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Assessment of Virtual Lab Integration Capacity Improvement Need of University Teachers in Electrical/Electronic Technology Practical Class to Surpass Lockdown Barriers

Sunkanmi Afeez Yekinni [a*] and Theresa Chinyere Ogbuanya [b]

[a] *Department of Industrial Technical Education, University of Nigeria, Nsukka*
[b] *Senior research fellow, school of education Studies, Faculty of Education, University of Free State, Bloemfontein, South Africa*

Abstract

Global Outbreaks such as infections, natural disasters and societal unrest/conflict affect all aspects of human activities including education. Outbreaks, which always prompted closure of educational institutions globally purposely to flatten the epidemiological curve and avert morbidity and mortality caused by them, caused all educational activities in electrical/electronics technology related courses done at home through online mode. Thus, theory classes are conveniently conducted online. Still, educational institutions found it challenging to complete part of syllabus related to electrical/electronics technology laboratory experiments because university teachers have lesser ability in developing and implementing virtual lab technology. The study assessed virtual lab integration capacity improvement needs of University teachers during electrical/electronics technology practical class to surpass lockdown barriers. The study answered three research questions. The study adopted a descriptive research design. The study surveyed 129 research participants comprising 82 electrical/electronics technology teachers (instructors and lecturers) and 47 computer education lecturers in the three universities in south-east geo-political zone in Nigeria. The study adopted questionnaire which has three scales developed by researchers for data collection. The reliability coefficients for the three scales of the instrument were 0.76, 0.88 and 0.80. The data collected from the respondents was analysed using mean, standard deviation, weighted mean and Improvement Required Index (IRI), and Cohen'd formula. Finding of the study claimed that all 23 virtual lab capacity improvement needs item inventory are required by EET teachers in the universities. Finding claimed that all 22-item list are the perceived problems obstructing the integration of virtual lab in teaching EET courses in universities. Finally, finding upholds that all 13-item list are the perceived way forwards to the problems obstructing the integration of virtual lab in teaching EET courses in universities.

Keywords: Virtual Lab; physical laboratory; Electrical/Electronic Technology; Teacher; Capacity Improvement Needs.

Introduction

The outbreaks such as infections, natural disasters (flooding, cyclones, earthquakes, hurricanes) and societal conflict/ insurgencies do cause local and global disruptions and breakdown (Dhawan, 2020; Di Pietro, 2017). Precisely, 2009 tropical cyclone in Idai Southeastern Africa and 2018 earthquake in Papua New Guinea rendered over 1,00,000 people homeless, caused buildings and structures to collapse, and caused severe loss of life and properties (Guarner, 2020; Save the Children, 2014; Save the Children. 2017). In 2015, AlShabaab took credit for killing 148 people on college campus in Garissa, Kenya (International Crisis Group, 15 April 2020). Emergency of SARS between 2002 and 2004 responsible for 8,437 confirmed cases and 813 deaths in 29 countries (Stockman, Bellamy & Garner, 2006; Rabi, Zoubi, Kasasbeh, Salameh & Al-Nasser, 2020; WHO, 2020; Pal, Berhanu, Desalegn & Kandi, 2020; Pal, 2018; Weiss,

*Corresponding author email address: sunkanmi.yekinni.pg81780@unn.edu.ng
DOI:

& Leibowitz, 2011; Rajendran, Rajagopal, Alagumanian, et al., 2020; Rohde, 2020) while Middle East Respiratory Syndrome CoronaVirus (MERS-CoV) caused a devastating pandemic in 2012 with 37% mortality rate (Rabi, Zoubi, Kasasbeh, Salameh & Al-Nasser, 2020; Rajendran, Rajagopal, Alagumanian, et al., 2020; Rohde, 2020). The recent pandemic-SARSCoV2 (COVID-19)-data, as of 26 September 2021, recorded over 231 million confirmed cases and more than 4.7 million deaths cases globally (Anjorin, 2020; Dhawan, 2020; Lu, Zhao, Li et al., 2020; Zhou, Yang, Wang, et al., 2020; Pal, Berhanu, Desalegn, & Kandi, 2020; Guarner, 2020; Rajendran, Rajagopal, Alagumanian, et al., 2020; World Health Organization, 2021).

The outbreaks of COVID-19, natural disasters, and societal unrest/insurgencies affected all aspects of human activities such as educational and research activities globally (Di Pietro, 2017; Onyema, Eucheria, Obafemi et al., 2020; World Health Organization, February 2020). Thus, outbreaks of infectious diseases, natural disasters, and societal unrest often prompt closure of primary, secondary, and tertiary institutions locally and globally (Dhawan, 2020; Abdollahi, Haworth-Brockman, Keynan, Langley & Moghadas, 2020; Onyema, Eucheria, Obafemi, et al., 2020; Rajendran, Rajagopal, Alagumanian, et al., 2020; World Health Organization, February 2020; Viner, Russell, Croker, Packer, Ward, Stansfield, et al. 2020; International Crisis Group, 15 April 2020), sharpening the epidemiological curve and increase morbidity and mortality among human beings in the societies (Abdollahi, Haworth-Brockman, Keynan, Langley & Moghadas, 2020; Viner, Russell, Croker, Packer, Ward, Stansfield, et al., 2020; Litvinova, Liu, Kulikov & Ajelli, 2019; World Health Organization, 2020; Eze, Sefotho, Onyishi, & Eseadi, 2021). Specifically, Book haram Insurgency in northern Nigeria has led to closing down of some schools in Zamfara, Niger, Borno, Yobe and Adamawa states (Orjinmo, 2021; Ugochukwu-Ibe & Ibeke, 2021). A study which investigated 424 universities around the world reported that institutions were affected by the COVID-19 pandemic in terms of research, conferences, international mobility and education delivery (Dhawan, 2020; Coman, Tîru, an-Schmitz, Stanciu, & Bularca, 2020; Suresh, Priya & Gayathri, 2018) and causing them to either postpone or cancel all campus face-to-face academic activities (Aji, (2021; Gamage, Wijesuriya, Ekanayake, et al., 2020; Mustafa, 2020). Evidence upheld that over 1576021858 which constitute about 91.3% of all learners across the globe, were affected by the closure of educational institutions (Dhawan, 2020; Fong, Qadan, McKinney et al., 2020; Mustafa, 2020; Principi, Bosis, & Esposito, 2021; Sadique, Adams & Edmunds, 2008; Brown, Tai, Bailey, et al., 2011). In Nigeria, closing down of schools affected over 46 million students (including Electrical/Electronic Technology (EET) students) during COVID-19 (Education in Emergencies Working Group, 2020; Ugochukwu-Ibe & Ibeke, 2021).

