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INFLUENCE OF VIDEO AND SIMULATED MODES OF VIRTUAL LABORATORY ON UNDERGRADUATES' SCIENCE MANIPULATIVE SKILLS IN PHARMACOLOGY IN NORTH- CENTRAL NIGERIA

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INFLUENCE OF VIDEO AND SIMULATED MODES OF VIRTUAL LABORATORY ON UNDERGRADUATES' SCIENCE MANIPULATIVE SKILLS IN PHARMACOLOGY IN NORTH- CENTRAL NIGERIA

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Abstract

*The purpose of this study was to determine the influence of video and simulated modes of virtual laboratory on undergraduates' science manipulative skills in pharmacology in North-Central Nigeria. The study employed a Pretest-posttest control group quasi-experimental design. A multistage sampling technique was used, three universities were purposefully sampled, and a purposive sampling technique was also used to select three programmes: Medical Sciences, Veterinary Medicine and Nursing Sciences. Intact class was used, and treatments were randomly assigned to institutions. The institutions were assigned to Virtual laboratory simulation (VLS) (41), Virtual laboratory video (VLV) (53) and the control group (41) Total participants were 135. The Students' Virtual Laboratory Manipulative Skills Checklist (**SV_LMCL**) was the measuring instrument used. Virtual Laboratory video package (VLVP), Virtual Laboratory Simulation Package (VLSP), Physical Laboratory (PL), were the procedural instruments used. Two null hypotheses were formulated and tested at 0.05 level of significance. Analysis of covariance (ANCOVA) with Scheffe post hoc tests were used. Treatment significantly affected students' science manipulative skills ($F_{(2, 115)}= 8.03$; $p<.05$; $\eta^2 =.46$). Undergraduates in the VLS group obtained higher mean score in manipulative skills in Pharmacology Practical ($\bar{x} = 38.54$) than those in the VLV ($\bar{x} =36.54$) control group ($\bar{x} =28.65$). Gender had no significant effect ($F_{(1, 115)} = .33$; $p>.05$; $\eta^2 =..99$), The findings of the study strongly affirm improved students' science manipulative skills in Pharmacology through VLS and VLV. Based on these findings, it was recommended that Lecturers and laboratory technologists/Scientists handling Pharmacology practical be encouraged through training, workshops and provision of resources to integrate the video and simulated modes of the virtual laboratory in teaching and learning Pharmacology in the institutions of higher learning in North-Central Nigeria*

Introduction

Information communication Technology (ICT) has presented educational institutions with great opportunities which can be harnessed through educational technology, for instance undergraduates in science and health sciences programme can use virtual realities, virtual laboratory simulations gamifications marker space and videos to enhance laboratory teaching and learning. There is emphasis, in this computerized age on life-long learning to enhance performance and science

manipulative skills, and the universities are expected to do these using new technologies, these technologies can bring about cost-effective and Workable Platform for institutions, for example Teaching a practical course to a large population of students could take several days for every student to directly part take, in government-owned universities, where student population is in the increase the laboratory equipment available, do not go around all the students, in most cases, they are grouped, you can have up to 10 students or more in a group and only one person handles the equipment. The situation may deteriorate if equipment malfunctions because of over-usage or if there arises the need to restock the shortage of reagents or replace worn equipment. The virtual laboratory does not suffer the above constraints; hence, fixed, and variable expenditures are reduced. Budai and Kuczmann (2018), stated that virtual laboratory does not wear out of age which reduces their operating cost. According to Stanford University (2019), converting physical experiments into virtual ones requires relative effort and then you have it as long as you want. It allows Science, Technology, Medical, Health Sciences, Engineering, and Mathematics students to experiment inexpensive laboratory at a fraction of the cost hence, providing cost-saving benefits. Students can repeatedly practice or experiment to gain science manipulative skills and they are also unable to cause damage to the platform because of making mistakes, this makes it sustainable, this is not obtainable with physical laboratory once students are taught, they cannot practice or revise for examination due to high cost of reagents, drugs, chemicals, and equipment. If the virtual laboratory is web-based and users access the platform via a computer with internet access or a Virtual Reality (VR) headset, no additional infrastructure may be needed. Since it is not constrained by place, time, or space, its usability, adaptability, and scalability are essentially endless. Additionally, maintaining and setting up a virtual laboratory is more affordable. It gives educational institutions the chance to keep up with and adjust laboratory needs in line with industrial and technical development.

