Electrical Engineering Practicum: The Place of Virtual Laboratory in Nigerian Universities

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***Abstract*—This study examined the level of awareness, perception, and utilization of virtual laboratories in Nigerian Universities by Electrical Engineering lecturers. The study was guided by three specific objectives and three survey research types. One hundred twenty-one lecturers in electrical engineering from 8 universities in Nigeria's Northeast comprised the study's population. Because the total population size was manageable, the study used whole-population sampling. Data was collected using a validated questionnaire. A reliability index of 0.79 was determined using Cronbach Alpha. Mean, and standard deviation were used to answer the research questions. The findings revealed that all the electrical engineering lecturers in Nigerian Universities are highly aware of Virtual Laboratories, and all the electrical engineering lecturers in Nigerian Universities rarely utilized Virtual Laboratories. The study recommended that the National University Commission should use all of its resources to promote the development of electrical engineering practicum by providing virtual laboratories to all universities in Nigeria, as the study found that electrical engineering lecturers in Nigerian universities have a high level of awareness of virtual laboratories; in addition to supporting physical laboratories in the universities, the administration should provide for the training of laboratory technicians and electrical engineering lecturers in Nigerian universities on how to effectively use the virtual laboratory facilities for conducting various types of experiments.**

Keywords—electrical engineering, practicum, virtual laboratory

I. INTRODUCTION

Electrical engineering is the study and application of electricity, electronics, and electromagnetism. This field became more pronounced after electrical gadgets such as electric telegraphs, telephones, and electric power distributions and consumption were commercialized in the mid-nineteenth century. Because of this, the building of new electronic circuits and components became commonplace, which invariably required proficiency in students for better circuit development [1]. Electrical engineers operate in various industries, and the competencies necessary vary accordingly. These span from circuit theory to project management abilities. Individual engineers may require a wide range of tools and equipment, from a simple voltmeter to more complicated design and software development [2].

The activities leading to circuitry building by electrical engineering students in universities required practical exercises, which in the conventional sense is the physical laboratory. Electrical Engineering Practicum is a capstone course that allows students to apply their knowledge and skills from previous electrical engineering courses in a professional working environment. According to Ref. [2], students develop problem-solving, research, communication, data analysis, teamwork, project management abilities, and an understanding of the professional and ethical issues that electrical engineers and technologists face in the workplace. The practicum course is adapted to meet the needs of the local system, with instruction provided through school laboratory training or work-based learning opportunities such as internships, cooperative education, service learning, mentorship, and job shadowing. After completing the practicum, students will be prepared for the world of work [3].

Nigerian University is marred by poor infrastructure, and the available one needs to be improved for lecturers and students. The poor infrastructure has prompted the Academic Staff Union of Universities to embark on continuous industrial action to demand better infrastructure, tools, and equipment for laboratories and workshops. The demand is premised on the fact that there is high demand for university education, and student enrollment has increased tremendously, thereby resulting in an inadequate number of laboratory equipment for practical activities. Against this backdrop, this study aimed to determine the level of awareness of lecturers on the alternative to the physical laboratory, which is the virtual laboratory, and if the virtual laboratory is utilized for practical activities.

The objectives of the study were to determine the following:

- Level of awareness among electrical engineering lecturers on the application of Virtual Laboratories in Nigerian Universities;

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- Perception of electrical engineering lecturers on the application of Virtual Laboratories in Nigerian Universities;
- Level of the utilization of Virtual Laboratories among electrical engineering lecturers in Nigerian Universities

II. Literature Review

A. The Laboratories

The laboratories offer an atmosphere for conducting experiments and executing tasks or doing practical work relevant to the area of the course of study. Laboratory experiments aid learning by enhancing concept understanding, assisting students in developing experimental skills such as experimental design, data collection, analysis, and interpretation of results, and assisting students in developing problem-solving and critical thinking abilities [4]. Mastering analytical concepts, preparing for professional practice and less-than-ideal settings, mastering the tools, and establishing collaborative capabilities are all pedagogical motivations for laboratories [5]. Lectures and demonstration methods of instruction are called "constructivist" approaches that prioritize explanation delivery, whereas "constructivist" approaches emphasize learning exercises in which learners can develop their knowledge [30]. Following the presentation of a theory or concept, the laboratory allows students to conduct tests or experiments that increase their learning and enable them to reconceptualize the idea or notion. Collaboration and discourse are essential in laboratory settings and promote learning effectiveness [31].

