Innovations

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

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Abstract

The global Outbreaks such as infections, natural disasters and societal unrest/conflict are affecting all aspects of human activities including education. Outbreaks, which always prompted closure of educational institutions globally and specifically caused all educational activities in electrical/electronics technology related courses done at home through online mode. Thus, theory classes were conveniently conducted online, but educational institutions found it difficult and 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 need of University teachers during electrical/electronics technology practical class to surpass lockdown barriers. The study answered three research questions. The study adopted descriptive research design. The study surveyed 129 research participants which included 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, as instrument for data collection. The reliability coefficient for the three scales of the instrument were 0.76, 0.88 and 0.80. The data collected from the respondents were analyzed using mean, standard deviation, weighted mean and Improvement Required Index (IRI) and Cohen' d formula. Finding of the study claimed that all the 23 virtual lab capacity improvement needs item inventory are required by EET teachers in the universities. Finding claimed that all 22-item inventory are the perceived problems obstructing the integration of virtual lab in teaching of EET courses in universities. Finally, finding claimed that all 13-item inventory are the perceived way forwards for the problems obstructing the integration of virtual lab in teaching of EET courses in universities.

Introduction

The outbreaks such as infections, natural disasters (flooding, cyclones, earthquakes, hurricanes) and societal conflict/ insurgencies cause local and global disruptions and breakdown (Dhawan, 2020; Di Pietro, 2017).

Specifically, 2009 tropical cyclone in Idai Southeastern Africa and 2018 earthquake in Papua New Guinea rendered 1,00,000 people homeless, caused buildings and structures to collapse, and there was severe loss of life and properties (Guarner, 2020; Save the Children, 2014; Save the Children. 2017). In 2015, AlShabaab took credit of 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, & 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 outbreak of COVID-19, natural disasters, and societal unrest/insurgencies affected all aspects of human activities including 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, existence of Book haram Insurgency in northern Nigeria has led to shutting down of 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 1,576, 021, 858, which constitute about 91.3% of all the 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, closure of schools affected over 46 million students during COVID-19 (Education in Emergencies Working Group, 2020; Ugochukwu-Ibe & Ibeke, 2021) including electrical/electronic technology (EET) students.

Aims and objectives 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 curriculum requirement for academic accreditation by many professional bodies like Engineering Council of the United Kingdom, Hong Kong Institution of Engineers and National University Commission (Adeoti, 2015; Chan. & Fok, 2009; Yusuf, Oseni, & Adejoh, 2016). This 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 EET programme are the primary facilities needed for the training and development of students' practical skill and competency of their chosen career (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). Meanwhile, scholars reported that teaching of knowledge and theory could be conveniently conducted online, but educational institutions found it difficult and challenging to complete part of syllabus related to laboratory experiments and training due to the usual closure of schools including universities and low access to physical laboratories during outbreaks (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 device strategies to carrying out practical lesson and activity with students exclusively online (Anjorin, 2020; Coman, Tîru, an-Schmitz, Stanciu, & Bularca, 2020; Chen, 2020). This is because Dhawan (2020) claimed that online learning serves as a panacea in the time of crisis. Scholars remarked that many universities, during outbreak such as Hurricane Katrina's landfall in August 2005, H1N1 Influenza virus in 2009, covid-19 among others, switched from face-to-face classes (traditional method) to modern approach of teaching (online delivery) including sift 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 advanced nations have 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, it was found 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, virtual labs, remote control labs or 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 lab in developing nations like Nigeria and in EET related field of study during lockdown due to pandemics and other natural hazards rest on the adoption of virtual laboratory in the universities in Nigeria (Nwandu, Okada, Ohanu etal., 2023; Zhai, Wang & Liu, 2012).

The virtual laboratory is an alternatives 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 control, observing, experimenting and imitating real laboratory experiences through Internet (National Science Teachers Association, 2007; Babateen, 2011; Mishra, Gupta & Shree, 2020). In virtual laboratory, students are provided with environment to interact with virtual objects and apparatus, through software interface which is connected to a 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 especially 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), require less setup time and provide results of lengthy investigations instantaneously, enable 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 use 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 important 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, promote students' motivation and engagement, and improve 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).

Evidence 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). Virtual experiments can also be repeated multiple times, providing students with the chances of changing the parameters of their experiment (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).

