will be through digital communications;
4. **The Programs of the Virtual Laboratory:** These programs are represented in the simulation programs, which are designed by professional. It is necessary to design this program in an interesting and attractive form; as these programs were designed to attract students' attentions and urge them to complete the experiment. This is maintained by the animation techniques, video, and the three dimensions pictures;
5. **Co-operation Programs and Management:** These programs are concerned with the method of managing the laboratory and the ones who perform the experiment, including students and researchers. These special programs register students in the laboratory program and determine the kinds of access that should be provided to each users in the different experiments;
6. **Technical Staff:** These are people that provide technical assistance to students when need arise.

### ***Benefits of Blending the Virtual and Physical Laboratory***

1. **It helps in Enhancing Mastery of Subject Matter:** When blended laboratory learning approach is used, it may enhance student understanding of specific scientific facts and concepts and of the way in which these facts and concepts are organized in the scientific disciplines.
2. **It helps in Developing Scientific Reasoning:** Blended laboratory experiences may promote student's ability to identify questions and concepts that guide scientific

investigations; to design and conduct scientific investigations; to develop and revise scientific explanations and models; to recognize and analyze alternative explanations and models; and to make and defend a scientific argument. Making a scientific argument includes such abilities as writing, reviewing information, using scientific language appropriately, constructing a reasoned argument, and responding to critical comments.

3. **It helps in Understanding the Complexity and Ambiguity of Empirical Work:** Interacting with the unconstrained environment of the material world in a blended laboratory situation may help students concretely understand the inherent complexity and ambiguity of natural phenomena. Blended laboratory experiences may help students learn to address the challenges inherent in directly observing and manipulating the material world, including troubleshooting equipment used to make observations, understanding measurement error, and interpreting and aggregating the resulting data.
4. **It helps in Developing Practical Skills:** In blended laboratory situations, students may learn to use the tools and conventions of science. For example, they may develop skills in using scientific equipment correctly and safely, making observations, taking measurements, and carrying out well-defined scientific procedures without necessarily interacting with the real equipment.
5. **It helps in Understanding the Nature of Science:** blended laboratory experiences may help students to understand the values and assumptions inherent in the development and interpretation of scientific knowledge, such as the idea that science is a human endeavor that seeks to understand the material world and that scientific theories, models, and explanations change over time on the basis of new evidence.
6. **It helps in Cultivating Interest in Science and Interest in Learning Science:** As a result of blended laboratory experiences that make science “come alive,” students may become interested in learning more about science and see it as relevant to everyday life in this era of information and communication technology.
7. **It helps in Developing Teamwork Abilities:** blended laboratory experiences may also promote a student’s ability to collaborate effectively with others in carrying out complex tasks, to share the work of the task, to assume different roles at different times, and to contribute and respond to ideas. (itemized by the committee report on America laboratory, 2005)

Helping all senior schools students achieve these science learning goals is critical to improving Nigeria scientific literacy and preparing the next generation of scientists and engineers to face the challenges of the 21<sup>st</sup> century. Although the use of virtual or physical laboratory alone may not make it easy for the above learning goals to be achieved, but the combination of both may be of significance effects.

### ***Challenges facing the Use of Blended Laboratory Approach in Nigeria***

1. **Erratic Power Supply:** Lack of adequate power supply is one of the factor that affects effective use of blended laboratory approach to science teaching

2. Inadequate Internet Services: Most of Nigeria secondary schools are located in remote areas where there may not be internet facilities
3. Technical know-how: The needed man powers to operate most of the equipment or computers are not adequate and technical staff to put the existing system in order are not on ground.
4. Inadequate Funding: the cost of maintaining the available computers is high a time the needed fund is not available
5. High cost of purchase of Information and Communication Technology (ICT) facilities and physical laboratory equipment:

## SUGGESTIONS

The following suggestions were therefore made:

1. Provision of alternative power supply by the concerned authority in case there is power outage and for some part of the country where there is no power supply
2. Internet supporting devices and facility should be made available to all secondary schools in the country.
3. There should be training and retraining of the staff (teachers and supporting staff) who are in charge of laboratory activities.
4. Government should make adequate financial provision for day-to-day running of Nigerian secondary school laboratory as well as all other concern stakeholders.
5. Government and other concern stakeholders should try as much as possible to subsidies ICT facilities and all relevant supporting facilities that will help sustain the use of virtual laboratory in Nigerian schools.

## CONCLUSION

Previous research has demonstrated that virtual manipulatives can be as effective as physical manipulatives in some circumstances, but that is no concluding facts that it can replace the use of physical laboratory. Therefore this paper suggests the use of the two approaches (blending virtual and physical laboratory) in the teaching of sciences in our schools in order to meet the global challenges of knowledge and information economy.

## REFERENCES

- Abimbola, I. O. (2013). Study technology – an evolving universal tool for educating pre-service teachers. *Journal of Mathematical Science Education*, 2(1), 257 – 270.
- Agboola, O. S., & Haruna, J. O. (2007). Effects of physical and virtual laboratory experimentation on students' learning outcomes in basic science in Ife central local government Area, Osun State. *Journal of Curriculum and Instruction*, 10(2), 186 – 197.
- Al-Baiati. (2006). The applied and scientific dimensions in electronic learning. *The Arabian net for open electronic learning*, Amman, Jordan. Pp.: 13.
- America's Lab Report: Investigations in high school science (2005) <http://www.nap.edu/catalog/11311.html>.

- Arons, A. 1993. Guiding insight and inquiry in the introductory physics laboratory. *The Physics Teacher* 31: 278–282.
- Bandeke, S. O. (2003). The universal basic education in perspective, need for formative evaluation. Nigeria. *Journal of Educational Research and Evaluation*. 1(4), 54-56.
- Edward, B. & Harrt, E. (2005). Making real virtual Lab. *The Science Education Review*. Pp: 29.
- Federal Republic of Nigeria (2004). *National policy on education* (4<sup>th</sup> ed.), Lagos NERDC Press.
- Lunetta, V. N., (1998). Evaluating science laboratory skills. *The Science Teacher*. 22–25.
- The Oxford Advanced Learner Dictionary, (2006). 6<sup>th</sup> Ed. Macmillan Publishers, London.
- West African Examinations Council. (2015). *Laboratory equipment checklists for secondary schools*. Lagos.