Laboratory experiments are designed to help students to see how things work in real life, build and follow a flow chart, get experience via practice, learn crucial components of experimental work (such as procedures and report writing), and understand the theory. Cooperation and communication with others are essential goals, as is understanding scientists' work methods and how experiments are organized and know how difficult it is to transition from theory to practice. Conclusions from laboratory experiments appear more robust than those drawn from classroom demonstrations of experiments; nonetheless, the author argues in Ref. [6] that laboratory experiment findings are sometimes challenging to transfer outside of the laboratory. Instructional laboratories have been critical in providing undergraduates with a thorough comprehension of abstract topics because they help students cope with real-life issues and gain hands-on experience [7].

B. Electrical Engineering Laboratory

Engineering is distinct because it is an objective hard science and frequently necessitates practice-based learning using physical equipment [8]. Examining engineering students requires demonstrating their ability to use the equipment to conduct experiments correctly. Engineering is a scientific discipline that relies on physical experiments [9]. As a result, laboratory sessions requiring physical work with equipment are an essential element of the curriculum for engineering students. According to the authors of [10], engineers with good design capability can tolerate ambiguity, take a macro view of the system, have the flexibility to manage uncertainty, make decisions, develop teamwork skills, and have the ability to visualize and communicate design ideas. The author states in Ref. [11] that one essential purpose of technology education is to encourage intellectual curiosity. Intellectual curiosity entails information processing, information synthesis, and concept evaluation. Electrical engineering is a practical field that works with materials, energy, and knowledge to improve humanity. Experiments in laboratories help to strengthen this practical knowledge [12].

Network theory, transformers, AC-DC circuits, and electrical power generation and utilization are all standard courses in electrical engineering [14]. Electrical engineering laboratories assist students in understanding complex structures and circuit designs through experiments that allow readings on actual systems to be compared to theoretical models. When students work in groups to learn the experiments, hands-on laboratory exercises develop their teamwork skills. It boosts student interaction and increases their interest in the subject of their studies. The requirement for laboratory practical activities in engineering that educate students on how to operate equipment in the actual world is undeniable [15]-[17].

C. The Evolution of the Electrical Engineering Laboratories

Widespread computer use and online distance learning growth have profoundly impacted laboratory instruction. Simulation, automatic access, data analysis and presentation, and the capacity to manipulate an outfit at any time have all revolutionized the laboratory paradigm [18]. Because the capabilities of computers have improved, the use of simulations has also increased [19]. Studies have emphasized the importance of building remote laboratories that can assist in performing laboratory duties from remote locations as an integrated system into the electrical engineering curriculum in universities.

According to Ref. [20], the gradual progression of technology from conventional analogue to digital systems, from macro to micro size, from wired to wireless systems, and other improvements have decreased the popularity and usage of physical laboratories compared to virtual laboratories. Newer concepts, such as smart virtual laboratories, in which students do experiments using mobile devices, may eventually shift traditional education away towards e-Learning [21][22]. Furthermore, due to financial constraints, universities must consider simulation and remote-access laboratory systems as alternatives. While universities strive to capitalize on technological improvements, some argue that students should be exposed to the real world rather than the simulated world [22]. Nevertheless, despite its recent popularity, some people still view the virtual laboratory as an addition to conventional laboratories rather than their replacement [23].