Conducting a hands-on practical experiment in the science laboratory involves scientific process skills, and science manipulative skills where students can investigate phenomena, test hypotheses, and draw a conclusion, they also practice the scientific skills in handling apparatus that lead to meaningful learning. Fadzil and Saat, (2017) reported that the non-availability of science laboratory equipment is the major limiting factor for students in developing science process and science manipulative skills in laboratory experiments. The development of manipulative skills is one significant aim of experiments in the laboratory (Abrahams *et al*., 2014). Manipulative skills can best be defined as psychomotor skills that relate individual cognitive function with corresponding physical movement, which mean student's inability of acquiring science manipulative skills can seriously affect the acquisition of science process skill in the laboratory. Students who are competent in science manipulative skills will have a better opportunity to concentrate on the development of science process skills which involve skills such as observing, classifying, measuring, inferring, predicting, communicating, interpreting, making hypotheses, experimenting, and analysis. Some studies have shown that Virtual laboratories can aid students to carry out difficult experiments in an easier way, it can also help students master science process

and manipulative skill in doing complex experiment. The virtual laboratory can be programmed to promote science process skills (Abrahams *et al*., 2014).

The proper use and handling of scientific equipment, laboratory animals and chemical/drug substances during laboratory research is emphasized by manipulative skills in science, in addition, students learn the correct methods for handling, maintaining, and storing scientific equipment. The inability of students to acquire science manipulative skills can have a significant impact on their capacity to acquire other desirable abilities in the laboratory. For instance, if they find it difficult to operate a piece of equipment, this could result in their failing to make critical observations and collect pertinent data. Fadzil & Saat, (2014).

The obvious difficulty in Nigerian university education is the availability and effective use of new technological tools that will enable graduates to meet the challenges of a rapidly changing world to compete on a global scale, new technology devices are redefining science laboratory practical and experiments (Anjorin, 2022).These new and emerging technologies could also create availability and sharing of expensive equipment, help institutions maintain flexible curriculum, acceleration of Student engagement, effective technology could also help to eradicate hazard and safety concerns in the laboratories A high risk coefficient makes it impossible to teach and exhibit some experiments (radioactive, high-power voltage, concentrated acidic liquids, animal bite, etc.) Students encounter several difficulties in the physical laboratory, such as: limited access to equipment, inadequate reagent, drugs, poor technical support, time restrictions, concerns for personal safety, and equipment limitations. These can lessen students' enthusiasm for practical subjects or courses Ari-Gur *et al*.,(2013)

Students' ability to manipulate objects is crucial to their ability to successfully accomplish science-related tasks. In order to acquire experience in manipulating specific scientific apparatus, students should do a variety of experiments using a particular scientific apparatus in order to gain experience handling it. A scientific apparatus's handling and manipulation approach is crucial because it can preve nt, reduce, and regulate misinterpretations and potentially lower the amount of mistake in scientific investigations. Many studies have shown that with virtual laboratory students gain a better science practical skill which was reflected in their performance in the real lab (Radhamani et al., 2014: Alneyadi, 2019). The results Fadzil and Saat (2017) demonstrate how basic the students' manipulation skill learning was during their scientific practical practice. The mastery of fundamental abilities had a significant impact on the students' capacity to acquire advanced skills. There is a pattern in which students pick up various talents, and this pattern can function as a hierarchy. Lack of exposure to "hands-on" and "minds-on" activities may prevent students from developing manipulative abilities during practical sessions time. Students' development of manipulative skills and scientific concepts will be more beneficial than merely knowing how to operate scientific apparatus in theory. In the study of Ogunleye, (2009) on student ability and practical skill, he concluded that practical skill should be given the required attention by chemistry teachers in the course of teaching. The study of Alexander, Joseph and

Ernest (2022) reveal that the use of virtual laboratory improved the student teachers' practical skills in Integrated Science lessons.

