# ICT Deployment for Teaching in the COVID-19 Era: A Quantitative Assessment of Resource Availability and Challenges in Public Universities

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Despite the changes in human behaviour and interactions occasioned by the COVID-19 pandemic, many institutions are yet to adapt to the new normal fully. While some educational institutions switched entirely to e-learning to promote teaching and learning, others could not offer education due to physical and social restrictions. Previous studies in Africa have identified reasons for the poor ICT adoption for educational purposes. However, the degree to which these factors affect ICT utilisation is barely analysed. Using a quantitative approach, this study assessed ICT deployment for teaching in the COVID-19 era by focusing on their availability and challenges. A sample of 344 respondents from a population of 2,867 academic staff at two Nigerian public universities participated in the study. After receiving face validity from experts, a structured questionnaire was used for data collection. Cronbach alpha reliability indices of the questionnaire ranged from 0.72 to 0.94. Descriptive statistics (simple percentages, mean, and standard deviation) and inferential statistics (one-way ANOVA) were used for data analysis. Findings generally revealed a moderate extent in the availability of ICT resources in public universities. The cost of data, computer literacy, and electricity supply are challenges that significantly affected ICT deployment in the COVID-19 era. Based on this finding, it was concluded that personal and institutional challenges affect how ICT resources are deployed in public universities. It was recommended, among other things, that the management of each tertiary institution should apportion proceeds from internally generated revenue to procure ICT resources specific to the need of the school. The study provides the ground for further research into students' use of ICT for educational purposes.

**Keywords: academic staff, cost of data, electricity supply, ICT literacy, utilisation**

# INTRODUCTION

The COVID-19 pandemic ushered in what is popularly referred to as the "new normal." A term used to describe individuals' behavioural and adaptive changes occasioned by the experience of a deadly virus, whose origin is traceable to the Wuhan City in China. Infections with the coronavirus may range from the common cold to the more severe acute respiratory syndrome (Ogunode et al., 2021). The new virus was identified to be a novel Coronavirus (Gorbalenya et al., 2020), and the disease it causes is now referred to as "Corona Virus Disease-2019" (COVID-19) by the World Health Organization (Nkwoemeka et al., 2020; Owan et al., 2021a). There have never been so many deaths from a pandemic as there have been with COVID-19. At the beginning of the pandemic, many activities, including travelling, physical and social gatherings requiring crowds, businesses, and institutions of learning, were shut down in many countries, including Nigeria. The educational sector suffered from the scourge of the COVID-19 pandemic, as schooling activities at all levels were grounded. Only institutions with the capacity for virtual learning could carry on with academic activities while the lockdown lasted. As a country that could not provide a quality e-learning environment for teaching and learning, academic activities in Nigeria were at a standstill until the lockdown was lifted (Owan et al., 2021b).

Previous studies on COVID-19 in the education sector continue to focus attention on its impact on teaching and learning (Aristovnik et al., 2020; Daniel, 2020; Rashid and Yadav, 2020; Zhu and Liu, 2020; Zhao and Watterston, 2021). It has been suggested that switching to electronic or digital teaching and learning is essential (Chick et al., 2020; Owan, 2020). Ideally, to respond to a pandemic of COVID-19 magnitude, there is a need for quality e-learning systems to be made available. Unfortunately, the situation met high unpreparedness among Nigerian educational institutions. Research in Africa on ICT reveals a high degree of unavailability of relevant infrastructure for teaching and learning (e.g., Tella, 2011; Ibrahim et al., 2020).

The COVID-19 outbreak highlighted the necessity for educational institutions to reconsider their ICT resource purchase. The procurement of relevant infrastructure increases availability (Ukpabio et al., 2020) and promotes utilisation (Odigwe and Owan, 2020). Due to the importance of resource procurement, several studies are continually interested in finding out the extent of availability (Ternenge and Kashimana, 2019; Bhardwaj, 2021), functionality (Tor et al., 2019), adequacy (Ademiluyi, 2019; Jack, 2021), accessibility (Ali, 2018; Asubiojo and Lawrence, 2019; Islam et al., 2020; Oluwalola, 2021), and utilisation (Fachal et al., 2019; Bervell and Arkorful, 2020; Okoye et al., 2020) of ICT resources. Furthermore, the COVID-19 pandemic also sprouted a growing body of literature in Nigeria and beyond to assess the deployment of e-learning materials (e.g., Mallillin et al., 2020; Turnbull et al., 2021; Yeo et al., 2021; Edem and Jibril, 2022; Salmani et al., 2022).

