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Usage of Electronic Infrastructures and Students' Learning Effectiveness in Nigerian Universities

A Polytomous Logistic Prediction

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Usage of Electronic Infrastructures and Students' Learning Effectiveness in Nigerian Universities: A Polytomous Logistic Prediction

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Abstract: A preponderance of empirical research in higher education exists on the use of electronic resources to promote university education and learning. This suggests that this area of research has attracted significant interest worldwide. However, there seems to be inadequate information on the association between specific electronic infrastructures, how they are utilized for learning, and their effects on students' learning effectiveness in higher institutions in Nigeria. This research draws on previous studies and seeks to establish how different electronic resources are used in universities and how they impact students' learning effectiveness. Using a descriptive survey design, this survey examined 1,452 participants (undergraduates and postgraduates) from Nigerian universities. The data were analyzed using mean and standard deviation, while a Polytomous Logistic Regression Model was used in testing the hypothesis formulated. Findings showed that the degree of the use of digital infrastructures in universities is low. The extent of learning effectiveness among students in universities is also low. The usage of e-infrastructures (such as e-learning, e-communication, and e-library tools) significantly predicted students' levels of learning effectiveness. Based on these results, conclusions and relevant theoretical and practical implications are discussed for policy reforms in education and e-learning. This study faces a limitation arising from the small number of universities studied. However, it is suggested that future related studies extend their focus beyond the context of Nigeria.

Keywords: Effectiveness, Electronic, Infrastructure, Learning, Online Resources, Universities

Introduction

A sound and dynamic university system is a formidable instrument for ensuring the development of any nation towards economic viability and global competitiveness. This is because universities are set up to develop a competitive workforce by supplying graduates with the right expertise, abilities, competencies, and skills. Higher education places a premium value on the production of a workforce with a high degree of intelligence and commitment to learning (Arop et al., 2018; Bassey, Owan and Agunwa 2019). The world economy has progressively advanced from industrial-based to knowledge-based, where economic progress is measured by the type of skills acquired, applied, and reconstructed by its workforce (Sepehrdoust, Davarikish, and Setarehie 2019).

It becomes imperative for every developing nation to create a functional university system capable of producing a global-based and knowledge-oriented workforce. Unfortunately, universities in developing countries tend to turn out graduates, most of whom lack the appropriate skills to fit into the labor market demands. In the Nigerian context, it has been argued that the quality of graduates provided by universities is increasingly deteriorating against the twenty-first century needs and labor market demands (Odigwe, Offem, and Owan 2018). Furthermore, other researchers have also noted the skill deficiencies characterized by the products of Nigerian universities in the twenty-first century. For example, scholars have found that most graduates lacked basic skills (in areas such as entrepreneurship, communication, personal management, teamwork, computer literacy, and leadership), which results in an

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increasing level of unemployment in the country (Nwosu and John 2018; Odigwe, Offem, and Owan 2018). These observed inadequacies among graduates may be attributed to their learning ineffectiveness and universities' failure in preparing these graduates for economic transformation. This is because the quality of university graduates is directly impacted by the quality of learning (Bassey, Owan, and Eze 2019). Therefore, when the learning process is ineffective, the outputs tend to be of poor quality.

Students' learning effectiveness is defined as the degree to which students are engaged in school programs and their commitment to accomplishing stated goals (Owan and Ekaette 2019). Some higher education scholars conceive learning effectiveness as the degree to which students have an uninterrupted flow of experiences with their instructors for guidance, feedback, correction, and clarification (Swan 2002; Johnson, Johnson, and Salas 2008; Long, Ibrahim, and Kowang 2014). This requires positive approaches to timeliness, lectures, tasks, tests, and other co-curricular school programs (Robert and Owan 2019; Owan, Bassey, and Ekpe 2020). Learning effectiveness is maximized when there are sufficient resources for students to partake in constructive learning activities (such as group meetings, exchanging ideas/opinions on previous learning content/experiences) and participate in realistic exercises (Adwan 2016; Bukoye 2019; Darling-Hammond et al. 2020; Savasci and Tomul 2013). Learning effectiveness may be holistically measured using students' access to materials for independent learning and research practices. The availability of platforms for group study and interactive learning among students and between students and lecturers constitutes another aspect of learning effectiveness (Jimaa 2011; Watkins, Carnell, and Lodge 2007).