Contributions made by teachers in 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 for the purpose of guiding EET students to acquire knowledge, skills and attitude that can transform them into useful member of a society (Ogbuanya & Oziegbunam, 2012; Ogbuanya & Usoro, 2009; Yekinni, 2015; Goodyear, Salmon, Spector, Steeples & Tickner, 2001; McConnell, 2002). Remote and virtual labs are educational tools which 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). Thus, skillful teachers, through the supports from computer specialists and school administrator 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, number of virtual labs are available for teachers to adopt for teaching practical lessons in EET program. Specifically, Library of Labs (Lila), Virtual computer integrated manufacturing Laboratory (VCIMLAB), The Virtual Laboratory for Robotics (VLR), Virtual Electric Machine Laboratory, Virtual Lab for Electronic Circuits (VLEC), Virtual Engineering Sciences Learning Lab (VESLL), 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 competences of teachers determine their level of ICT uptake 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 delivered properly 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 teachers are the leading teaching resource in technology schools (Keeney-Kennicutt & Winkelmann, 2013), and without perfect, skillful and knowledgeable teachers in the school and without 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). 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, evidences shown that despite the increasing number of computers, internets and other relevant ICT tools in Nigerian schools and universities, many technology education lecturers are reluctant in adopting new instructional digital technology during teaching and learning due to their lack of adequate technical skills needed to effectively use technology in teaching (Kabir, Islam & Deena, 2020; Nwandu, Okada, Ohanu etal., 2023; Zhao, Pugh, Sheldon & Byers, 2002; Ololube, 2011; Olelewe, & Okwor, 2017). Meanwhile, National Research Council (2006) submitted that one important factor responsible for the weakness of current laboratory experiences is a lack of preparation and ongoing support for school/university science/technology teachers. The online virtual lab, through its facilities for students and teachers, requires sets of new and expanded skills (Peachey, 2017). This is because improving school/college science and technology teachers' capacity to lead laboratory experiences effectively is critical to advancing the educational goals of these experiences (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 lab during practical class in India leads to the establishment of Nodal center program by Republic of India government (Radhamani, Divakar, Nair, et al., 2018).This speed up the adoption and implementation of virtual labs as curriculum material by various educational institutions (Radhamani, Divakar, Nair, et al., 2018). Thus, periodical training was given 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 online but the level at which practical classes is organized is very low which may be interpreted to as lack of adequate skills in design, development and usage of virtual lab for EET practical class. Resultantly, 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.

Method and Materials

Descriptive survey research design was adopted for this study. A survey design is a type of design in which data is collected so as to use such data to describe a given situation (Nworgu, 2015). It provides data that was used to answer pre-indefinite information needs. Survey design was therefore suitable for this study since it was used to obtain data directly from the electrical/electronic and computer science lecturers through the use of questionnaire. Thus, this study was conducted in south-east geo-political zone universities, Nigeria. 129 research participants that comprised of 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 zone. The structured questionnaire which has four sections: A-D was used as instrument for data collection. Section A requested for 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 that was measured using 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 lab 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 for the problems obstructing the integration of virtual lab in teaching of EET courses in universities. Section C and D were measured using five-point rating scales ranging between 5- strongly agree and 1-strongly disagree. Before administration of the questionnaire, the questionnaire was subjected to three (3) experts' judgement in computer education departments in two universities for validation. The comments from experts/validators were used to update the instrument accordingly. Afterward, the reliability of the instrument was ascertained via trial testing 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 participants opinions. The Improvement Required Index (IRI) was used to determine the require virtual lab integration capacity need 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 require 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 required. A cut-off points 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).

With reference to Table 1 above, 129 university teachers formed research participants for this study.91of the participants were male participants and 38 were female participants, 82 participants were EET university teachers (lecturers and laboratory instructors) and 47 participants were computer science teachers. 23 of the participants were bachelor degree holders, 62 participants were master degree holders while 44 participants were PhD holders. Also, participants with 18-30 years of age were 22 in number, participants with 31-40 years of age were 52, participants with 41-50 years of age were 25, participants with 51-60 years of age were 19, and participants with 61 and above years of age were 11. Finally, participants with 1-10 years of experience were 82, participants with 11-22 years of experience were 27, participants with 21-30 years of experience were 16 and participants with 31-40 years of experience were 4.

With respect to demographic profile of the research respondents, factor 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 effect 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 significant effect on the opinion of respondents on the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching of EET courses in universities. However, qualifications (F=.325, p=.723), had no significant effect on the opinion of respondents on the perceived way