Many challenges seem to have bedevilled the Nigerian educational institutions' response to the pandemic, ranging from inconsistent power supply to inadequate knowledge, expertise and capacity of both staff and students to optimise ICT resources for e-learning (Ajagbe et al., 2021; Ogunode et al., 2021). Other challenges affecting ICT utilisation are inconsistent electricity, non-existing/poor access to Internet facilities at home and workplace, unstable connection by service providers, lack of operational skills, inadequate awareness, poor job motivation, tight work schedules, lack of conviction on the benefits of ICT, poor perception and resistance to innovations, excessive data usage by mobile operators, increased prices of internet packages and subscriptions, and poor remuneration (Owan et al., 2021c). In comparison to the conventional face-to-face teaching and learning approach, it has been shown that distance learning programmes encounter interactions, communication and integrity difficulties and constraints (Reine et al., 2021). The limitations imposed by these challenges have reduced students' satisfaction with how ICT studies are taught at almost all levels of education (Owan and Asuquo, 2021).

For an effective switch from conventional teaching to online or remote teaching and learning, supporting technologies (such as learning management systems, remote and virtual laboratories, interactive quizzes and remote invigilation) and enabling technologies (such as 5G/6G communication systems, big data and data analytics, artificial intelligence, sensors and Internet of things, augmented and virtual reality) are important (Reine et al., 2021; Salta et al., 2022). Furthermore, computers, cellphones, tablets, and cloud-based resources have all been incorporated into educational institutions, resulting in changes to instructional methodologies and pedagogical practices (Bati and Workneh, 2021; Dudar et al., 2021). For instance, different digital internet sites are being implemented to replace conventional classrooms in the COVID-19 era (Aiyedun and Ogunode, 2020). For instructors, there are several benefits to using technology in the classrooms, including more convenient storage of teaching materials, improved communication, and the freedom to move about the classroom with the teaching materials (Tuma, 2021). Consequently, many people are embracing new technology to improve the entire learning experience (Amankwah-Amoah et al., 2021; Poquet and de Laat, 2021; Egielewa et al., 2022).

Nevertheless, it is surprising that many institutions in developing countries are yet to procure ICT resources after reopening schools. The failure is attributable to inadequate funding, ICT infrastructures, poor ICT policy implementation, ICT facility costs, low ICT literacy levels among teachers and students, and inadequate staffing (Ibrahim et al., 2020; Rahiem, 2020; Olatunde-Aiyedun et al., 2021). Although these reasons are regularly featured in the literature, the degree to which each contributes to ICT deployment is rarely quantified. It is crucial to estimate how preconceived variables predict teachers' use of ICT for teaching. This will provide evidence to back up or extinguish subjective claims to understand the problem better. Along these lines, we designed this study to quantify the availability of ICT facilities in public universities. We also determined how the cost of data, computer literacy, and electricity supply contribute to ICT deployment for teaching among academic staff in public universities.

We considered the availability of ICT resources to obtain baseline information on the status. The three challenges studied (such as cost of data, computer literacy, and electricity supply) were studied empirically to bridge the gap in the literature.

Using a combination of different search strings and keywords and combining them with Boolean operators on the Google Scholar database (the world's most extensive abstracting and indexing database) did not provide any empirical literature on "cost of data" and "ICT deployment" nor other synonyms used. However, our search for literature on computer literacy and ICT utilisation indicated that several research foci had been paid to teachers in primary (e.g., Bhebhe and Maphosa, 2016; Ngeno et al., 2020) and secondary (e.g., Akingbade and Olaopa, 2019) schools, with little attention on academic staff in public universities. Much research attention has been paid particularly to students' computer literacy and their use of ICT at all levels of education (e.g., Bhatti and Qureshi, 2016; Hergüner, 2016; Abubakar and Chollom, 2017; Popoola and Olajide, 2021). The only related study focused on higher education was Cameroon-based (Bediang et al., 2013). This ushered in the need for further studies to be conducted for a better understanding. Studies on electricity supply and ICT deployment in public universities are scarce, as our search did not provide valuable results. It was based on these gaps that this study was conducted.

## Theoretical Framework

This study is grounded in the drive reduction theory (Hull, 1943). Drive, according to Hull, is a motivator that develops from a psychological or physiological need. It functions as an internal stimulation that drives a person to satisfy the desire. According to theorists like Hull, drive reduction is a crucial factor responsible for learning and behaviour. Primary drives are inherent (thirst, hunger, sex, and ICT usage), while secondary drives are learned by conditioning (e.g., money, facilities, data, electricity, illiteracy). To Hull, a person is in a condition of need when his survival is endangered. When a person's drive develops, he will be in an uncomfortable state of tension, and he will act in such a manner that this tension is lessened. To relieve the stress, he will start looking for methods to meet his requirements. For example, if a person is thirsty, he will seek water to drink. If a person is hungry, he will seek food. According to the idea, humans and animals will repeat any behaviour that lowers the urges. This is because the decrease in drive acts as positive reinforcement (i.e., a reward) for the behaviour that produced the decrease in desire.