In Nigerian educational system, universities is offering Technical vocational education and training programmes leading to the award of Bachelor of Science in Education in Technical/Technology education to students who have fulfilled the University Faculty of Education requirements in broad areas of specialization such as electrical/electronic technology, computer system maintenance, among others for the purpose of promoting the acquisition of requisite theoretical knowledge as well as practical skills among students for increased productivity and sustainability upon graduation (Kennedy, Ekong & Okorie, 2022; Owo & Deebom, 2020, Keijzer, Rijst, Schooten & Admiraal, 2021; Cattaneo, Antonietti & Rauseo, 2022). Aim and objective of every field of study, including Electrical/Electronic Technology (EET) at university level, do emphasize the importance of developing theoretical knowledge and practical skills in students (Gamage, Wijesuriya, Ekanayake et al., 2020; Yekinni, 2020). Aside from classroom training instruction, practical/laboratory training in EET is a mandatory part of the curriculum requirement for academic accreditation by many professional bodies like the Engineering Council of the United Kingdom, the Hong Kong Institution of Engineers and the National University Commission (Adeoti, 2015; Chan. & Fok, 2009; Yusuf, Oseni, & Adejoh, 2016). Practical/laboratory training will help to establish the foundation, technical competence as well as developing technical understanding of equipment and plants in EET students to enable them excel in their chosen profession after graduation (Zervas, Sergis, Sampson & Fyskilis, 2015; Yekinni, 2020). Laboratory training helps to produce skillful technologists and technicians for industries and highly competent workers who can handle and use electrical/electronic tools and equipment safely and confidently, identify possible hazards, learn to assess and control risks associated with their job, conduct research in laboratories and preparing experiment reports (Gambari, Kawu & Falode, 2018; Josephsen & Kristensen, 2006; Garcia-Luque, Ortega, Forja & Gomez-Perra, 2004; Shin, Yoon, Park & Lee, 2002).

Laboratories in the EET program are the primary facilities needed for the training and development of students' practical skills and competencies in their chosen careers (Abdulwahed & Nagy, 2009; Lucas, Spencer & Claxton, 2012; Haruna, 1996; Lampi, 2013; Umar & Ma'aji, 2010; Pangestu & Sukardi 2019; Rufai, BinMusta'amal, Bin Kamin & Bin Saud, 2013). Scholars reported that teaching the theoretical part of academic programs could be conveniently conducted online whereas educational institutions found it difficult and challenging to complete part of the syllabus related to laboratory experiments and training due to the usual closure of schools and, or low access to physical laboratories during outbreaks in the universities (Dhawan, 2020; Wijanarka, 2011; El Kharki, Berrada & Burgos, 2021; Alexiou, Bouras & Giannaka, 2005; Chen, 2020; Sobaih, Hasanein & Abu Elnasr, 2020; Murphy, 2020). Scholars remarked that university teachers were forced to plan strategies to carry out practical lessons and activities with students exclusively online (Anjorin, 2020; Coman, Tîru, an-Schmitz, Stanciu, & Bularca, 2020; Chen, 2020). Because, Dhawan (2020) claimed that online learning serves as a panacea during crisis. Scholars remarked that many universities, during outbreak such as Hurricane Katrina's landfall in August 2005, the H1N1 Influenza virus in 2009 and covid-19 among others, switched from face-to-face classroom interaction (traditional method) to a modern approach to teaching (online delivery), including shift from physical lab to virtual laboratory, learning from classroom to Zoom, from personal to virtual and from seminars to webinars (Dhawan, 2020; Gamage, Wijesuriya, Ekanayake, et al., 2020; Sobaih, Hasanein & Abu Elnasr, 2020; Murphy, 2020).

Evidences affirmed that universities in most of the advanced nations adopted the potential utilization of offsite experimentations such as web-based laboratory activities as alternative to traditional laboratory (Mishra, Gupta & Shree, 2020; Nair, et al., 2012; Radhamani, Divakar, Nair, et al., 2018). Similarly, scholars attest that virtual labs have been used to teach practical part of EET-related topics like circuit building (Gamage, Wijesuriya, Ekanayake, et al., 2020; Lampi, 2013; Gedik, Kiraz & Ozden, 2013; Ogbonna, 2020; Radhamani, Divakar, Nair et al., 2018). Because, experts claimed that virtual labs, remote control labs and video-based labs are good choices when students are not physically located on campus (Gamage, Wijesuriya, Ekanayake, et al., 2020; Gedik, Kiraz & Ozden, 2013). Thus, efforts to surpass limited access to physical labs in developing nations like Nigeria and in EET related fields of study during lockdown due to pandemics and other natural hazards rest on the adoption of virtual laboratories in the universities in Nigeria (Nwandu, Okada, Ohanu et al., 2023; Zhai, Wang & Liu, 2012).