D. Deployment of Virtual Laboratory in Nigerian Universities

Understanding the advantages of laboratories is the first step in deploying a virtual laboratory. According to Ref. [25], laboratories often have educational benefits that include fostering conceptual comprehension, facilitating the acquisition of inquiry skills, promoting an interest in learning about science and improving collaborative abilities. The capabilities of troubleshooting equipment, putting up equipment for observations, and receiving tactile feedback are provided by physical laboratories. Additionally, Human-Computer Interaction (HCI) possibilities are provided by the realization that virtual laboratories facilitate access via an online and offline interface. Virtual laboratories offer greater

versatility because of their capacity to modify reality, according to the authors in Ref. [26]. The exploration of unobservable phenomena, such as in a circuit, the voltages and currents at unfounded places, the reactions of chemicals, and thermodynamics, can be done, for instance, by removing confounding information, adjusting time scales, and exploring these phenomena. According to Ref. [27], time scales can be sped up or slowed down. Programs for learning analytics can record user interactions for further processing. Equipment "failures" can be planned out or avoided. Conditions for experiments can be carefully regulated. These affordances provide the students with more control over their educational experiences.

Analyzing the necessary software and hardware infrastructure is essential for establishing a virtual laboratory [28]. The equipment must be specifically selected for a remote laboratory so that it can be managed remotely, and the reactions to stimuli must be able to be recorded. Students must use software to plan their use of the remote equipment, create the experimental inputs, and get the findings. Additionally, the user interface can produce a sufficient level of realism. To encourage innovation and unrestricted exploration, the system should permit flexibility in the definition of experiments.

Different user interface devices, including PCs or tablets, must be considered while designing virtual laboratories [29]. The creation and administration of laboratories need to be revised. For instance, multiple access levels may apply to visitors, students, and tutors. The support personnel working in virtual laboratories must actively participate in knowledge creation, student encouragement, student guidance, and recognizing and addressing their issues [30] [32]. These virtual laboratories demand highly competent programmers since even commercially available software frequently requires unique customization [31] [33]. Additionally, they must know the experiment's procedures, goals, and user requirements for the students.

It is best to use clear language and make it straightforward to grasp how an experiment will be conducted on the system [34]. The software must be user-friendly, portable across several platforms, and offer flexibility by enabling program development in segments. It should also be in line with the current code and compatible with the available hardware [35]. Options for debugging and assistance are crucial. Features that boost the system's adaptability include expandable program libraries. Particular importance is placed on multimedia elements [36]. However, in the context of learning and cognition, the interface's usability is more crucial than the simplicity of navigation [32]. The system must be flexible and adaptable, and the virtual labs must consider individual student characteristics and academic levels. Real-time assistance and support can be offered by help features [31].

A virtual laboratory should ideally feature a real-world situation from which the learner can gather data in a true-to-life setting [37]. It is since using a simulation is equivalent to testing an algorithm that aims to replicate the real world. The discoveries discovered throughout experiments can be those about the algorithm. One method enables the management of the system like a genuine lab [38]. In response, the lab provides a video of the experiment. Students can watch the film, control the equipment remotely, and collect data throughout the video. The student-generated data is gathered and presented by the software.

In contrast, the simulation uses data already given to the algorithm [39]. The system is improved by using animation techniques, films, and 3D models to benefit the students [40] [44]. The system is more appealing for the pupils with animation techniques, movies, and 3D models [42]. Some of the seven elements for designing a remote laboratory that was presented in [41] [43] [45] include adapting "(i) instructions to skill level, (ii) supporting both linear and non-linear presentation of content, (iii) limiting the number of sound-based instructions, (iv) displaying content in various forms, (v) including interactive content, (vi) limiting the amount of text-based content, and (vii) providing a helpful feedback system".

E. Comparison of Virtual Laboratory and Physical Laboratory

To facilitate learning and collaboration, virtual laboratories recreate the ambience of natural laboratories and include interactive data-gathering tools. Students' actions might be directed to assess their performance and promote their learning [46]. Physical laboratories are generally more expensive than virtual laboratories, even though the 'realism' of reality is difficult to imitate [47]. Monitoring can be more rigorous in virtual laboratories since students submit data into the system, and teachers can view recordings of their activity. Furthermore, a virtual environment provides greater versatility regarding variable modification; for example, one might mimic high-power circuits impractical in a physical lab. Virtual laboratories can assist in the execution of experiments that would be unsafe and costly to carry out using conventional procedures.