Even though information and resources are very scanty on student's science manipulative skills, and performance in virtual laboratory simulation and videos in pharmacology, most of the study reviewed are still stuck in basic sciences, physic, biology, and chemistry, and in respect to gender, it becomes an interest of research in this study.

Statement of the Problem

Experimental laboratory-based practical classes have been the cornerstone of undergraduate pharmacology; it supports the development of scientific and research skills in students, such as experimental design, data analysis, statistics, and report writing. These skills expose students to experimental techniques and methodology, aid students to comprehend pharmacological concepts, and understand the mechanisms of how chemical compounds and drugs interact with the living tissues and cells to affect their function. Not all universities in Nigeria seem to have the facilities students need to build confidence in experimental methods. There are also issues with the difficulty of conducting animal experiments due to problems of availability, procurement, cost, maintenance, non-reproducibility in experiments, and equipment restriction (John, 2013;Okeke *et al*., 2014). The conventional laboratory is coming under increasing pressure due to the increase in student's population with no provision for expansion because of funding difficulties and poor infrastructure. All these are required to provide hands-on experience, and a better understanding of theory taught during lectures by students. This can affect student performance and can also have an adverse impact on students attaining science manipulative skills.

There is emphasis, in this computerized age on life-long learning to enhance performance and the universities are expected to do these using new technologies like video and simulated modes of the virtual laboratory which could significantly improve students' science manipulative skills in Pharmacology. Thus, this study determined the impact of video and simulated modes of virtual laboratory in the teaching and learning of pharmacology. It also determines the effects of moderator variables gender on student's science manipulative skills in Pharmacology practical.

Objectives of the study

The main objective of this study was to determine the influence of video and simulated modes of virtual laboratory on undergraduates' science manipulative skills in pharmacology laboratory teaching and learning in North-Central Nigeria. The specific objectives include to:

(i) determine the pretest and post-test mean science manipulative skills scores among undergraduates exposed to the video virtual laboratory, simulated virtual laboratory, and traditional laboratory in Pharmacology.

(ii) determine the pretest and post-test mean science manipulative skills scores of male and female undergraduates in Pharmacology exposed to the video virtual laboratory, simulated virtual laboratory, and traditional laboratory

Research Questions

The following research questions were attempted during the study:

(i) What are the pretest and post-test mean science manipulative skills scores among undergraduates exposed to the video virtual laboratory, simulated virtual laboratory and traditional laboratory?

(ii) What are the pretest and post-test mean science manipulative skills scores of male and female undergraduates exposed to the video virtual laboratory, simulated virtual laboratory and traditional laboratory?

Hypotheses

The following null hypotheses tested at 0.05 level of significance, were proposed:

Ho_1: There is no significant main effect of Treatment (video and simulated modes of virtual laboratory) on undergraduate's science manipulative skills in Pharmacology.

Ho_2: There is no significant main effect of gender on undergraduates' science manipulative skills.