The virtual laboratory is an alternative and complete replacement to hands-on physical laboratories (Dikke, Tsourlidaki, Zervas, et al., 2014; Yekinni, 2020; de Jong, Linn & Zacharia, 2013). Virtual laboratory has software to simulate the lab environment and vary interactive multimedia content for illustrating experimental concepts and controlling, observing, experimenting and imitating real laboratory experiences via Internet (National Science Teachers Association, 2007; Babateen, 2011; Mishra, Gupta & Shree, 2020). In virtual laboratories, students are provided with environments to interact with virtual objects and apparatus, through software interface which is connected to hardware in one centralized place (Diwakar, Achuthan, Nedungadi & Nair, 2012). Virtual laboratory proved effective when used for learning in many fields of science, technology and engineering (Baladoh, Elgamal, & Abas, 2016; Ogbonna, 2020; Shanku, Sharko, & Prifti, 2011; Xie, Tudoreanu, Shi, 2007; Ericson, 2007; Casti, 2014) because it gives remote access to students mainly during lockdown or in experiments that may be limited due to distance (Yang & Heh, 2007; Auer, Pester, Ursutiu & Samoila, 2003), allows students to work at their own pace to master the skills needed in their chosen career, gives the opportunity to correct their mistakes without loss of materials, prevents cause damages to equipment and injury to human beings (Ouyang, 2016; Zacharia, Olympiou, & Papaevripidou, 2008; Baladoh, Elgamal, & Abas, 2016), requires less setup time and provides results of lengthy investigations instantaneously, enables students conduct experiments that may not be possible to carry out in real life due to its harmful effect (Wijanarka, 2011; Dikke, Tsourlidaki, Zervas, et al. 2014; Mishra, Gupta, & Shree, 2020; Katterfeld & Sester, 2012; Dikke, Tsourlidaki, Zervas, et al., 2014), and uses to show various equipment and virtual training environment that is impossible to be used in traditional lab (Auer, Pester, Ursutiu, & Samoila, 2003). Studies confirmed that virtual lab is an essential educational tool needed to gain practical experience (Alexiou, Bouras, Giannaka, et al., 2004) because it increases students' technological, practical, and laboratory skills by improving student understanding of learning contents through the availability of sufficient and repeatable training, promotes students' motivation and engagement, and enhances student positive attitude towards science and technology related courses (Guimaraes, Maffeis, Pereire, et al., 2003; Dikke, Tsourlidaki, Zervas, et al. 2014; National Science Teachers Association, 2007; Ahmed & Hasegawa, 2019: Ahmed & Hasegawa, 2014; Chiu & Li, 2015).

Evidences, over the last several decades, presented that virtual laboratory interventions have positive impacts on student learning outcomes such as improving students' knowledge and performance in examinations (Guimaraes, Maffeis, Pereire, et al., 2003; Ahmed & Hasegawa, 2019). Also, virtual experiments can be repeated multiple times, providing students with the chances of changing the parameters of their investigation (Lindgren, Tscholl, Wang & Johnson, 2016), and help to immediately observe the effects in the visually presented results (Yasin, Nordin, Rahim, & Yunus, 2014). Similarly, virtual lab Promotes knowledge retention, self-learning and laboratory skill development among students, and it is an extension of instructional tools for teachers irrespective of geographical and socio-economic barriers in STEM-related subjects (National Research Council, 2006; Nunn, 2009; Murniza, Halimah & Azlina, 2010; Mahmoud & Zoltan, 2009; Chen, Lambert, & Guidry, 2010; Mishra, Gupta & Shree, 2020; Babateen, 2011).

Teachers are expected to integrate, prioritize and employ suitable digital technologies into the teaching and learning process in order to prepare and produce digitally literate students for job development in the twenty-first century (Bashir, Asukwo, Ibanga & Amusa, 2023; Falloon, 2020; Harrell & Bynum, 2018). Contributions made by teachers at the student level of academic achievement are significant (Prabhakaran, Chandrashekhar, Gutjahr, Raman & Nedungadi, 2018). EET teachers facilitate teaching and learning activities and processes in the physical and online classrooms and laboratories to guide EET students to acquire knowledge, skills, and attitudes that can transform them into helpful members of society (Ogbuanya & Oziegbunam, 2012; Ogbuanya & Usoro, 2009; Yekinni, 2015; Goodyear, Salmon, Spector, Steeples & Tickner, 2001; McConnell, 2002). Remote and virtual labs are educational tools that can have a significant role in supporting science and technology teachers in their daily teaching practice (de Jong, Linn & Zacharia, 2013; Zervas, Sergio, Sampson & Fyskili, 2015). Corbeil and Corbeil (2015); Kennedy, Ekong and Okorie, (2022) and UNESCO (2020), stressed that digital technological tools enable teachers to work with experts outside their areas to enhance the quality and relevance of their training provision. Thus, skillful teachers, through the support from computer specialists and school administrators are expected to design and develop virtual labs and share these with other users or build on the existing resource network (Gambari, Kawu & Falode, 2018; Tanyildizi & Orhan, 2009; Zervas, Sergis, Sampson, & Fyskilis, 2015; ElKharki, Berrada & Burgos, 2021). Alternatively, series of virtual labs are available for teachers to adopt for teaching practical lessons in EET program. Specifically, the Library of Labs (Lila), the Virtual computer integrated manufacturing Laboratory (VCIMLAB), the Virtual Laboratory for Robotics (VLR), the Virtual Electric Machine Laboratory, the Virtual Lab for Electronic Circuits (VLEC), the Virtual Engineering Sciences Learning Lab (VESLL), the Go-Lab and NASA’s virtual laboratory among others are the examples of existing web-based interactive educational platforms that help the students to improve their laboratory and practical skills and techniques during training (Mishra, Gupta & Shree, 2020; Lynch & Ghergulescu, 2017; Potkonjak, Gardner, Callaghan, et al., 2016).