Another significant benefit of virtual laboratories, particularly simulation labs, is that user feedback is not confined to those seen in physical labs. A virtual laboratory can replicate and display factors that are impossible to physically define in a natural laboratory, such as magnetic fields, the inside of a nucleus, or changes in radioactive decay that occur over long periods. Such insights can improve learning outcomes and understanding while inspiring students to be more exploratory [48]. Virtual laboratories are more adaptable and open than physical laboratories, allowing for the production of diverse experiments using various components [49]. There is integration between the theoretical and the practical aspects, the learning is continuous, and the teaching methods can be varied. The learning is necessarily based on multimedia or similar tools [50].

Virtual laboratories require software updates, whereas physical laboratories require physical upkeep. Therefore, the infrastructure and maintenance requirements are also different [51]. It is impossible to practically include all potential scenarios in any virtual laboratory system since the simulation environment lacks the physical parts of experimentation, such as the feel and sight of substances. As a result, when applying their knowledge in real-world situations, pupils could encounter something completely different [46]. Physical laboratories typically take a long time to put up and take down [52].

When there is a lack of room or money or a problem with the equipment, virtual laboratories can be used in place of or in addition to physical laboratories [53]. Virtual laboratories provide a safer environment and are cost-effective [46]. By doing the experiments judiciously, students' energy can be directed into their areas of interest. The freedom boosts interaction and raises interest and motivation levels. The procedure takes less time than you might think [49]. Such

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laboratories are suitable for creation and testing within their constraints, assuming users can handle the level of abstraction. Multiple students can use the equipment simultaneously in virtual laboratories, making it easier for different teaching organizations to share the lab resources [51].

Ref. [54] gives the following comparison between the virtual laboratory and physical laboratory (See Table I).

TABLE I. COMPARISON BETWEEN VIRTUAL LABORATORY AND PHYSICAL LABORATORY

Parameters	Virtual Laboratory	Physical Laboratory
Number of users	A large number of users	A small number of users
Accessibility	It could be anytime and from anywhere	Within a location at the scheduled time
Usage time	Long period	Short period
Setup and Maintenance Cost	Relatively Cheaper	Expensive
Safety and Security	Very safe	Could be unsafe
Teaching Method	Student-Centered	Teacher-centered
Practical Sensation	Immersive/ Intangible	Physical/ Tangible
Practical Experience	Virtual hands-on	Real hands-on
Technology	Fully	Might not be
Support	Technology based	Technology-based
Space Confined	Open	Close
Plagiarism Risk	High	Low
User Precaution	Not safety conscious	Safety conscious
Resource Sharing	Easy	Complex
User Distraction	Higher distraction due to game-like	Minimal distraction
IT Literacy	Required	It might not be required

F. Characteristics of a Virtual Laboratory

Virtual laboratories are computerized systems that may replicate the elements and processes of actual experiments conducted in physical laboratories [74]. Based on many attributes, virtual laboratories can be divided into categories and distinguished from one another.

Multimedia interactive objects are used in varied formats in virtual laboratories. Texts, sound, hypertext, photos, videos, animations, and graphics are among these media [55]. Students or users can manipulate and interact with graphical units representing experimental objects in the virtual learning environment, which can be found on websites. Utilizing input devices, the trials are carried out online [56]. To some extent, computers, simulation, animation, and, more recently, mobile devices are used to conduct and control experiments in a virtual laboratory. Internet access is used whether the entry is local or remote. In these labs, experiments are visualized using graphical representations of the actual investigation. Through the animations, the user may see the progression and outcome.

The level of replication realism differs among different virtual laboratory models [57]. Some types and levels of virtual laboratories include software sharing, equipment sharing, and remote-control laboratories. The server shares the local simulation program in this manner. It executes client instructions and presents experiment results. The instruments used to experiment with the instrument-sharing type are given commands by users. The program aids in the analysis of the results. Little involvement or immersion is going on.

The remote-control virtual laboratory users can direct the experiment's course, but doing so needs more immediate communication between the client and the system [57]. The degree of immersion, or experience of "being there" or "sense of presence," for the laboratory's users can vary depending on how well the virtual environment can simulate reality [58]. Because consumers know they are interacting with natural objects, immersion still needs to be higher, but engagement increases.