One factor militating against effective and quality learning in higher education appears to be the shortage of state-of-the-art facilities. On many occasions, some university students complain about the lack of suitable lecture halls, ill-functioning laboratories and libraries, and the unavailability of essential modern information resources as issues hindering their smooth learning processes. Some universities have taken drastic measures to improve the learning situation among students. For instance, many universities worldwide tend to have digital libraries and lecture theatres to accommodate the increasing number of students. It is further contended that effective and full integration of electronic infrastructure (EI) into learning may create unlimited access to education and information resources. The integration of EI can also enable constant contact between students and lecturers, thereby enhancing collaborative and integrative research engagements among students of different institutions. This may potentially remove barriers to effective learning in universities.

Again, the pace at which students learn in universities may be used to quantify the degree at which institutions have accomplished specified priorities and objectives. If this is true, then students' learning effectiveness is at the core of successful universities worldwide. Since it has been argued that the capacity to think innovatively and respond to change is a requirement in the twenty-first century (Kereluik et al. 2013), students must have access to materials for collaborative learning to meet this demand. Working in coordinated teams with other peers on the same learning task has been reported to boost students' perception, learning motivation, and effectiveness (Krejčová, Chýlová, and Michálek 2019). Nevertheless, the students have the ultimate role in deciding how best to study for improved results. The reason is that students who are deeply involved in learning activities are likely to show deep interest in their academic work and obtain higher test grades (Jindrová, Vostrá, and Dömeová 2013; Ladd and Dinella 2009; Li and Lerner 2011). Furthermore, studies have documented that learning is a reflective activity that involves students' active meta-cognition processes in planning, monitoring, and reflecting on experiences through interaction, practice, and discussions (Dunlosky et al. 2013; Owan and Ekaette 2019). This should enable them to understand and evaluate the present while shaping future actions to formulate new knowledge.

However, considering the complexities of the twenty-first century, it is evident that no institution can encourage effective learning without sufficient use of EI (Perera and Richardson 2010; Apuke and Iyendo 2018). EI are internet-based facilities that enhance teaching and learning in

educational institutions and allow students to explore different ways of improving their learning (Ankrah and Atuase 2018). This study is informed by the need to provide an empirical answer to the question: what is the association between the use of various EI and students' learning effectiveness in universities? The study was specifically designed to assess the usage of e-learning, e-communication, and e-library infrastructures in universities. Each of these specific areas is treated briefly below, including a review of related studies.

e-Learning Infrastructures

E-learning is a learning paradigm that uses digital technologies to provide feedback and allow students to view curricula beyond conventional classrooms and to obtain other related content and facilities that are not accessible within the university (Górska 2016; Eze, Chinedu-Eze, and Bello 2018; Valverde-Berrocoso et al. 2020). Previous studies on e-learning have identified various platforms that can be used to enhance online instructional delivery. These studies have also highlighted the importance of these platforms. For instance, research highlighted the importance of Poll Everywhere (an e-learning platform) in reducing students' test anxiety while promoting a good academic performance in Mathematics (Owan et al. 2020).

In science and engineering education, the role of virtual laboratories was extensively buttressed by a study (Potkonjak et al. 2016). The cited authors contended that the effective teaching of science courses faced a problem due to the poor adoption of virtual laboratories, especially for distance education purposes. Although the authors advocated that laboratories, real or software-based, be adopted in schools, they did not explore how institutions currently utilized virtual laboratories. Reacting to this gap, recent research found that the rate at which institutional leaders are aware of, procure, and manage virtual laboratories in high schools is low, but it attributed this finding to the poor supply of cutting-edge facilities to schools (Ukpabio et al. 2020). The research of Ukpabio and colleagues made a case that the use of virtual laboratories is dependent on the degree of availability through procurement and effective management.