in Pharmacology

Conceptual Framework

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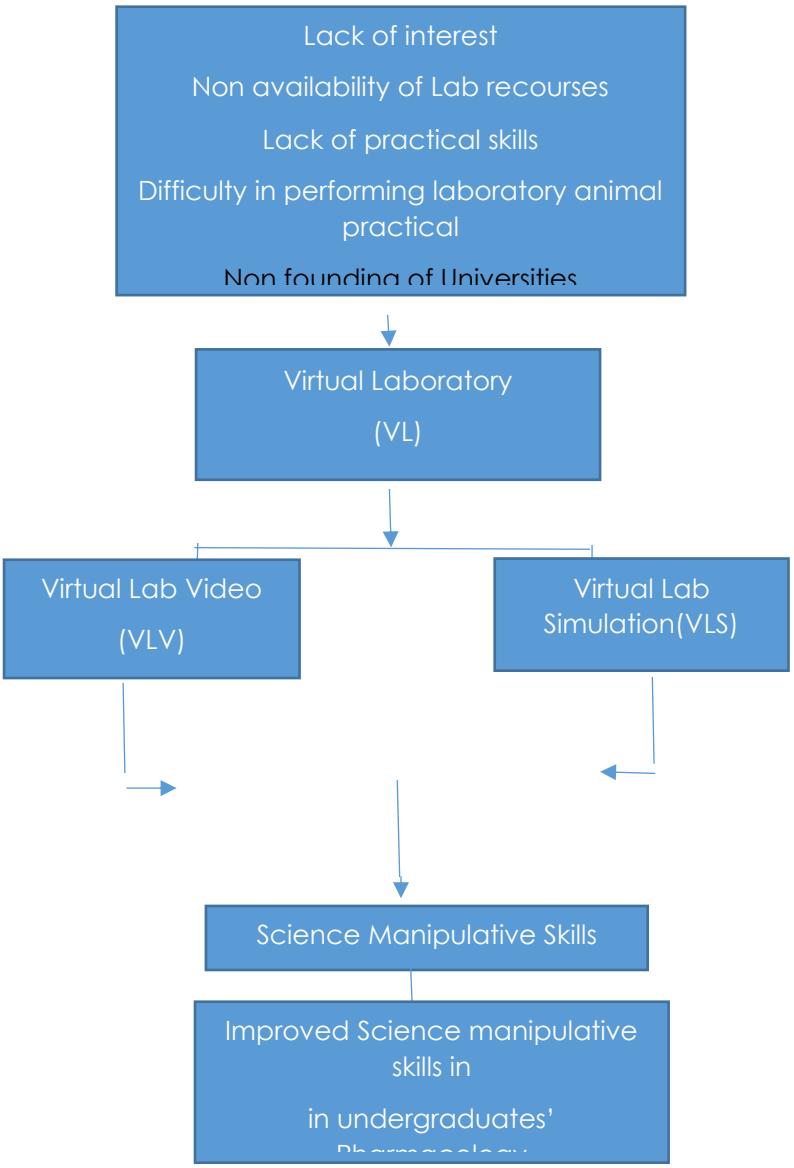

Fig 1.1: Diagrammatic Representation of Conceptual Framework Model

Fig 2 shows the relationship of variables determining the influence of virtual laboratory simulation and video on undergraduates' science manipulative skills in Pharmacology. The dependent variable science manipulative skills are influenced by various factors. They include non-availability of laboratory recourses, lack of manipulative skills, lack of interest, difficulty in performing laboratory animal experiments in Pharmacology and non-founding of Nigerian Universities are shown in the figure. The independent variables are the virtual laboratory simulation and the virtual laboratory video as the laboratory teaching approach. There is also the effects of moderating variables: gender. In this study, any difference found in undergraduates'

science manipulative skills could therefore be attributed to the mode of instruction employed thus the use of Virtual laboratory video (VLV) and Virtual Laboratory simulation (VLS)

Theoretical Framework

This study seeks to explore the impact of virtual laboratory videos and simulations on undergraduates' achievement in pharmacology. Therefore, the theoretical reinforcement of this study was derived from the following theories: Experiential learning theory (EXL), Gagne's theory of instructional design for sciences.

Methodology

The study adopted a pretest posttest control group, quasi-experimental research design. This design has been found to be among the most effective approaches in carrying out studies of this nature because it controls and minimizes the effect of regression, experimental mortality, instrumentation attrition, and testing (Adekola, 2016). The pretest is to test the previous knowledge of the students, it was administered before the students' exposure to treatments; the independent variable was varied at three levels; virtual laboratory simulation (treatment), virtual laboratory videos (treatment), and conventional(physical) laboratory (control), dependent variable science manipulative skills, moderator variable: gender (male and female). In this study, there were three levels of the independent variables: virtual laboratory simulation group (Experimental treatment group I). The virtual laboratory video group (Experimental treatment group II), and conventional practical laboratory group (control group). There are two levels of gender (male and female) and the dependent variable: Science manipulative skills.