Depending on the data utilized for testing, simulations of experiments can be classified as either "numerical simulation based, measurement data based, real-time data based, remote trigger based, remote control based, or hybrid" [59]. Virtualization based on measurement data provides a precise picture of the experiment, whereas numerical simulation is theoretical. It is predicated on the system's capacity to consider many input parameter permutations to replicate the experiment environment. Real-time data and real-world trials are employed in virtualization. The user has no control over the experiment other than the fact that they gather the data online.

Electrical simulation software is widely available. Some of them, such as Multisim, Pspice, Eagle, KeilUvision, Matlab, LabVIEW, Proteus, and AutoCAD, are crucial in electrical laboratories [61]. A simulation program is called Multisim. Excellent simulation tools like LabVIEW and Proteus allow students to build a circuit and observe how it functions and what output it produces. There are numerous versions of the design software AutoCAD. For mechanical engineering, electrical engineering, and civil engineering, there is AutoCAD. Electrical engineering students must utilize Autocad (electrical), primarily a design software for electrical engineering. Matlab, on the other hand, is a design and analysis software. According to Ref. [60], a PCB design program called Eagle is mainly programmed to design PCBs. There are numerous PCB design programs. Software called KeilMicro Vision is available. It is employed in the programming of microprocessors and microcontrollers. It is a valuable tool that easily converts the program file to a writeable hex file.

G. Virtual Laboratory Adoption a Necessity in Nigerian University

Compared to a physical laboratory, research indicates that a virtual laboratory can enhance student learning performance and attitude [62]. Students who participated in virtual laboratory exercises acquired greater understanding than they would in a physical lab [29]. According to Ref. [11], using a virtual laboratory doubles pupils' learning capacity. As a result, the virtual laboratory can help students develop the real-world experience, abilities, and confidence they need to thrive in the workplace.

Over time, higher education in Nigeria has declined, and graduates have struggled to live up to expectations in their vocations. These issues in science and engineering-related disciplines include inadequate laboratory facilities, inadequate workshop/ laboratory space, in-experience personnel, overpopulated classrooms/ workshops/ laboratory, and obsolete curriculum [63]. These criteria are based on the Federal and State government's weak support for education. Ref. [60] claims that more than government funding for federal and state-owned universities will be required because education and institutions are not Nigeria's only priority. Institutions must look for a practical and long-lasting solution to alleviate infrastructural problems in light of these financial constraints. This study suggests that some physical infrastructure, such as the physical laboratory, be transformed into a virtual laboratory in light of this. According to [61], software-based infrastructure is more dependable and less expensive than physical infrastructure.

When there are many students, teaching a relatively simple practical course could take many days so that everyone can participate. The issue could worsen if equipment breaks down from excessive use, reagent runs low, or worn-out equipment needs to be replaced. Because the virtual laboratory is not subject to the abovementioned restrictions, fixed and variable costs are decreased. According to Budai and Kuczmann (2018), the Virtual Laboratory has cheaper operating costs because it never ages or wears out. Ref. [64] asserts that converting actual experiments into virtual ones takes minimal effort, after which you can use them for as long as you like.

It offers cost savings benefits by enabling electrical Engineering students to experiment in sophisticated laboratories for a small fraction of the price [60]. It is an emerging trend for technical courses since it allows students to continuously practice or explore without risking damaging the platform.

Users don't need additional hardware to access Virtual Laboratory if it is web-based; they only need a computer with internet connectivity or a Virtual Reality (VR) headset. It is more or less open to everyone and flexible because it is unrestricted by time, location, or place. A virtual laboratory can also be set up and run for less money. It allows academic institutions to stay current with and modify laboratory needs in light of advancements in industry and technology.

Virtual technology could be employed to share specialized, scarce, and expensive tools and resources with a finite number of users due to geographic time and location. It might be a way to make unused facilities available for best use. A more comprehensive range of students can access practical skills thanks to virtual laboratories, which offer the chance to escape the physical limitations of physical laboratories [65].