This theory has implications for ICT deployment in general and higher education. There has been a thirst for ICT adoption for teaching and learning in developing countries. However, no serious attention was given to ICT deployment in education until the COVID-19 came into play, ushering in the drive to adopt ICT, albeit at a dying moment. The drive to ICT deployment was welcome because schools were frustrated about kickstarting e-learning during the lockdown period. Even though the importance of ICT has now been felt in promoting educational activities at the comfort of individuals in remote locations, several challenges (secondary drives) could hinder the deployment of ICT in tertiary institutions. If the challenges (secondary drives) are not taken care of, they will hinder the degree to which academic staff deploy ICT resources for teaching during the COVID-19 era to quench the primary drive (teaching remotely).

## MATERIALS AND METHODS

### Research Design and Participants

A descriptive survey approach was used in this investigation. The context of this research is Cross River State, Nigeria. The population of this study comprised 2,867 academic staff of the two public universities in Cross River State. Following the information gathered from the academic planning units of the two public universities, the University of Calabar has 2,410 academic staff, while the University of Cross River State (UNICROSS) has a total of 457 academic staff. This population cuts from Assistant Lecturers to Professors in both universities. We adopted a multi-stage sampling procedure in selecting the sample of the study.

Forty per cent of the available faculties in both universities were randomly selected. UNICAL has 16 faculties (six were selected), whereas UNICROSS has eight faculties (3 were selected) in Stage 1. Faculties of Arts, Education, Management Sciences, Medicine, Physical Sciences, and Social Sciences were selected for UNICAL; while for UNICROSS, three faculties selected included Engineering, Environmental Sciences and Education. Thus, nine faculties were selected in stage 1. In stage 2, the researchers adopted the simple random sampling technique in selecting 25% of the available departments in each of the selected faculties per university. Fourteen departments were selected from the two universities (UNICAL = 11, UNICROSS = 3) from 58 departments. In Stage 3, the researchers adopted the purposive sampling technique to select the entire academic staff in isolated departments. In each isolated department, only academic staff sited in their offices and who consented to participate during data collection were utilised as the sample for the study. Three hundred and forty-four (344) academic staff participated in the study. Academic staff of different disciplinary backgrounds were surveyed to cover a broader scope of respondents for inclusiveness.

### Measures and Instrument

Five measures were studied – availability of ICT resources, cost of data, computer literacy, electricity supply and ICT deployment. Availability of ICT resources refers to how a myriad of ICT tools can be found in a department or otherwise. Cost of data refers to fees allocated by service providers to different Internet bundle plans for individuals to purchase. It is the amount individuals pay to service providers for surfing the Internet for a given duration. We defined computer literacy as academic staff proficiency with computers and other technological tools, from primary usage to sophisticated programming and problem-solving. Electricity supply refers to the frequency (number of times) with which electrical power is supplied to the household over time. It also refers to the amount of voltage supplied to a household over a period. The deployment of ICT is how a myriad of ICT devices and resources are used for various purposes by academic staff.

Having defined the measures of this study operationally, we used a questionnaire for data collection. We structured the questionnaire into three sections. **Supplementary Appendix Section A** obtained respondents' biodata such as gender, rank

**TABLE 1 |** Cronbach reliability estimates of the instrument that will be used for data collection.

| Variables | N of Items | $\bar{x}$ | SD | $S^2$ | $\alpha$ |
|---|---|---|---|---|---|
| Availability of facilities | 20 | 13.23 | 4.64 | 21.54 | 0.84 |
| Cost of data | 6 | 14.43 | 4.49 | 20.11 | 0.79 |
| Computer Literacy | 6 | 14.50 | 4.53 | 20.49 | 0.78 |
| Electricity supply | 6 | 13.60 | 3.72 | 13.80 | 0.72 |
| Deployment of ICT | 6 | 24.93 | 8.80 | 77.45 | 0.94 |
| Instrument total | 44 | 80.70 | 12.61 | 158.93 | 0.79 |

and years of work experience. **Supplementary Appendix Section B** contained a list of 20 ICT resources that respondents ticked the extent of their availability on a scale of zero to five. A rating of zero indicated that the item was not available and a rating of 5 indicated that the item was excellently available. Scores between zero and five indicate how much an ICT resource is available, with values closer to five indicating higher availability than those closer to zero. **Supplementary Appendix Section C** of the questionnaire contained 24 items grouped into four domains. The four domains represented variables such as cost of data, ICT literacy, electricity supply and ICT deployment in the COVID-19 era. Each domain comprised six items on a four-point scale (ranging from Strongly Disagree to Strongly Agree).