The population of this study comprised all the 400-level undergraduate students in three universities (University of Jos, University of Abuja and University of Ilorin) in the north-central geographical zone of Nigeria. The researcher took stock of Universities in the North-Central that offer all three programmes: Medical Sciences, Veterinary Sciences and Nursing Sciences, which was what made them eligible for the study The population of undergraduates in the three universities to whom this study was generalized is 788. The 400level undergraduates were used because they had not been exposed to such treatment. Multi-stage sampling technique was used in the first stage, three universities that satisfied the inclusive criteria of well-equipped laboratory and adequacy of pharmacology lecturers and laboratory technologists, that handle laboratory experiments and practical were purposefully sampled. In the second stage, the purposive sampling technique was used to select Universities in North- Central that offer the three programmes: Medical Sciences, Veterinary Sciences and Nursing Sciences, which made them eligible to participate in the study. Lastly, intact class was used for each of the experimental groups and control groups per university. Universities were randomly assigned to treatments. A total size of 135 undergraduates participated in the study.

Instrumentation

Four research instruments were used for data collection for this study. They are classified into.

1. Procedural Instruments
2. Measuring Instruments

Procedural Instruments

i) Virtual Laboratory Simulation Software Package (VLSP)
ii) Virtual Laboratory Video Package (VLVP)
iii) Physical Laboratory (Conventional Laboratory) (PL)

Measuring Instruments

vi) Students' Virtual Laboratory Manipulative skills checklist (SV_LMCL)

Virtual Pharmacology Laboratory Simulation Software

The virtual laboratory simulation for undergraduate Pharmacology is a software package adapted. The software was developed by Neur-dynamic company, Institute of Physiology and Pharmacology, the University of Marburg for teaching and learning of Pharmacology, the updated version was used.

Virtual Pharmacology Laboratory Video Package

The virtual Pharmacology Laboratory Video Package developed by the researcher is the virtual videos of Pharmacology experiments from practical laboratory manual of University of Jos, University of Abuja and University of Ilorin. The video gave the illustration of step-by-step practical procedures on practical topics in a video format. Participants in experimental group II were exposed to this treatment.

Physical Pharmacology Laboratory: This is a traditional **(**conventional) Science laboratory where students performed hands-on practical experiments on the practical topics chosen students and a demonstrator used the physical equipment and animal tissue in the laboratory to perform experiments. The control group were exposed to this treatment.

Students' Virtual Laboratory Science Manipulative skills checklist (SV_LMCL)

This is a 10-item instrument it consisted of statements concerning science manipulative skills in Pharmacology, the research assistants who are Pharmacology Lecturers and Pharmacology Laboratory Technologist/Scientists assessed participants as they carry out experiments in the virtual laboratories and Physical Laboratory. It consisted of two sections, A and B. Section A consisted personal information about students like Gender, Age. Section B consisted of ten items which deals on the science manipulative skill in Pharmacology. The statements were rated 5,4,3,2,1 and students were scored as they are being assessed.

Pre-Treatment Phase

This phase involved the administration of pre-test. Students' Virtual Laboratory Science Manipulative skills checklist (SV_LMCL) was administered to undergraduates in pharmacology to assess their performance and determine their level of science practical skill. The Pharmacology lecturers and Laboratory Technologists and scientists accessed undergraduates as the performed experiments. All scripts were retrieved, marked and recorded; the scores were collated for further processing.

Treatment Phase

The treatment phase involves the administration of all the procedural instruments: Virtual Laboratory Simulation Software Package (VLSP), Virtual Laboratory Video Package (VLVP) Physical Laboratory (PL),

Post Treatment Phase

This involves the administration of posttest, the Students' Virtual Laboratory Science Manipulative skills checklist (SV_LMCL) was administered to undergraduates in Pharmacology after the treatment to see if there was an impact of the use of the VLSP, VLVP, PL on their Science manipulative skills in Pharmacology.

Validation and Reliability of Instrument

The Procedural Instruments were all validated by experts in the field. Students' Virtual Laboratory Manipulative Skills Checklist (SV_LMCL**)** was also validated.

Students' Virtual Laboratory Manipulative Skills Checklist (SV_LMCL) Reliability was carried out. The instrument consists of ten items assessed by lecturers and laboratory technologist while students perform practical to check their manipulative skills. The instrument reliability index was calculated using Cronbach Alpha's measure and the instrument yielded a reliability index of 0.91.