However, ICT-supported teaching competency of teachers determines their level of ICT uptakes during teaching and learning interactions (Zervas, Sergis, Sampson & Fyskilis, 2015; Vanderlinde, Aesaert & Van Braak, 2014). Similarly, scholars affirmed that to ensure that virtual labs are appropriately delivered and prove their worth, virtual labs must be handled and taken by experienced, skilled, and competent teachers (Prabhakaran, Chandrashekhar, Gutjahr, Raman & Nedungadi, 2018; Nedungadi, Ramesh, Pradeep & Raman, 2018; Nedungadi & Raman, 2016). This is because evidence holds that teachers are the leading teaching resource in technology schools (Keeney-Kennicutt & Winkelmann, 2013). Without perfect, skillful and knowledgeable teachers in the school and the stability of teaching staff, the quality of teaching activities is unlikely to get deserved guarantee (Baladoh, Elgamal & Abas, 2016; Lynch & Ghergulescu, 2017; Zhang, 2009; Uwaifo & Uwaifo, 2009).

Studies revealed that the implementation of virtual reality technology in teaching and learning of technological programs like EET educational program is in its infancy, especially in Africa (Ogbonna, 2020; Radhamani, Divakar, Nair, et al., 2018; Adeoti, 2015). Evidence held that in Nigeria today, very few universities take up academic activities through digital technologies (Kennedy, Ekong & Okorie, 2022). Thus, there is a noticeable deficiency in the usage of digital technologies in classrooms due to inadequate supply of trained teachers (Prabhakaran, Chandrashekhar, Gutjahr, Raman & Nedungadi, 2018; Zhao, Pugh, Sheldon & Byers, 2002). Similarly, shred of evidence have shown that despite the increasing number of computers, internet, and other relevant ICT tools in Nigerian schools and universities, many technology education lecturers are reluctant to adopt new instructional digital technology during teaching and learning due to their lack of adequate technical skills needed to use technology in teaching effectively (Kabir, Islam & Deena, 2020; Nwandu, Okada, Ohanu et al., 2023; Zhao, Pugh, Sheldon & Byers, 2002; Ololube, 2011; Olelewe, & Okwor, 2017). Meanwhile, the National Research Council (2006) submitted that one crucial factor responsible for the weakness of current laboratory experiences is lack of adequate preparation and support for school/university science/technology teachers. The online virtual lab, through its facilities for students and teachers, requires set of new and expanded skills (Peachey, 2017). This is because improving school/college science and technology teachers’ capacity to develop laboratory experiences effectively is critical to advancing the attainment of educational goals (National Research Council, 2006). Modern teachers should be competent in the use and application of modern methods and technologies of teaching and diagnosing (Nedungadi & Raman, 2016).

Needs for effective and efficient utilizations of virtual labs during practical classes in India lead to the establishment of Nodal center program by Indian government (Radhamani, Divakar, Nair, et al., 2018). The establishment of Nodal center program speeds up the adoption and implementation of virtual labs, as curriculum material, by various educational institutions in India (Radhamani, Divakar, Nair, et al., 2018). Thus, periodical trainings were scheduled and provided to university lecturers via online and, or onsite workshops on virtual lab design and implementation (Radhamani, Divakar, Nair et al., 2018). However, none of these steps have been reported or recorded in Nigeria. Evidences upheld that teachers in Nigerian universities have been organizing and delivering theoretical classes using online platforms. Meanwhile, the level at which practical classes is been organized via online platforms is shallow, which may imply lack of adequate skills in design, development and usage of virtual lab for EET practical class. To ensure adequate and efficient use of the virtual lab for the purpose of teaching and learning in Nigerian universities, it is necessary to establish the competencies required by teachers in transforming EET program in the 21st-century in tertiary institutions (Bashir, Asukwo, Ibanga & Amusa, 2023). Reflection through literature reviewed, it is noticed that limited studies exist on identification of virtual lab training skills required by university lecturers for practical lesson delivery. However, this study will identify the necessary skills needed to train lecturers on virtual lab development and implementation for practical lessons delivery during lockdown in universities. This is the contribution of this study. This study assessed virtual lab integration capacity improvement needs of university teachers during EET practical class to surpass lockdown berries. The study answered the following research questions:

1. What are the virtual lab integration capacity need gaps of University teachers during EET practical class?
2. What are the perceived problems obstructing the effective integration of virtual lab in teaching EET courses in universities?
3. What are the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching EET courses in universities?