Sample items for the cost of data are "I often struggle to buy data due to its high cost" and "My internet service provider (ISP) offers huge data volume for just a small amount of money." Sample items for computer literacy are "I have received extensive training on computer applications" and "I have difficulties using the Internet to search for any information of my choice." Sample items for electricity supply are "I generate private electricity daily through my generator/solar system to complement inconsistent power supply from Power Holding Company of Nigeria" and "The quality of electricity voltage supplied in my area is such that it cannot power a heavy electronic device." Sample items on ICT deployment are "I used the Zoom videoconferencing application to organise lessons for my students in the COVID-19 era" and "I did not use academic internet outlets to disseminate my research after publication in the COVID-19 era."

## Validity and Reliability of the Instrument

A psychometric specialist and four educational technology professionals evaluated the instruments' face and content validity. This team of specialists made sure that the contents and arrangements of the items were as straightforward as possible by avoiding and amending any unclear items. A pilot study was conducted on 50 academic staff from the non-participating population of the study. After pilot testing, we established the instrument's reliability based on a measure of internal consistency. Cronbach alpha reliability values ranged from 0.72 to 0.94 (see **Table 1**).

## Data Collection and Analysis

We collected primary data for this study by administering copies of the instruments to the respondents. The questionnaire

was physically administered to the study's main participants based on the scheduled date allocated for each department. On our visits to the departments, we solicited the assistance of general office employees, who were able to direct us to the offices of faculty and staff in each unit we visited. Although some staff were not available during this process, only those who were available were used for the study. This means that data collection for this study was accidental contingent on availability and voluntary willingness to participate. We met some extremely busy staff and could not give us their attention. Nevertheless, we did not enable our respondents to take home copies of their questionnaire to minimise loss and retrieval concerns. Employees who agreed to participate in the exercise were made fully aware of the significance and the need to provide candid answers to the questions asked by the instruments. They were guaranteed that their information would be kept strictly secret once deidentified. We eventually collected data from 344 staff who had responded and submitted their copies back to us for analysis. The collection process lasted 5 weeks.

Collected data were scored and coded accordingly per variable. Items in **Supplementary Appendix Section B** of the instrument were scored 0 = Not Available (NA), 1 = Somewhat Available (SA), 2 = Moderately Available (MA), 3 = Highly Available (HA), 4 = Very Highly Available (VHA), 5 = Excellently Available (EA). After the scoring, all the scores were coded on a person-by-item matrix with a computer spreadsheet program. Different variables were coded differently based on the data obtained and the measurement scale. The scoring of the items on the four-point scale (Section C of the **Supplementary Appendix**) were done differently for positively and negatively worded items. All responses of strongly agree, agree, disagree, and strongly disagree were awarded 4 points, 3 points, 2 points, and 1 point, respectively. A reverse scoring approach was implemented for negatively worded items. Statistical techniques such as frequency counts, simple percentages, mean, standard deviation and one-way analysis of variance were used (where applicable) for data analysis.

## RESULTS

## Research Question 1

To what extent are ICT resources available in public universities in the COVID-19 era? **Table 2** shows that no ICT resource was very highly available or excellently available. However, very available ICT resources include laptop/desktop computers, software licenses, projectors, and school social media platforms/forums. Furthermore, moderately available ICT resources include printers, scanners, photocopiers, Wireless Fidelity (Wi-Fi) Network, Local Area Network (LAN), active Internet bundle, routers, switches/bridges, firewalls, memory cards/pen drives, school website hosting, CD/DVD ROM drives, school digital database manager and external hard drives. **Table 2** also indicates that cloud storage systems such as Dropbox, Google drives, Microsoft OneDrive, and Mega, among others,

**TABLE 2 |** Frequency distribution showing the availability of ICT resources in public Universities during the COVID-19 pandemic.