In a related study, Kučírková, Kučera, and Vostrá Vydrová (2012) found that students' post-test scores in the experimental group were neither better nor worse than that of the control group after exposure to e-learning platforms in terms of their listening and vocabulary reading, translation, and writing skills. The implication of the result of the cited study suggests that exposing students to e-learning platforms does not improve their language skills significantly. On the contrary, another study proved that key elements of e-learning, such as online assessments, played a substantial role in examination preparation (Kunstová 2012). In the same direction, a case study inquiry did not find significant differences (for most courses) in traditional students' academic performance versus those in virtual classroom situations taught by the same instructors (Al-Nuaim 2012). While the researcher did not explain the reasons for this finding, the importance of virtual classrooms was acknowledged. From another context, a related study confirmed a statistically meaningful gap in the pre and posttest scores of students regarding the processes, components, and creation of e-learning systems to promote creative thinking (Songkram 2015). This suggests that the group was pleased with the e-learning method in a simulated learning environment to improve creative thinking. As a gap arising from the cited Songkram's study, little information was offered concerning the effect of e-learning on students' learning effectiveness.

Some studies have documented that students' motivation and achievement improved while they practiced course materials using ICT in contrast to those who practiced with papers (Bawa, Kaushal, and Dhillon 2020; Kuncová and Vojáčková 2015; Shopova 2014; Widenská 2014). Some more specific studies have clarified that students' mathematical skills improved significantly after using multimedia resources such as Zoom and YouTube (Subhi et al. 2020). The utilization of Zoom and the integration of YouTube applications were concluded to be helpful in potentially affecting the delivery of mathematics lectures to distance education learners. While the study of Subhi et al. is important, the extent to which distance education

students and instructors used these applications was not covered. This is what the present study addresses by providing information on the extent to which these applications are utilized and how they impact the learning effectiveness of higher education students. It can also be argued that achievement is a product of learning effectiveness; however, both variables are not the same as some previous studies portrayed.

A cross-cultural study by Kobayashi (2015) analyzed students' perception of the usefulness and ease of using Google Hangouts as a learning tool in Japan and the United States. It was concluded that Google Hangouts is not very easy to use but very important as an instructional tool. Similarly, another research reviewed 219 studies focused on Massive Open Online Courses (MOOCs) (Al-Rahmi et al. 2019). The scholars tested five dynamics related to the enhancement of MOOCs. They concluded that students' academic success could be affected by the MOOC, which can encourage the learning process by providing materials and allowing knowledge exchange. The conclusions of this study were somewhat subjective and not based on empirical evidence, necessitating further research to justify the claims made.

Three uses of the Socrative mobile e-learning application were explored in a recent study (Cerqueiro and Harrison 2019). Results indicated that students welcomed the Socrative app but can increase their perceived satisfaction if it is integrated with gamification strategies. The cited research demonstrated how the Socrative app is an effective way of getting constructive input and improving time-saving during classes, which affects students' learning effectiveness. However, beyond these findings, the research was conducted using a small group of first-year university students in a school of education in Spain, warranting further investigation, especially from developing nations in Sub-Saharan Africa.

Other e-learning applications that have caught scholars' attention include Educlipper, Edmodo, Mentimeter, Kahoot games, Google Classroom, Seesaw, ClassDojo, Podcasting, and Prezi. For example, research used forty participants in two experimental and two control groups to assess the effect of the Edmodo learning application on Iranian students' writing skills (Ma'azi and Janfeshan 2018). It was observed that using the Edmodo social learning network substantially influenced the writing abilities of Iranian intermediate learners. Furthermore, the Kahoot and Mentimeter applications have been shown to significantly impact the e-learning provision of prospective teachers' training in the teaching department of the school (Gökbulut 2020).

Another research provided a critical analysis of the Kahoot game as an instructional tool for creating engagement in online classes and confirmed its wide acceptance by undergraduate and postgraduate students (Plump and LaRosa 2017). However, the studies of Plump and LaRosa, and Gökbulut did not associate the use of Kahoot with the learning effectiveness of students in higher education. The present study addresses this gap. However, in terms of using the Google Classroom e-learning application, a study found its impact in enhancing students' writing and speaking skills, primarily through assignments (Ratnaningsih 2019). This implies that students' learning effectiveness in speaking and writing can be improved by using the Google Classroom application. Similarly, another study found that optimized adaptive e-courseware enhanced students' learning at VSB-Technical University of Ostrava (Juřičková 2013).