Method and Materials

A descriptive survey research design was adopted for this study. A descriptive survey design is a type of design in which data is collected purposely to describe a given situation (Nworgu, 2015). descriptive survey design is therefore suitable for this study since it is used to obtain data directly from the electrical/electronic and computer science lecturers through the use of a questionnaire. Thus, this study was conducted in south-east geo-political zone universities, Nigeria. One hundred and twenty-nine (129) research participants, comprising 82 EET teachers (lecturers and laboratory instructors) and 47 computer science teachers in the universities, were sampled for this study from three universities in the geopolitical south-east zone. The structured questionnaire, comprising four sections: A-D, was used as instrument for data collection. Section A requested the demographic profile (gender, age, qualification, experience and area of specialization) of research participants. Section B of the instrument is a scale requested for the virtual lab skill possessed/required by university teachers during EET practical class from research participants. The scale has 23 items rated on 5-point response scale ranging from 5- very highly possessed/required to 1- not possessed/required. Section C of the questionnaire is a scale, which has 22 items, requested for the research participants' perceived problems obstructing the integration of virtual labs in teaching of EET courses in the universities. Finally, section D of the questionnaire, which has 13 items, requested for research participants' perceived way forwards to the problems obstructing the integration of virtual labs in teaching EET courses in universities. Sections C and D were measured using five-point rating scales ranging between 5- strongly agree and 1-strongly disagree. Before the administration of the questionnaire, the questionnaire wss subjected to three (3) experts' judgement in computer education departments in two universities for instruments' validation. Comments from experts/validators were used to update the instrument accordingly. Afterward, the instrument's reliability was ascertained via trial testing of the instrument on 25 EET lecturers in two polytechnics in south east zone, Nigeria. The Cronbach alpha reliability coefficients for the three scales (section B, C and D) of the questionnaire were: 0.76, 0.88 and 0.80 respectively. Thus, 129 copies of instruments were administered to research participants through face-to-face mode. The data collected from the respondents were analyzed. Thus, Weighted Mean and Improvement Required Index (IRI) was used to answer the research questions 1. Meanwhile, Mean, Standard Deviation and Effect Size (Cohen'd) formula was adopted to answer research question 2 and 3. Similarly, t-test and one-way ANOVA were used to test mean differences in the participant's opinions. The Improvement Required Index (IRI) was used to determine the required virtual lab integration capacity gap of university teachers on section B of the instrument using the following steps:

a.) The weighted mean (Xr) of the required response option for each item is calculated.

b.) The weighted mean (Xp) of the possessed response option for each item is calculated.

c.) The required gap (Rg) is determined by calculating the differences between the values of Xr and XP for each item. Thus, Rg= Xr- Xp (Ogbuanya & Yekinni, 2018; Asogwa, 2016; Eze & Asogwa, 2013; Lawal, Onipede, Oketoobo & Famiwole, 2014; Tsojon, 2016; Eze & Adeyemi, 2012). However, where Rg is zero (0), it means improvement was not required, where Rg is positive (+) it means skill was required and where Rg is negative (-) it means skill was not needed. A cut-off point of 3.00 was used as benchmark for decision making for section C and D of the instrument. Questionnaire item with a mean value of 3.00 and above is considered as agree while any item with mean value less than 3.00 is considered as disagree for section C and D of the instrument. Differences in the mean responses of research participants was ascertained using effect size (Cohen d) formula.

Cohen's d = $\frac{M1-M2}{SD_{pooled}}$ meanwhile, SDpooled = $\sqrt{\frac{SD_1^2+SD_2^2}{2}}$. M= Mean, SD= Standard deviation. Cohen estimated that the effect size values of .20 are small (low), .50 are medium (moderate), and .80 are large (high) (Cohen, 1988; Crank, 2008; Pallant, 2007).

Presentation of result

Table 1. Demographic profile of the study participants

Demographic profiles		Frequency	Percent	Perceived problems			perceived way forwards		
				Mean (SD)	t/F	p	Mean (SD)	t/F	p
Age	18-30	22	17.1	1.88 (.40)	1.915	.112	3.09 (.62)	**17.840**	**.000**
	31-40	52	40.3	3.58 (.66)			2.96 (.68)		
	41-50	25	19.4	3.88 (.46)			3.68 (.86)		
	51-60	19	14.7	3.79 (.41)			4.13 (.28)		
	61≥	11	8.5	3.75 (.58)			4.08 (.21		
Gender	Male	91	70.5	3.75 (.59)	.458	.648	3.31 (.85)	**-2.220**	**.029**
	Female	38	29.5	3.70 (.47)			3.60 (.59)		
Qualification	B.Sc/B.Ed	23	17.8	3.78 (.47)	.085	.918	3.39 (.80)	.325	.723
	Master	62	48.1	3.73 (.59)			3.34 (.79)		
	Ph.D	44	34.1	3.73 (.55)			3.47 (.80)		
Experience	1-10	79	61.2	3.79 (.54)	2.143	.098	3.54 (.60)	**3.668**	**.014**
	11-20	20	15.5	3.84 (.45)			3.34 (.67)		
	21-30	24	18.6	3.56 (.66)			2.96 (1.19)		
	31-40	6	4.7	3.39 (.35)			3.28 (.92)		
Area of specialization	EET Teachers (lecturers and laboratory instructors)	82	63.6	3.66 (.61)	**-2.235**	**.027**	3.03 (,69)	**-9.493**	**.000**
	Computer science lecturers	47	36.4	3.86 (.41)			4.03 (.51)		

Concerning Table 1 above, 129 university teachers formed research participants for this study. 91 (70.5%) of the participants were male while 38 (29.5%) of the participants were female. 82 (63.6%) of the participants were EET university teachers (lecturers and laboratory instructors) and 47 (36.4%) of the participants were computer science teachers. 23 (17.8%) of the participants were bachelor degree holders, 62 (48.1%) of the participants were master degree holders while 44 (34.1%) of the participants were Ph.D holders. Also, participants with 18-30 years of age were 22 (17.1%) in number, participants with 31-40 years of age were 52 (40.3%), participants with 41-50 years of age were 25 (19.4%), participants with 51-60 years of age were 19 (14.7%), and participants with 61 and above years of age were 11 (8.5%). Finally, participants with 1-10 years of experience were 79 (61.2%), participants with 11-20 years of experience were 20 (15.5%), participants with 21-30 years of experience were 24 (18.6%), and participants with 31-40 years of experience were 6 (4.7%).