| ICT Resources | NA (%) | SA (%) | MA (%) | VA (%) | VHA (%) | EA (%) | Total (%) | $\bar{x}$ SD | Remark |
|---|---|---|---|---|---|---|---|---|---|
| Laptop/Desktop Computers | 45 (13.1) | 62 (18) | 58 (16.9) | 60 (17.4) | 56 (16.3) | 63 (18.3) | 344 (100) | 2.61 1.68 | VA |
| Printers | 56 (16.3) | 56 (16.3) | 67 (19.5) | 57 (16.6) | 64 (18.6) | 44 (12.8) | 344 (100) | 2.43 1.64 | MA |
| Scanners | 58 (16.9) | 63 (18.3) | 52 (15.1) | 56 (16.3) | 55 (16) | 60 (17.4) | 344 (100) | 2.49 1.73 | MA |
| Software licenses | 59 (17.2) | 60 (17.4) | 43 (12.5) | 58 (16.9) | 61 (17.7) | 63 (18.3) | 344 (100) | 2.56 1.76 | VA |
| Projectors | 50 (14.5) | 58 (16.9) | 56 (16.3) | 48 (14) | 67 (19.5) | 65 (18.9) | 344 (100) | 2.64 1.72 | VA |
| Photocopiers | 60 (17.4) | 66 (19.2) | 53 (15.4) | 63 (18.3) | 43 (12.5) | 59 (17.2) | 344 (100) | 2.41 1.72 | MA |
| Wireless Fidelity(Wi-Fi) Network | 63 (18.3) | 54 (15.7) | 56 (16.3) | 55 (16) | 60 (17.4) | 56 (16.3) | 344 (100) | 2.47 1.73 | MA |
| Local Area Network(LAN) | 74 (21.5) | 48 (14) | 55 (16) | 60 (17.4) | 51 (14.8) | 56 (16.3) | 344 100 | 2.39 1.76 | MA |
| Active Internet Bundle | 106 (30.8) | 50 (14.5) | 48 (14) | 49 (14.2) | 42 (12.2) | 49 (14.2) | 344 (100) | 2.05 1.82 | MA |
| Routers | 116 (33.7) | 48 (14) | 40 (11.6) | 56 (16.3) | 43 (12.5) | 41 (11.9) | 344 (100) | 1.96 1.80 | MA |
| Switches/Bridges | 126 (36.6) | 45 (13.1) | 53 (15.4) | 43 (12.5) | 49 (14.2) | 28 (8.1) | 344 (100) | 1.79 1.73 | MA |
| Firewalls | 144 (41.9) | 47 (13.7) | 47 (13.7) | 38 (11) | 37 (10.8) | 31 (9) | 344 (100) | 1.62 1.74 | MA |
| Cloud storage systems | 176 (51.2) | 45 (13.1) | 41 (11.9) | 30 (8.7) | 29 (8.4) | 23 (6.7) | 344 (100) | 1.30 1.65 | SA |
| School social media forums | 58 (16.9) | 45 (13.1) | 52 (15.1) | 54 (15.7) | 77 (22.4) | 58 (16.9) | 344 (100) | 2.64 1.72 | VA |
| School digital bulletin boards | 238 (69.2) | 106 (30.8) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 344 (100) | 0.31 0.46 | NA |
| Memory cards/Pen drives | 59 (17.2) | 66 (19.2) | 63 (18.3) | 55 (16) | 44 (12.8) | 57 (16.6) | 344 (100) | 2.38 1.71 | MA |
| School website hosting | 63 (18.3) | 55 (16) | 58 (16.9) | 61 (17.7) | 59 (17.2) | 48 (14) | 344 (100) | 2.41 1.69 | MA |
| CD/DVD ROM drives | 42 (12.2) | 102 (29.7) | 46 (13.4) | 51 (14.8) | 57 (16.6) | 46 (13.4) | 344 (100) | 2.34 1.64 | MA |
| School digital database manager | 135 (39.2) | 81 (23.5) | 34 (9.9) | 36 (10.5) | 29 (8.4) | 29 (8.4) | 344 (100) | 1.51 1.66 | MA |
| External hard drives | 108 (31.4) | 86 (25) | 35 (10.2) | 54 (15.7) | 39 (11.3) | 22 (6.4) | 344 (100) | 1.7 1.62 | MA |

*Key: Mean threshold. NA = Not Available 0.00–0.49. SA = Somewhat Available 0.05–1.49. MA = Moderately Available 1.50–2.49. VA = Very Available 2.50–3.49. VHA = Very Highly Available 3.50–4.49. EA = Excellently Available 4.50–5.00.*

are somewhat available. School digital bulletin boards are not available in public universities in Cross River State, according to **Table 2**.

## Research Question 2

What is the difference in ICT deployment based on the cost of data level reported by academic staff in public universities? We performed a one-way ANOVA to compare the mean of ICT deployment across three groups of academic staff, perceiving the cost of data as high, moderate and low. **Table 3** shows that ICT deployment is higher among respondents in the low cost of data category. Those in the moderate and high cost of data categories follow this. Using the grand mean value of 15.28 as the

reference point, the deployment of ICT among academic staff in the low category is relatively high, while it is low for the moderate and high categories. The ANOVA revealed a significant mean difference in the deployment of ICT based on the cost of data $[F_{(2, 341)} = 139.11, p < 0.05]$.