Research focusing on podcasting showed that most students in the courses elected to use podcasts. Few students used podcasts in the mobile mode, but most use them in their private study spaces as an additional resource (Collier-Reed, Case, and Stott 2013). It was concluded that podcasting is used widely in the production of assessments and exams. Although the study by Collier-Reed and others proved that there is a unique advantage for learners who are not first-language speakers, nothing was said about the linkages between podcasting and learning effectiveness. The present study seeks to bridge this gap by assessing the extent to which podcasting and other e-learning infrastructures are used and how their utility affects students' learning effectiveness in higher education.

e-Communication Infrastructures

E-communication infrastructures are another set of electronic resources that may impact students' learning in modern university systems. E-communication means any communication happening within the sphere of a digital environment through an electronic or digital medium (Akbaba and Başkan 2017). In providing higher education in the twenty-first century around the world, electronic communication resources have been substantially important (Talebian, Mohammadi, and Rezvanfar 2014). Researchers have also recognized the relevance of e-communication services to promote conversations, exchange of ideas, study and learning among university students worldwide (Gregory and Bannister-Tyrrell 2017).

Popular electronic communication infrastructures include emails, Skype, YouTube, text messages, Instant messaging, video calls, blogs, Flickr, Wikis, Google+, Myspace, and videoconferencing. Social media such as Telegram, Instagram, Facebook, Twitter, WhatsApp, and others are also considered e-communication infrastructure. Generally, e-communication services have gathered much attention from a growing body of studies (Okan and Taraf 2013; Kuznekoff, Munz, and Titsworth 2015). Expressly, the research results of a study indicated that Flickr and Skype were used to encourage interaction and sharing between learners in geographically distant places (Fleischmann 2014). Fleischmann also discovered that Web 2.0 technology was used to bridge the gap by facilitating exchange, cooperation, and coordination in the simulated space. This indicates that some learning outcomes could not have been accomplished without using Flickr and Skype as exchange and networking resources in the virtual environment.

Another study discussed Wikis and their importance for learning group management, research-based subject collection, instructor scaffolding, and student assessment (Zheng, Niiya, and Warschauer 2015). Another investigation put Google+ to test, focusing on areas such as circles, hangouts, and huddles (Erkollar and Oberer 2013). As a preliminary evaluation, the research did not present any concrete evidence but concluded that any online service could be used in educational settings. Therefore, Google+ provides the possibility for constructive contact with teachers themselves, and more of a connection between students and teachers.

In terms of social media, a study indicated the significance of Facebook, Twitter, WeChat, Telegram, Snapchat, WhatsApp, Skype, Instagram, Eskimi, and YouTube on students' attitudes towards academic activities (Owan and Robert 2019). Admittedly, students' attitudes towards learning and learners' effectiveness are not synonymous, but are related because learners' attitudes could affect their effectiveness in education. Similarly, the research of other scholars investigated the effect of Telegram on the colloquial learning of forty EFL students from Iran who were tested via a language ability test (Vahdat, Shooshtari, and Mazareian 2020). The study confirmed the effects of Telegram in improving colloquial knowledge among Iranian high school students. This suggests that Telegram, as a new mobile application, successfully facilitated EFL instruction and provided numerous pedagogical benefits. Having reviewed studies in this section, the researchers considered the present research unique. Unlike previous studies, this study was designed to analyze several e-communication infrastructures, the extent of adoption, and their impact on students learning effectiveness in a developing country.

e-Library Infrastructures

Electronic library services have already had a noticeable impact on university libraries globally (Erich 2013; Akussah, Asante, and Adu-Sarkodee 2015). In the twenty-first century, it is apparent that no university system can offer students ample access to information for individualized and study group-oriented practices without digitizing libraries. There has been abundant evidence of an increase in the learning and research rate among students of higher education institutions (Imran and Malik 2017; Luna-Nevarez and McGovern 2018). This ushered in the need for well-

equipped libraries to be provided by higher education institutions (HEIs). Research on students' access to specific e-library resources such as e-books, e-newspapers, web pages, electronic conferences, e-maps, email magazines, e-references, and e-portals continue to receive considerable attention in the literature (Fojtik 2015; Camassola and Notari 2017; Owan et al. 2021; Mawere and Sai 2018; Owan, Agurokpon, and Owan 2022).