Concerning the demographic profile of the research respondents, factors such as gender (t=-.458, p=.648), age (F=1.915, P=.112), qualifications (F=.085, p=.918), and experience (F=2.143, p=.098) had no significant influence on the opinion of respondents on the perceived problems obstructing the effective integration of virtual lab in teaching of EET courses in universities. Meanwhile, area of specialization (t= -2.235, p=.027) had a significant influence on the opinion of respondents on the perceived problems obstructing the effective integration of virtual lab in teaching of EET courses in universities. Correspondingly, gender (t= -2.220, p=.029), age (F=17.840, P=.000), experience (F=3.668, p=.014), and area of specialization (t= -9.493, p=.000), had a significant influence on the opinion of respondents on the perceived way forwards for the problems obstructing the effective integration of virtual lab in the teaching of EET courses in universities. However, qualifications (F=.325, p=.723), had no significant influence on respondent's opinion on the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching of EET courses in universities.

Research question 1: What are the virtual lab integration capacity need gaps of University teachers during EET *practical class?*

Table 2. Need Gap Analysis of the mean scores of skills required and possessed by EET university teachers on effective the integration of virtual lab during practical class.

S/N	virtual lab capacity improvement needs of University teachers during Electrical/Electronic Technology practical class	XP	Xr	Rg	Rmk.
1	Ability to identify and apply suitable tools and mobile applications such as management software, smart boards, audio and visual media for virtual lab teaching and learning	2.10	4.12	2.20	TN
2	Ability to provide good administration of the virtual lab tools and equipment.	1.98	3.68	1.70	TN
3	Ability to include and use interactive content and other tools needed in designing virtual lab.	2.44	3.72	1.28	TN
4	Ability to carry out debugging on existing or new virtual lab	1.96	3.96	2.00	TN
5	Ability to modify created Inquiry Learning Space (ILS) by adding sub-spaces, tools (out of Repository), and resources and delete the needless tools and content in the virtual lab platform Portal.	1.59	4.11	2.52	TN
6	Ability to install virtual lab on a LAMP (Linux-Apache-MySQL-PHP) server	1.87	3.79	1.92	TN
7	Ability to test virtual lab in the real environment	1.72	4.15	2.43	TN
8	Ability to use a group of ready-made virtual lab templates while designing	1.93	4.19	2.26	TN
9	Ability to produce a simulation for virtual experimentation using Adobe-Photoshop, Adobe Animate CC etc.	1.65	3.28	1.63	TN
10	Ability to conduct Feedback assessments for analyzing the impact of virtual lab activities on education system among students.	1.74	4.06	2.32	TN
11	Ability to organize content of instruction and modules in a sequential order on virtual labs.	1.76	4.15	2.39	TN
12	Ability to conduct an online evaluations of what students learnt through a virtual lab platform.	1.89	4.21	2.32	TN
13	Ability to establish a domain name for a virtual lab.	2.10	3.57	1.47	TN
14	Ability to use UML, CakePHP framework, PHP, CSS, JavaScript, and MySQL database applications for a virtual lab development.	1.98	3.45	1.47	TN
15	Ability to use the internet to search, find, retrieve, and select appropriate online virtual labs and additional tools suitable for a subject domain, educational objectives, students' age, grade level, and teaching approach	2.24	3.55	1.31	TN

Table 2. Need Gap Analysis of the mean scores of skills required and possessed by EET university teachers on effective the integration of virtual lab during practical class. *(Continued)*

16	Ability to use communication tools (like e-mail, communities and chats) to contact, and request virtual lab from other experts or virtual lab designers.	1.96	3.85	1.89	TN
17	Ability to use virtual lab Repository to find appropriate and adapted virtual lab and other learning applications and contents.	1.59	4.26	2.67	TN
18	Ability to assemble online labs, applications, and resources in an Inquiry Learning Space (ILS) and structure this space according to the phases of the inquiry learning process in any virtual Lab portal	1.87	4.36	2.49	TN
19	Ability to share created ILS with students through URL.	1.72	4.13	2.41	TN
20	Ability to provide worksheets and online guidance for students during virtual lab classes.	1.93	4.21	2.28	TN
21	Ability to help students to install appropriate software of virtual experimentation on their computers.	1.68	3.81	2.13	TN
22	Ability to develop and execute an algorithm needed for writing virtual lab program	1.74	4.11	2.37	TN
23	Ability to design a model representative of a real virtual lab that contains all variables concepts and their relations that can be used for predicting system behavior	2.56	4.34	1.78	TN

TN = Training skill needed, (XP)= Skill possessed, (Xr)=Skill required, Rg= Xr + XP= Skill needed gap, Rmk. = Remark

Data in Table 2 indicated that the need gap values of the 23 virtual lab capacity integration need gap items inventory ranged between 1.28 and 2.67. It implied that EET university teachers need training in all the twenty-three virtual lab ability areas to improve their capacity in design and implementation of virtual labs in EET practical classes.