Based on this result, we concluded that a significant difference exists in the deployment of ICT resources by academic staff reporting a high, moderate or low cost of data. Due to the statistically significant result obtained in **Table 3**, a *post hoc* test using the Fisher's Least Significant Difference (LSD) of multiple pairwise comparisons was performed. The aim was to compare, in a bivariate sense, the three cost of data categories. **Table 4** shows a significant difference in ICT deployment for teaching

**TABLE 3** | One-way analysis of variance of the mean difference in ICT deployment by academic staff based on the cost of data levels.

| Cost of data | N | Mean | SD |
|---|---|---|---|
| Low | 58 | 18.97 | 4.74 |
| Moderate | 125 | 13.10 | 3.62 |
| High | 161 | 9.74 | 2.55 |
| Total | 344 | 15.28 | 5.44 |

| Source | SS | Df | MS | F | P |
|---|---|---|---|---|---|
| Between groups | 4562.04 | 2 | 2281.02 | 139.11 | 0.000 |
| Within groups | 5591.61 | 341 | 16.40 | | |
| Total | 10153.65 | 343 | | | |

**TABLE 4** | Fisher's LSD test of multiple comparisons of ICT deployment based on the cost of data level among academic staff in public universities.

| (I) Cost of data | (J) Cost of data | Mean Difference (I–J) | SE | p |
|---|---|---|---|---|
| Low | Moderate | 5.87* | 0.48 | 0.00 |
| | High | 9.23* | 0.62 | 0.00 |
| Moderate | High | 3.36* | 0.64 | 0.00 |

*The mean difference is significant at the 0.05 level.*

**TABLE 5** | One-way analysis of variance of the mean difference in ICT deployment by academic staff based on their computer literacy levels.

| Computer literacy levels | N | Mean | SD |
|---|---|---|---|
| Low | 180 | 10.88 | 3.03 |
| Moderate | 73 | 17.64 | 1.66 |
| High | 91 | 22.09 | 1.52 |
| Total | 344 | 15.28 | 5.44 |

| Source of variation | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Between groups | 8105.06 | 2 | 4052.53 | 674.57 | 0.000 |
| Within groups | 2048.59 | 341 | 6.01 | | |
| Total | 10153.65 | 343 | | | |

between academic staff reporting a low versus those reporting a high and moderate cost of data. There is also a significant difference in ICT deployment between academic staff reporting moderate and high cost of data.

## Research Question 3

How much is there variation in ICT deployment by academic staff in public universities based on their computer literacy levels? To address this research question, respondents were classified into three groups (high, moderate, and low) based on their replies to the four-point scale items. To compare the mean of ICT deployment across the three categories, we performed a one-way analysis of variance. **Table 5** demonstrates that respondents with a low level of computer literacy had the lowest deployment of ICT. Those with a moderate level of computer literacy follow this, whereas those with a high level of computer literacy tended to deploy ICT to the greatest extent of the three groups. Using the grand mean value of 15.28 as a reference point, it was discovered that ICT deployment among respondents with a low level of computer literacy is relatively low, whereas it is high among those

**TABLE 6** | Fisher's LSD test of multiple comparisons of ICT deployment based on the computer literacy levels of academic staff in public universities.

| (I) Computer literacy | (J) Computer literacy | Mean Difference (I–J) | SE | P |
|---|---|---|---|---|
| High | Moderate | 4.44* | 0.39 | 0.00 |
| | Low | 11.21* | 0.32 | 0.00 |
| Moderate | Low | 6.76* | 0.34 | 0.00 |

*The mean difference is significant at the 0.05 level.*

**TABLE 7** | One-way analysis of variance of the mean difference in ICT deployment by academic staff based on the degree of electricity supply.

| Levels of electricity supply | N | Mean | SD |
|---|---|---|---|
| Low | 219 | 11.84 | 3.4 |
| Moderate | 46 | 19.04 | 0.79 |
| High | 79 | 22.63 | 1.09 |
| Total | 344 | 15.28 | 5.44 |

| Source of variation | SS | Df | MS | F | p |
|---|---|---|---|---|---|
| Between groups | 7513.97 | 2 | 3756.99 | 485.34 | 0.000 |
| Within groups | 2639.67 | 341 | 7.74 | | |
| Total | 10153.65 | 343 | | | |

with a moderate and high level of computer literacy. **Table 5** further reveals a significant mean difference in ICT utilisation among academic staff with high, moderate or low levels of computer literacy [$F_{(2, 341)} = 674.57$, $p < 0.05$].

Being an omnibus test, the ANOVA result did not tell the group that significantly differed from which. We further performed a *post hoc* test using Fisher's LSD test of multiple pairwise comparisons to address this limitation. The goal was to compare the three computer literacy categories (in pairs) to determine the groups that differ significantly from the others. **Table 6** indicates a significant mean difference in ICT deployment between academic staff with high versus moderate and high versus low computer literacy levels. There is also a significant mean disparity in ICT deployment between academic staff with moderate and low levels of computer literacy in public universities.