Data Analysis

The data was analyzed using the Statistical Package for the Social Sciences (SPSS Version 26). With the pre-test score as covariates to answer the research questions and test hypotheses Analysis of covariance (ANCOVA) was used to single out the initial group differences. Also, the Estimated Marginal Mean (EMM) of the ANCOVA was used to detect the magnitude and direction of difference where a significant main effect was detected, Scheffe post hoc was employed, and graphs was used in the case of significant interaction effect.

Results

The presentation of the results of this study was done in accordance with the hypotheses formulated for the study.

Ho 1: There is no significant main effect of treatment (video virtual lab and virtual lab simulation) on undergraduates' science manipulative skills in Pharmacology Practical

Table 1: Summary of Analysis of Covariance (ANCOVA) of Posttest Science Manipulative Skills in Pharmacology by Treatment and Gender

Source		Type III Sum of Square	Df	Mean Square	F	Sig	Partial Eta Square
Intercept	Hypothesis	5355.52	1	5255.52	148.29	.00	.98
	Error	82.83	2.34	35.44			
Pretest	Hypothesis	31.32	1	31.32	10.98	.00	.09
	Error	328.04	115	2.85			
Treatment	Hypothesis	12736.65	2	6368.33	8.03	.03*	.46
	Error	3262.57	4.12	792.80			
Gender	Hypothesis	.274	1	.274	.02	.89	.01
	Error	28.77	2.17	13.24			
					.		

*Sig at p<.05

Table 1 reveals a significant effect of treatment on undergraduates' science manipulative skills in Pharmacology ($F_{(2, 115)}$= 8.03; p<.05; η^2 =.46). The class effect size is .46. This means that there is a significant effect of treatment on the posttest science manipulative skills scores of undergraduates in Pharmacology. The null hypothesis is, therefore, rejected.

Table 1 presents the mean scores for the three levels of treatment group.

Table 2: Estimated Marginal Means for Undergraduate' Science Manipulative Skills in Pharmacology Practical Scores in the Three Groups

Grand mean =34.57

Treatment	Mean	Std. Error	95% Confidence Interval	
			LB	UB
Virtual Video	36.54	.20	34.25	36.94
Virtual Simulation	38.54	.25	37.24	39.52
Control	28.65	.55	24.25	30.85

From Table 2, undergraduates exposed to the Virtual Simulation laboratory group obtained higher estimated marginal science manipulative skills in Pharmacology Practical ($\bar{x}$ = 38.54) than those in the Video Virtual Laboratory ($\bar{x}$ =36.54) and the control group ($\bar{x}$ =28.65) in that order. Treatment has therefore improved students' manipulative skills in the two experimental groups more than the impact made on the control. In order to trace the actual sources of the significant effect of treatment on achievement, Scheffe post hoc test was used.
Table 2 presents the summary of Scheffe post hoc tests.

Table 3: Scheffe Pairwise Comparisons of Estimated Manipulative Skills in Pharmacology Practical Means Scores by Treatment

Treatment	N	Mean	Treatment Groups		
			Synchronous	Asynchronous	Conventional
1.VirtualVideo-	53	36.54			*
2.Virtual Simulation	41	38.54			*
3. Control	41	28.65	*	*	

*Significant Pairwise Comparison

Table 3 shows that the group exposed to the Video Virtual Laboratory ($\bar{x}$ = 36.54) and the Virtual Simulation Lab ($\bar{x}$ =38.54) significantly differ from the control group in terms of manipulative skills scores ($\bar{x}$ =28.65). However, the two experimental groups do not differ from one another to any significant extent. The significant pairwise differences show that the significant effect of treatment on students' manipulative skills in Pharmacology is due to the differences between each of the experimental groups and control.

H_O2: There is no significant main effect of gender on undergraduates' science manipulative skills in Pharmacology.
From Table 3 there is no significant effect of gender on undergraduates' science manipulative skills in Pharmacology ($F_{(1, 115)}$ =.02; p>.05; η^2 =.01). Hypothesis 2c is therefore, not rejected.

Table 4: Estimated Marginal Means for Male and Female Students' Science Manipulative Skills Scores

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	35.32	.41	37.60	39.00
Female	33.58	.38	36.45	37.85

From Table 4, the estimated posttest mean science manipulative skills scores for the male students is slightly higher ($\bar{x}$ = 35.32) than that of their female counterparts ($\bar{x}$ =33.58).