Finding of a study by Kabir, Islam and Deena (2020) supports the present study wherein revealed that most instructors in higher education are not trained and hence do not have the required skills to use available technologies in teaching. Results of a study conducted by Alneyadi (2019) agreed with the present study, wherein reported that more than half of the science teachers reported that they did not use VLs at all (51%) and that most teachers agreed that they have not receive trainings on how to integrate VL software into lessons, or even that they were not provided with them. Similarly, shred of evidence affirmed that adopting e-learning during lockdown demands upskilling the users within a short time (Ali, 2020; Anu, 2020).

Research question 2: What are the perceived problems obstructing the effective integration of virtual labs in teaching EET courses in universities?

The results shown in Table 3 indicate that the grand mean of the perceived problems obstructing the effective integration of virtual lab in the teaching EET practical courses in universities was 3.66±1.19 and 3.86±0.92, respectively. The mean scores exceeded the cut-off point of 3.00. It implied that all the twenty-two-item inventory are the perceived problems obstructing the effective integration of virtual labs in teaching EET courses in universities. Additionally, the effect size (strength of differences) between the opinions of EET teachers and computer science teachers on the perceived problems obstructing the effective integration of virtual labs in the teaching EET courses in universities was (0.19). It indicated that effect size was small (low).

Afgan et al. (2015) reported that some obstacles evolved when using Virtual Science Labs (VLS) in schools. A study conducted by Ebohon, Obienu, Irabor et al. (2021) agreed with this study wherein claimed that problems of online teaching according to teachers were the limited interactions between teacher and student, and between student and students which negatively affected student satisfaction significantly. Nwandu, Okada, Ohanu etal. (2023) found that technical supports for adopting Technology-enhanced learning are not put in place by TVET institutions. Teachers around the country are finding it challenging to engage in digital teaching and learning due to a lack of training, or capacity, dependable technology, internet connectivity, or both (Bashir, Asukwo, Ibanga & Amusa, 2023). Similarly, scholars reported that teachers need to be trained on how to apply the VSL in practical courses (Ayesh, 2004). Many teachers refuse to use VSL but prefer traditional methods (Radhamani, Divakar, Nair, et al., 2018), while some schools cannot afford the computers and other technology.

What are the perceived way forward for the problems obstructing the effective integration of virtual labs in teaching EET courses in universities?

Table 3. Descriptive analysis of perceived problems obstructing the effective integration of virtual labs in teaching EET courses in universities

		Total (N=129)		EET Teachers (n=82)		Computer Scientists (n=47)		
S/N	**Perceived problems obstructing the integration of virtual lab in teaching of EET courses in universities**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Effect size**
1	Devices/technologies needed for virtual lab teaching and learning exercises are expensive and difficult to afford.	3.85	1.08	3.73	1.23	4.06	.70	.33
2	Difficulties in dividing students to sub-groups for group tasks and activities during web-based classes.	4.02	.97	3.95	1.14	4.15	.55	.22
3	Poor or unstable internet connections needed for virtual lab classes.	3.88	1.07	3.70	1.15	4.21	.81	.51
4	Limited knowledge and technical skills to develop and conduct virtual lab classes.	3.56	1.15	3.55	1.20	3.57	1.08	.56
5	Insufficient technical support from computer specialists to assist teachers in developing and conducting virtual lab	3.46	1.29	3.46	1.36	3.45	1.16	.01
6	The need for computers with special standards/specifications such as big storage capacity and highly rated processor.	3.60	1.26	3.62	1.12	3.55	1.49	.05
7	Staff resistance and negative attitudes toward transition to web-based practical class	3.70	1.21	3.61	1.21	3.85	1.20	.20
8	Need to organize training for students on manipulation of virtual lab objects, materials, and instruments before real virtual class	3.67	1.16	3.90	1.08	3.28	1.19	.55
9	Epileptic power supply affects the application of virtual lab devices and equipment possessed by teachers and students.	3.97	1.00	3.74	1.12	4.36	.57	.70
10	Lack of incentives/non-repayment of teachers' self-funding internet services used during web-based practical class	3.85	1.05	3.68	1.22	4.13	.58	.47
11	Poor/limited physical interaction between teacher and students during web-based practical class.	3.76	1.22	3.50	1.43	4.21	.51	.66
12	Difficulties in providing online guidance and help for students during virtual lab class	3.39	1.13	3.15	1.23	3.81	.80	.64
13	Lack of appropriate methods available for teachers to implement curriculum featuring virtual lab.	3.23	1.06	3.04	1.00	3.57	1.08	.51
14	Difficulties in motivating students during web-based practical class	3.60	1.20	3.68	1.22	3.45	1.16	.19
15	Lack of students' progress monitoring strategies during virtual practical class	3.78	1.34	3.90	1.24	3.55	1.49	.26
16	Imbalances in digital skills possessed between students from urban and rural areas to handle virtual practical classes.	3.91	1.20	3.94	1.20	3.85	1.20	1.97
17	Imbalances in the access to digital devices between students from urban and rural area to handle virtual practical class.	3.77	1.16	4.05	1.04	3.28	1.19	.69
18	Lack of suitable and conducive environment at home to participate in online practical classes (e.g., distractions from other family members)	3.93	1.06	3.68	1.20	4.36	.57	.72
19	Insufficient trainings are provided to teachers for the development and implementation of virtual laboratories.	3.79	1.09	3.60	1.26	4.13	.58	.54
20	Absence of real workshop/laboratory feelings	3.95	1.12	3.79	1.33	4.21	.51	.42
21	Procrastination by university teachers to organize online classes/lessons	3.67	1.14	3.59	1.30	3.81	.80	.20
22	Most virtual labs cannot provide feedback to students	3.85	.93	3.68	.87	4.15	.96	.51
	Grand mean	**3.74**	**1.13**	**3.66**	**1.19**	**3.86**	**.92**	**.19**