## Research Question 4

To what extent is there variation in ICT deployment by academic staff in public universities based on the degree of electricity supply? We performed a one-way ANOVA to answer this research question, classifying respondents into three independent groups (high, moderate, and low) based on the degree of electricity supplied to them, using their responses to the four-point scale items. One-way ANOVA was performed to compare the three groups with varying degrees of electricity supply, using the mean of ICT deployment as the criterion variable. **Table 7** shows that academic staff with a low degree of electricity supply had the least amount of ICT deployment. This is followed by those with a moderate degree of electricity supply. Those with a high level of electricity supply deployed ICT relatively to the greatest extent of the three groups. Using the grand mean value of 15.28 as a reference point, ICT deployment is comparatively

**TABLE 8 |** Fisher's LSD test of multiple comparisons of ICT deployment based on the degree of electricity supplied to academic staff in public universities.

| (I) Electricity supply | (J) Electricity supply | Mean Difference (I–J) | SE | P |
|---|---|---|---|---|
| High | Moderate | 3.589* | 0.516 | 0.000 |
| | Low | 10.793* | 0.365 | 0.000 |
| Moderate | Low | 7.203* | 0.451 | 0.000 |

*The mean difference is significant at the 0.05 level.*

low among respondents with a low electricity supply but high among moderate and high electricity supply levels. **Table 7** further revealed a significant variation in ICT deployment among academic staff in public universities based on the degree of electricity supplied [$F_{(2, 341)} = 485.34$, $p < 0.05$].

Because the findings revealed a statistically significant difference, and the one-way ANOVA could not reveal the groups that differ significantly or otherwise (being an omnibus test), a *post hoc* test (Fisher's LSD test of multiple pairwise comparisons) was used to compare the three electricity supply groups to identify groups that vary substantially from others. **Table 8** shows a significant mean difference in ICT deployment for teaching between academic staff with high and moderate levels of electricity supply. The bivariate comparison between staff with high and low levels of electricity supply reveals a significant mean difference. There is also a substantial mean discrepancy in ICT deployment for teaching between academic staff with moderate and low levels of electricity supply in public universities.

## DISCUSSION OF FINDINGS

This study examined the contribution of some factors to ICT deployment for teaching in the era of COVID-19 by academic staff in public universities. Our first finding reveals a moderate extent in the availability of ICT resources in public universities in Cross River State. This finding results from the moderate availability of ICT resources such as printers, scanners, photocopiers, Wireless Fidelity (Wi-Fi), Local Area networks (LAN), active Internet bundles, routers, switches/bridges, firewalls, memory cards/pen drives, school website hosting, CD/DVD ROM drives, school digital database manager and external hard drives in the two universities studied. Besides, only laptops/desktop computers, software licenses, projectors, and school social media platforms/forums were available. The moderate extent in the availability of ICT resources is attributed to the modest effort to promote ICT education in Nigeria. This result implies that public universities are still not fully ready to promote the deployment of ICT in the era of COVID-19. This is because staff cannot deploy what is not available. This means that the management of public universities must make efforts to procure ICT resources for quality instructional delivery in the COVID-19 pandemic era and beyond.

'This result agrees with the results of many Nigerian empirical investigations that Nigerian higher education institutions lack the necessary e-learning infrastructure to allow faculty to engage with their students in meaningful ways during and post-COVID-19 era (Tella, 2011; Irukaku and Arhueremu, 2021; Olatunde-Aiyedun et al., 2021). However, the result of this study disagrees with that of Calamanan and Vargas (2021) that all respondents' schools have access to presentation equipment, including LCD projectors and televisions. Only fax machines were missing from their classrooms. According to the referenced research, additional Microsoft office programs such as Word, Publisher, PowerPoint, Excel, and Access were found at each respondent's schools. The disagreement is attributable to differences in the context of both studies, the nature of respondents or the quality of data collected. The cited study was carried out in a developed country (Spain), whereas our study brings forth evidence from Nigeria.

The second finding in this study revealed a significant difference in ICT deployment for teaching based on the cost incurred in purchasing data by academic staff in public universities. This finding suggests that the deployment of ICT tools is higher (on average) when the cost of data is cheaper. This result is not surprising because the COVID-19 pandemic ushered in a paradigm where a high dependence on the Internet for educational content, materials, and e-learning was prevalent. Data or other forms of internet subscriptions and bundles must be acquired to access the Internet and tap from the abundance of its wealth. The quantity of data available depends on the quantity purchased. This implies that the cost associated with data affects how much data a person with a given income level can purchase. Therefore, staff who cannot afford internet subscriptions cannot connect to the Internet as much as their colleagues. This tends to limit their use of ICT. This result strengthens other studies (e.g., Bariu, 2020; Rahiem, 2020) that problems of incompatibility, difficulties in sharing gadgets with other family members, inconsistent internet connection, limited or unavailable internet access, data charges and acquiring new devices or applications were among the issues faced by ICT users.