Discussion of Findings

The findings of this study revealed a significant effect of treatment on undergraduates' science manipulative skills in Pharmacology, undergraduates exposed to the virtual laboratory simulation group obtained higher estimated marginal science manipulative skills in Pharmacology than those in virtual video laboratory and the control group. The finding showed that the group exposed to virtual laboratory simulation and virtual video laboratory significantly differed from the control group, the two experimental group did not differ from one another to any significant extent.

The supremacy of the two experimental groups over the control group could be attributed to the provision and accessibility of students to laboratory equipment which was lacking in the control group thereby making it easier for students to repeatedly learn and practice manipulative skills in the experimental groups than in the control group. According to Anyaehie *et al.,* (2014) student interest in laboratory exercises would remain poor due mainly to lack of equipment/manpower support and a large group but that when students were engaged in the virtual laboratory video and virtual laboratory simulation, they could grapple with apparatus and tools repeatedly until the science manipulative skills is acquired. Students could also acquire science manipulative skills through repetitive learning which was not possible in the conventional group. Fadzil and Saat (2017) reported that non-availability of sciences laboratory equipment was the major limiting factor for the students in developing science manipulative skills in laboratory experiments which is one significant aim of experiments in the laboratory (Abrahams *et al*., 2014). This study is in line the findings of Ibrahim (2011), that virtual laboratory can aid students to carry out difficult experiments in an easier way and could also help students master science process and manipulative skills in doing experiment. Also, there is alignment of the findings of this study with those of Ogunleye (2011), that confirmed the assumption that everyday phenomena could establish a positive transfer of learners' experiential paradigm to the formal paradigm. Science teachers should adopt the approach towards more effective students' learning and acquisition of practical skills. This study also corroborated Cheesman *et al*., (2014) findings which revealed that students can "perform" experiments with virtual laboratory equipment to foster their practical skills. This study is also in line with the study Alexander Hero *et al*., (2022), which showed Virtual laboratory improved the student teachers' cognitive practical skills in Integrated Science lessons.

The findings of this study showed that there was no significant effect of gender on undergraduates' science manipulative skills in Pharmacology. The estimated posttest mean science manipulative skills scores for the male students is slightly higher than that of their female counterparts. This study is equivalent to the findings of Murugan and Kamisah, (2018) which showed that gender factors did not yield significant differences with the science skill. The study of Ekon and Eni (2015) aligns with this study as it found that gender did not significantly influence science skill.

However, the study of Ratmun and Osman, (2018) and Ogunleye, (2011) refutes those obtained in this study.

Conclusion

The use of VLV and VLS has improved undergraduates' science manipulative skills in Pharmacology. This has shown that there is a great prospect in VLV and VLS as laboratory instructional strategy that can increase student practical skills in Pharmacology, based on the findings of this study it can be recommended that using the VLV and VLS in Pharmacology practical significantly improved students' manipulative skills. This has shown that the use of VLV and VLS in teaching and learning process in the laboratory can produce a positive impact on student practical skills.

Recommendations

Based on the findings and conclusion of this study that VLV and VLS when used in Pharmacology would increase undergraduates' science manipulative skills the following suggestions are made:

First, the lecturers and laboratory technologists/scientists handling Pharmacology practical be encouraged at the institutional level to include student-centered instructional strategy such as video and simulated modes of virtual laboratory which are laboratory based instructional activities that increases students' achievement.

Second, the lecturers and laboratory technologist handling Pharmacology practical should be motivated, encouraged and strengthened by the institutions with the skills of development, production and usage of virtual reality modes of teaching and learning laboratory practical like the video and simulated virtual laboratory, which could be used where laboratory equipment are not available.

Third, due to limited laboratory facilities in Nigerian Universities, it is recommended that Virtual reality training should be conducted by the institutions for lecturers and laboratory technologist from time to time to update and get them acquainted with the latest and emerging technologies.

Fourth, the University management/ Dean, HODs, Programme Coordinators should embrace and support the use of virtual laboratory simulation technologies.

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