One of the causes of Nigeria's low-quality graduates has been cited as outdated curricula [64] said that Nigeria's postsecondary education curriculum needed to be changed to accommodate the country's current economic development. According to [65], the primary justification for opposition to curriculum reform is the rapid rate at which different fields evolve. This study proposes that using software-assisted teaching and learning methods is one practical way to accomplish this. This study suggests that virtual platforms better meet the need for technical courses than trying to supply a variety of equipment for practical exercises, which can be expensive and difficult to adapt or upgrade as the curriculum changes.

III. METHOD

The study used a survey research design and was carried out in the northern region of Nigeria. The Zone includes the states of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe and is situated at latitude 6.260 and longitude 4.920 North East of Nigeria. One hundred twenty-one lecturers in electrical engineering from 8 universities in Nigeria comprised the study's population. Because the total population size was manageable, the study used whole-population sampling. The "Use of Virtual Laboratory in Nigerian Universities for Practicum Questionnaire (UVLNUPQ)" was a structured questionnaire that the researchers utilized to gather information. The questionnaire responses were organized on a 5-point scale with Highly Aware (HE)/ Strongly Agreed (SA)/ Always Utilized (AU) = 5 points, Aware (A) /Agreed (A)/ Often Utilized (OU) = 4 points, Moderately Aware (MA)/ Undecided (U)/ Sometimes Utilized (SU) = 3 points, Somewhat Aware (SA)/ Disagreed (D)/ Rarely Utilized (RU) = 2 Point, and Not Aware (NA)/ Strongly Disagreed (SD)/ Never Utilized = 1point. The questionnaire was subjected to face validation by three experts from the Department of Electrical Technology Education, Modibbo Adama University Yola, Adamawa State. A reliability index of 0.88 was obtained using Cronbach Alpha. The data for the study were analyzed using a mean statistic to answer the research questions. All items with a mean score of 3.5 or higher were judged "Aware/ Agreed/ often Utilized," while those with a mean score of less than 3.50 were rated "Not Aware/ Disagreed/ Rarely Utilized."

IV. RESULTS

A. *The level of awareness among electrical engineering lecturers*

Research Question 1: What is the level of awareness among electrical engineering lecturers on applying Virtual Laboratories in Nigerian Universities?

TABLE II. MEAN RESPONSE ON THE LEVEL OF AWARENESS

		N = 121		
S/NO	**Level Of Awareness**	$\bar{x}$	**SD**	**Remark**
1.	Using a virtual laboratory to test the workability of electrical circuits	4.33	0.70	HA
2.	Using a virtual laboratory to conduct investigations to answer questions during the activities in this class.	4.63	0.82	HA
3.	Using a virtual laboratory to explain the meaning of diagrams during activities in this class using virtual tools	4.04	1.23	HA
4.	use virtual components to construct electrical circuits in a virtual laboratory	4.00	0.88	HA
5.	Frequent use of the drag-and-drop user interface library by interactively customizing the hundreds of built-in user objects on the controls palette	3.21	1.32	HA
6.	Use of multiple high-level development tools**,** including the LabVIEW Statechart Module, LabVIEW Control Design and Simulation Module and LabVIEW FPGA Module	3.58	1.06	HA
7.	Utilization of professional development tools such **as** managing large, professional applications and tightly integrated project management tools; integrated graphical debugging tools; and standardized source code control integration.	3.63	0.71	HA
8.	Using a virtual laboratory for Signal and Image Processing	4.38	0.71	HA
9.	Using a virtual laboratory for Embedded System Programming	3.63	0.92	HA
10.	Using a virtual laboratory for the simulation of electrical circuits	3.54	0.98	HA
11.	Using a virtual laboratory for Prototyping	4.31	0.75	HA
12.	Using a virtual laboratory for Automatic Controls Systems	4.62	0.96	HA
13.	Using a virtual laboratory for Dynamic Systems Control	3.92	1.38	HA
14.	Using a virtual laboratory for Measurements	3.92	0.49	HA
15.	Using a virtual laboratory for Measurements and Instrumentation	3.15	1.07	HA
	Cumulative Average Mean	**3.93**		**HA**