The third finding of the current study indicated a significant mean difference in ICT deployment by academic staff in public universities based on their computer literacy level in the COVID-19 era. The result implied that staff with a high degree of computer literacy, on average, tended to deploy ICT for teaching than their counterparts with a moderate and low degree of computer literacy. This result is not a surprise because many modern ICT gadgets are difficult to manipulate due to their sophistication. Thus, only highly skilled individuals can manipulate such resources at an optimal level. Performing basic activities with the computer, such as processing and editing documents, producing a spreadsheet, editing images with paint, and file management, can be very difficult if a person has inadequate knowledge of ICT. Therefore, to deploy ICT resources fully, individuals must have mastered how to do so. This result corroborates several previous studies that have also documented that low commuter literacy levels accounted for many teachers not being able to deploy lessons through ICT means (Alufohai, 2020; Ryn and Sandaran, 2020; Owan et al., 2021c). The result tallies with the evidence earlier presented by Ibrahim et al. (2020) that teachers' general ICT literacy was still low and needed to be

enhanced, particularly in their Internet usage, to develop greater confidence when adopting ICT in their classrooms.

The fourth major finding of this study revealed significant variations in ICT deployment for teaching in the COVID-19 era based on the degree of electricity supplied to academic staff in public universities. This finding implies that a high degree of ICT deployment relates to a consistent supply of electricity. This result is because respondents who live in areas with a consistent supply, on average, indicated a higher degree of ICT deployment for teaching in the era of COVID-19 than those in areas with an inconsistent supply of electricity. The result is not surprising because almost all ICT devices rely on electric power to run. Even those with batteries need electricity for recharging purposes. Therefore, if there is little or no supply of electricity, academic staff in public universities cannot utilise ICT devices for intended purposes, thereby limiting their deployment. This result aligns with the results of other studies (e.g., Ogbomo, 2011; Armey and Hosman, 2016) that lack of electricity is a challenge to utilising ICT among students in Nigeria. Furthermore, another study has shown previously in Kaduna State in Nigeria that secondary school teachers in urban areas with access to electrical services utilised ICT resources more than their counterparts in rural without access to electricity (Yusuf et al., 2013).

## LIMITATIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Like every other study, this study faces the limitation of covering just two of the many universities in Nigeria, implying that the results may not picture things from a broader perspective. It is suggested that future studies expand their scope to cover more institutions in Nigeria or other developing nations. Secondly, this study assessed only the views of academic staff on the deployment of ICT for teaching. Since teaching is unreasonable without learning, the study is limited for not considering the views of learners/students. It is suggested that future studies consider both the views of teachers and students. Lastly, the study did not account for variations in ICT availability, deployment, and challenges academic staff face across discipline, gender, or age. Further studies may also consider these aspects for more information.

## CONCLUSION

Based on this study's findings, it was generally concluded that several challenges limit staff's full deployment of ICT resources in public universities. These challenges are personal, economic, and institutional. The personal variables that affect the use of ICT include the computer literacy level of individuals. Institutional factors include the availability of ICT resources and electronic supply. The cost of data is an economic factor that can reduce the ICT utilisation rate for various purposes. This study implies that the provision of quality ICT resources, improvements in computer literacy and electricity supply, and a reduction in the cost of data will improve the deployment of ICT resources in the COVID-19 era in public universities.

## RECOMMENDATIONS

Following the findings of this research, we recommend that:

i. The Federal and State governments, TETFund, as well regulatory bodies such as the Nigerian Universities Commission, Association of African Universities, and others should support the calls for adequate funding of public universities in Nigeria through the supply of modern ICT resources such as computers (both desk and laptops), printers, scanners, projectors, full software licenses, digital storage devices among others.

ii. The management of each tertiary institution should apportion proceeds from internally generated revenue to procure ICT resources specific to the institution's need.

iii. Every university staff should acquire at least basic ICT skills in word processing, spreadsheet, database management, internet surfing, basic hardware, software maintenance practices, and applications specific to their fields. The government can encourage this by budgetary allocations for academic staff training in ICT.

iv. Service providers such as MTN, Airtel, 9Mobile, and Glo should review the fees associated with their monthly data bundles. Furthermore, service providers should adopt the model used by Cable TV providers (such as DSTV, GOTV, StarTimes, and others) where data bundle can only be exhausted at the expiration date and not based on use.

v. The Port Harcourt Electricity Distribution (PHED) company should ensure improvement or consistency in electrical power supply in universities in Cross River State. This will enable staff, students, and other area inhabitants to utilise ICT and other electronic gadgets.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

LA: conceptualization, investigation, review and editing, and supervision. VO: formal analysis, writing original draft, and review and editing. DA: validation, methodology, and review and editing. FO: investigation and data curation. AU: project administration and review and editing. MO: investigation and supervision. VE and FU: investigation and software. IA: investigation and supervision.

EE and JU: investigation and resources. CE: investigation and funding support. FU: investigation and software. OA: investigation and project administration. OD and HN: investigation and validation. All the authors approved the work for publication.

# SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.920932/full#supplementary-material

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