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 contents 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 additional 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 group of ready-made virtual lab templates while design	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-based education system among the students.	1.74	4.06	2.32	TN
11	Ability to organize content of instruction and modules in a sequential order.	1.76	4.15	2.39	TN
12	Ability to conduct online evaluations on students learning through virtual lab platform.	1.89	4.21	2.32	TN
13	Ability to establish a domain name for virtual lab.	2.10	3.57	1.47	TN
14	Ability to use UML, CakePHP framework, PHP, CSS, JavaScript, and MySQL database applications for virtual lab development.	1.98	3.45	1.47	TN
15	Ability to use internet to search, find, retrieve and select appropriate online virtual labs and additional tools suitable for subject domain, educational objectives, students' age, grade level, and teaching approach	2.24	3.55	1.31	TN
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 application 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 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 teacher guidance for students during virtual lab class.	1.93	4.21	2.28	TN
21	Ability to help students install appropriate software for virtual experimentation on their computer.	1.68	3.81	2.13	TN
22	Ability to develop and executing an algorithm needed for writing virtual lab program	1.74	4.11	2.37	TN
23	Ability to design model representative of real virtual lab that contain all variables concepts and their relations that can be used for predicting system behaviour	2.56	4.34	1.78	TN

Please, make sure that TN are in the same line with the computed values

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 to +2.67. This implied that EET university teachers need training in all the twenty-three virtual lab ability area to improve their capacity in the design and implementation of virtual lab in EET practical class. Study by Kabir, Islam and Deena (2020), supports this wherein revealed that most instructors in the higher education are not trained and hence do not have the required skills to use available technologies in teaching. Results of study conducted by Alneyadi (2019) agreed with the present study where in 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 been trained to integrate VL software into lessons, or even that they were not provided with them. Similarly, evidences 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 lab in teaching of EET courses in universities?

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

S/N	Perceived problems obstructing the integration of virtual lab in teaching of EET courses in universities	Total (N=129)		EET Teachers (n=82)		Computer Scientists (n=47)		Effect size
		Mean	SD	Mean	SD	Mean	SD	
1	Devices / technologies needed for virtual lab teaching and learning exercise 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 task and activities during web-based class.	4.02	.97	3.95	1.14	4.15	.55	.22
3	Poor or unstable internet connections needed for virtual lab class.	3.88	1.07	3.70	1.15	4.21	.81	.51
4	Limited knowledge and technical skills to develop and conduct virtual lab class.	3.56	1.15	3.55	1.20	3.57	1.08	.56
5	Insufficient technical supports from computer specialists to assist teachers to develop and conduct virtual lab	3.46	1.29	3.46	1.36	3.45	1.16	.01
6	The need for computers with special standards/specification 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 application of virtual lab devices and equipment possessed by teacher and student.	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 level of 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 method 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 skill possessed between students from urban and rural areas to handle virtual practical class.	3.91	1.20	3.94	1.20	3.85	1.20	1.97
17	Imbalances in 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 class (e.g. distractions from other family members)	3.93	1.06	3.68	1.20	4.36	.57	.72
19	Insufficient training required by 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**

Values on SD colon on Computer Scientists should be rearranged

The results shown in Table 3 indicated that the average-weighted (grand mean) value of the perceived problems obstructing the effective integration of virtual lab in teaching of 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. This implied that all the twenty-two-item inventory are the perceived problems obstructing the effective integration of virtual lab in teaching of 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 lab in teaching of EET courses in universities was (0.19) which indicated that effect size was small (low). Afgan et al. (2015) reported that there are some obstacles in using Virtual Science Lab (VLS) in schools. Study conducted by Ebohon, Obienu, Irabor et al. (2021) agreed with this study wherein claimed that problems of online teaching according to teachers was 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 support for the adoption of Technology enhanced learning is not put in place by TVET institutions. Similarly, scholars reported that teachers need to be trained on how to apply the VSL in practical course (Ayesh, 2004). Many teachers refuse to use VSL but prefer using traditional methods (Radhamani, Divakar, Nair, et al., 2018) while some schools cannot afford the computers and other technology.

The results in Table 4 showed that the average-weighted mean (grand mean) value of the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching of 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. This implied that all the thirteen-item inventory are the perceived way forwards for the problems obstructing the effective integration of virtual lab in teaching of 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 lab in teaching of EET courses in universities was (1.07) which indicated that effect size was large.

Findings from past study 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 with skills to use the available technology and provided with technical support that would encourage educators to adopt technology while teaching. Scholars also submitted that the first thing, before thinking of 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 need of university teachers during EET practical class to surpass lockdown barriers. This study showed that university teachers need training in all the twenty-three virtual lab ability area to improve their capacity in the design and effective implementation of virtual lab in EET practical class. This study established that teachers in the universities have not been trained to integrate virtual lab in the teaching of practical lesson. Similarly, it was established that some problems such as insufficient technical supports from computer specialists to assist teachers to develop and conduct virtual lab class, unstable power supply and internet connections needed for virtual lab class among others are obstructing the effective integration of virtual lab in teaching of EET courses in universities. The study affirmed that to ensure the effective integration of virtual lab in teaching of EET courses in universities, there should be an improvement of internet bandwidth throughout the country, and regular training should be provided for University teachers on computer applications, programme and software development needed to design virtual lab

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