$\bar{x}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents, HA = Highly Aware

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Table II shows the level of awareness among electrical engineering lecturers on applying Virtual Laboratories in Nigerian Universities. The respondents point out that the electrical engineering lecturers in Nigerian Universities were highly aware of the virtual laboratory. It was indicated in the respondents' mean responses showing 4.63 as the highest mean, while 3.15 was the lowest mean. The standard deviation also ranges between of which 0.49 and 1.38, respectively. The cumulative mean of 3.93 implies that all the electrical engineering lecturers in Nigerian Universities are highly aware of Virtual Laboratories.

B. Lecturers' perception of applying Virtual Laboratories

Research Question 2: What is electrical engineering lecturers' perception of applying Virtual Laboratories in Nigerian Universities?

TABLE III. MEAN RESPONSE ON THE PERCEPTION OF ELECTRICAL ENGINEERING LECTURERS

		N = 121		
S/NO	**Perception of Electrical Engineering Lecturers**	$\bar{x}$	**SD**	**Remark**
1.	I prefer Virtual Laboratory because it requires one to be very versatile in the use of a computer	4.32	0.71	Agreed
2.	I am constrained from using virtual laboratory because there is no provision for it in the curriculum	4.62	0.86	Agreed
3.	I am restrained from using virtual laboratory because the students that are to be taught are not computer literate	4.00	1.27	Agreed
4.	I am restrained from using virtual laboratories because there is poor internet connection within the universities' environment which makes it difficult for lecturers to adopt	3.97	0.76	Disagreed
5.	I am not comfortable with the use of a virtual laboratory in place of a physical laboratory	2.19	1.22	Agreed
6.	I prefer using a virtual laboratory because it provides greater versatility in terms of variable modification	3.57	1.07	Agreed
7.	I prefer using a virtual laboratory because one might mimic very high-power circuits that are not practical in a physical lab	3.62	0.72	Agreed
8.	I prefer using a virtual laboratory because feedback provided to users is not confined to those seen in physical labs	4.35	0.79	Agreed
9.	I prefer using a virtual laboratory because it can replicate and display factors that are impossible to define in a real laboratory physically	3.62	0.86	Agreed
	Cumulative Average Mean	**3.81**		**Agreed**

$\bar{x}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents

Table III shows the perception of electrical engineering lecturers on applying Virtual Laboratories in Nigerian Universities. The respondents specified that items 1-4 and 6-9 are the perceptions of electrical engineering lecturers in Nigerian Universities on the application of virtual laboratories, with the mean response having 4.62 as the highest mean, while 3.62 was the lowest. The standard deviation also ranges between of which 0.71 and 1.27, respectively. However, the respondents disagreed with item 5, with a mean response of 2.19 and a standard deviation of 1.22, respectively. The cumulative mean of 3.81 implies that all the electrical engineering lecturers in Nigerian Universities positively perceive the application of Virtual Laboratories.

C. The utilization level of Virtual Laboratories among lecturers

Research Question 3: What is the utilization level of Virtual Laboratories among electrical engineering lecturers in Nigerian Universities?