Note: SD=Standard Deviation, effect size values of .20 are small (low), .50 are medium (moderate), and .80 and above are large

Table 4. Descriptive analysis of the perceived way forward for the problems obstructing the effective integration of virtual labs in teaching EET courses in universities

S/N	The perceived way forward for the problems obstructing the integration of virtual lab in teaching EET courses in universities.	Total (N=129)		EET Teachers (N=82)		Computer Scientists (n=47)		Effect size
		Mean	SD	Mean	SD	Mean	SD	
1	Governments should support virtual lab usage in universities through formulation of enabling policies, funding of teachers' virtual lab training, and provision of virtual lab facilities.	3.46	.98	3.02	.86	4.21	.69	1.53
2	Non-governmental bodies and philanthropists should provide grants for schools and students to purchase supportive devices and technologies needed for virtual lab lessons.	3.40	.98	3.04	.87	4.02	.85	1.14
3	Improvement of internet bandwidth throughout the country.	3.68	.96	3.35	.84	4.26	.90	1.05
4	Regular trainings should be provided for University teachers on computer applications, program, and software development needed to design virtual lab	3.19	1.14	2.78	1.08	3.89	.89	1.12
5	Computer specialists (skilled programmers and graphic designers) who can offer meaningful support for teachers in designing and preparing virtual classes should be employed.	3.83	.97	3.46	.89	4.47	.75	1.23
6	Arrangements for the upgrading of computers to meet up with special standards needed for virtual lab lessons should be organized for students.	3.29	1.06	2.84	.82	4.099	.97	1.40
7	Online group chart to discuss basic virtual lab content and tasks should be established.	3.42	1.08	3.05	1.04	4.06	.82	1.08
8	Provision of training for students to gain basic knowledge needed for the manipulation of virtual objects, materials, and instruments during virtual laboratory class	3.29	.99	2.89	.90	3.98	.74	1.32
9	Affordable alternative ways to be used for powering virtual lab devices and equipment should be available for students and schools.	3.00	1.29	2.88	1.20	3.21	1.43	0.25
10	Instructions, and virtual lab task and activity guides should often precede virtual lab classes.	3.54	1.15	3.07	1.00	4.36	.90	1.36
11	Teachers should be regularly trained on appropriate strategies or methods to be used while developing virtual lab class instructions.	3.53	1.21	3.32	1.25	3.91	1.06	.51
12	Students should be encouraged by teachers and parents to access their online virtual lab classes in a less-distracted and noisy area and a conducive environment.	3.42	.97	3.06	.79	4.04	.93	1.14
13	Provision of feedback mechanism or help menu for easy use of virtual lab.	3.04	1.12	2.56	.89	3.87	.99	1.39
	Grand mean	**3.39**	**1.07**	**3.02**	**.96**	**4.03**	**.92**	**1.07**

Note: SD=Standard, effect size values of .20 are small (low), .50 are medium (moderate) and .80 and above are large /

The results in Table 4 showed that the grand mean of the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching EET courses in universities was 3.02±.96 and 4.03±0.92, respectively. The mean scores exceeded the cut-off point of 3.00. It implied that all the thirteen-item inventories are the perceived way forwards for the problems obstructing the effective integration of virtual labs in teaching EET courses in universities. Additionally, the effect size (strength of differences) between the opinions of EET teachers and computer science teachers on the perceived way forwards for the problems obstructing the integration of virtual labs in teaching EET courses in universities was (1.07) indicating that effect size was large.

Findings from past studies revealed that students need adequate access to new technologies to increase their flexibility in learning (Bates, 2000; Asogwa, 2016). Kiula, Waiganjo and Kihoro (2017); Nwandu, Okada, Ohanu etal. (2023) found that teachers should be trained to use the available technologies and provided with technical supports that would encourage them to adopt up-to-date technologies while teaching. Scholars also submitted that the first perquisite, before materials and strategies for teaching via distance learning, is to ensure that learners have the infrastructure that can enable them gain access to the instructional content, via the internet (Gamage, Wijesuriya, Ekanayake, et al., 2020).

Conclusion

This study investigated virtual lab integration capacity improvement needs of university teachers during EET practical classes to surpass lockdown barriers. This study showed that university teachers need training in all the twenty-three virtual lab ability areas to improve their capacity in the designing and effectively implementing virtual labs lessons in EET practical classes. This study established that teachers in the university have not been trained to integrate virtual labs in the teaching of practical lessons. Similarly, finding of the study established that some problems - insufficient technical support from computer specialists to assist teachers develop and conduct virtual lab classes, unstable power supply, and unstable internet connections needed for virtual lab classes among others - are obstructing the effective integration of virtual lab in teaching EET courses in universities. The study affirmed that to maintain the effective integration of virtual lab in teaching of EET courses in universities, there should be an improvement on internet bandwidth throughout the country, and regular trainings should be provided for University teachers on computer applications, program, and software development needed to design virtual lab

Limitations of the study

The study was centred on single field of study 'electrical/electronics technology'. This may render the findings of this study not to be generalized across other fields of study. Similarly, data were collected through a self-reported questionnaire. The tendency of respondents to present forceful information may not be doubtful. Thus, the future studies in this area should combine numerous fields of study in technology. Also, longitudinal and evidence-based studies should be conducted in future.

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Data Materials Availability: All data associated with this study will be available based on the reasonable request to corresponding author.

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