TABLE IV. MEAN RESPONSE ON THE LEVEL OF UTILIZATION

		N = 121		
S/NO	**Level of Utilization of Virtual Laboratories**	$\bar{x}$	**SD**	**Remark**
1.	Testing the workability of electrical circuits in this class.	1.97	0.18	RU
2.	Carrying out investigations to answer questions during the activities in this class.	2.01	0.24	RU
3.	Explaining the meaning of diagrams during activities in this class using virtual tools	2.02	0.42	RU
4.	Use virtual components to construct electrical circuits in a virtual laboratory	2.03	0.59	RU
5.	Frequent use of the drag-and-drop user interface library by interactively customizing the hundreds of built-in user objects on the controls palette	2.01	0.24	RU
6.	Use of Multiple high-level development tools**,** including the LabVIEW Statechart Module, LabVIEW Control Design and Simulation Module, and LabVIEW FPGA Module	2.03	0.40	RU
7.	Utilization of Professional Development Tools such **as** managing large, professional applications and tightly integrated project management tools; integrated graphical debugging tools; and standardized source code control integration.	1.97	0.18	RU
8.	Using a virtual laboratory for signal and image processing	2.05	0.58	RU
9.	Using a virtual laboratory for embedded system programming	2.07	0.55	RU
10.	Using a virtual laboratory for the simulation of electrical circuits	2.16	0.65	RU
11.	Using a virtual laboratory for prototyping	1.97	0.18	RU
12.	Using a virtual laboratory for automatic controls Systems	2.33	0.98	RU
13.	Using a virtual laboratory for dynamic systems control	2.27	0.84	RU
14.	Using a virtual laboratory for measurements	2.25	0.83	RU
15.	Using a virtual laboratory for measurements and instrumentation	2.20	0.72	RU
	Cumulative Average Mean	**2.09**		**RU**

$\bar{x}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents

Table IV shows the utilization level of Virtual Laboratories among electrical engineering lecturers in Nigerian Universities. The respondents point out that the electrical engineering lecturers in Nigerian Universities were aware of the virtual laboratory. It was indicated in the respondents' mean responses showing 2.33 as the highest mean, while 1.97 was the lowest mean below the criterion mean of 3.00. The standard deviation also ranges between of which 0.18 and 1.98, respectively. The cumulative mean of 2.09 implies that all the electrical engineering lecturers in Nigerian Universities rarely utilized Virtual Laboratories.

V. Discussion

The study's findings revealed that all the electrical engineering lecturers in Nigerian Universities are highly aware of Virtual Laboratories. This finding agrees with Ref. [66] and [67]. The authors opined that the world is gradually drifting towards digitalization, and every aspect of life is consummated in the virtual environment. Nevertheless, every individual working in the school environment, be it tertiary institutions, or secondary or primary schools, is expected to be acquainted with the possible gadgets in their vocation. Ref. [70] opined that teachers are aware of the virtual environment, which allows them to relate effectively with learning materials, tools and equipment, and the students.

On the aspect of the lecturers' perception, the study revealed that all the electrical engineering lecturers in Nigerian Universities have a positive perception of the application of Virtual Laboratories. In line with the findings, Ref. [69] asserted that due to the overwhelming benefits of Virtual Laboratories, lecturers and students have developed positive attitudes towards the practice and use of Virtual Laboratories. Ref. [68] concluded that the advent of Virtual Laboratories had introduced easiness into the practice of electrical circuit building and made it fun for both students and lecturers, thereby making the user have positive thoughts towards the Virtual Laboratories practices.

The study revealed that all the electrical engineering lecturers in Nigerian Universities rarely utilized Virtual Laboratories. This finding is in tandem with Ref. [46] and [65], who reported that the use of Virtual Laboratories is not that pronounced in developing countries as their education system is yet to make proper provisions for its integration. Ref. [32] lamented the poor utilization of Virtual Laboratories in STEM-related courses. The author suggested that with the compulsory introduction of Virtual practical activities and courses, there will be a paradigm shift in using both virtual and physical laboratories.

VI. Conclusion

The study shows that the level of awareness of the use of virtual laboratories among electrical engineering lecturers in Nigerian Universities is generally high. However, the lecturers have a positive perception of using Virtual Laboratories. However, the Virtual Laboratories' utilisation rate could be more encouraging as the lecturers rarely employed Virtual Laboratories for teaching and learning in Nigerian Universities.

VII. Recommendation

The National University Commission should use all of its resources to promote the development of electrical engineering practicum by providing virtual laboratories to all universities in Nigeria, as the study found that electrical engineering lecturers in Nigerian universities have a high level of awareness of virtual laboratories. In addition to supporting physical laboratories in the universities, the administration should provide for the training of laboratory technicians and electrical engineering lecturers in Nigerian universities on how to effectively use the virtual laboratory facilities for conducting various types of experiments. For usage in Nigerian educational systems, instructional developers, educational designers, and computer programmers should produce suitable virtual laboratory packages.

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