For instance, a study used the reading of online journals to stimulate curiosity in reading and how revised texts can be chosen that attract students' attention (Camassola and Notari 2017). Findings revealed that 100 percent of the students were pleased with the case. The study concluded that while online journal reading is simple and easy, it develops the taste and habit of reading for various people. A similar research was planned to summarize the most common e-book technology and the ones embraced by Ostrava University students (Fojtik 2015). The investigator discovered that the most common platforms used by students in reading e-books were android and IOS devices. In contrast, some students planned to procure these devices for learning. This implies that not every higher education learner possesses the necessary e-library tools for effective learning.

A study reported that while many academic institutions in Zimbabwe have made electronic library facilities top of the agenda in their strategic plans, students' adoption rates remain very low (Mawere and Sai 2018). The researcher concluded that even though the millennial generation are identified as digital natives, it is pretty clear that their involvement in technological advances is still weak. These results were attributed to various causes, including counterproductive marketing tactics, students' lack of funding, and excessive data charges by Internet Service Providers (ISPs).

Another research presented evidence of students' satisfaction with electronic library resources in a university (Holley and Powell 2004). Extensive findings from the survey indicated that almost forty percent of the students who replied said they were unaware of electronic services. Students who were aware of electronic resources had heard more about them from their teachers (38.3%) than from the attempts of the library to publicize them (18.5%). Most students (68%) were pleased even when something went wrong. A substantial percentage of all students (92.4%) replied that the library should continue to expand its electronic services. The present study aims to build on the results of Holley and Powell by extending to assessing the rate at which students use specific e-library infrastructures and how such usage impacts their learning effectiveness in higher education.

Self-efficacy plays a part in students' quest for information and the utilization of the library's electronic services. This was the key subject of a survey which found that the use of a library was associated with the help of the library's electronic services (such as internet search and email, online reference, cataloguing and categorization, customer support, online database administration, subscription, electronic document delivery, and interoperability) to students (Waldman 2003). It was also documented that students who demonstrated curiosity in learning about the library's electronic resources were more likely to be more automatic. The study by Waldman appears to be the first of all cited studies to focus on specific electronic library resources and provided the extent of utility by students. Waldman's study revealed explicitly that the following resources were utilized by these percentages of students: Lexis/Nexis (44%), DPAC (36%), Academic Search Premier (29%), Ebsco Host (26%), DPER (9%), Dow Jones Interactive (8%), Book Review Index (6%), Business Source Premier (4%), Literature Resource Center (4%), PsycInfo (3%), America: History and Life (2%), C.Q. Researcher (2%), Ethnic Newswatch (2%), Sociological Abstracts (2%) and JSTOR (0.3%). The present study is similar to the research of Waldman but intends to focus on a different set of electronic library infrastructure from the ones studied earlier.

Based on students' knowledge and use of electronic library resources, a study indicated that 73 percent used computers daily, and 82 percent felt that their level of computer literacy was average or above (Renwick 2005). The cited study also revealed the perception of many respondents that electronic resources were important and that they were skilled users. Despite the

study's overall results, it failed to identify the specific resources that students did not use. The present study has been designed to outline some particular electronic library resources and how students utilize them. The extent of the utility is further associated with the levels of their learning effectiveness to get an idea of the state of things from a developing country's perspective.

Theoretical Framework

This study is rooted in Lev Vygotsky's sociocultural theory of learning effectiveness, published in 1978. Vygotsky submitted that learning is a collaborative process that occurs within a sociocultural environment through mediated tools. The sociocultural environment, according to Vygotsky, gives students a range of roles and demands for interacting with the environment Mental engagement is the premise of a media process in which abstract and sociocultural objects (technology) play an important role in individuals' mental lives (Kozulin 2002). "Learning as a mediated process is social in origin and then becomes individual due to mediated interaction between the child and teachers, making human relations mediated by physical and symbolic tools" (Wertsch 1991, 25). The employment of mediational tools fundamentally shapes the activities in the learning environment. The result of an integrated (mediated) technical process between teachers and students is efficient teaching and learning (Altinay-Gazi and Altinay-Aksal 2017).

The implication of the sociocultural theory of learning efficacy by Vygotsky for the study is that it highlights the fact that learning effectiveness is maximized when the learning environment promotes collaboration, interaction, and integration among learners and between learners and their instructors through mediated tools such as the electronic resources. This means that the availability of EI to enhance students' access to other learners within and outside their institutions is critical. Furthermore, access to information resources and lecturers for group, collaborative, interactive and integrative learning is basic for effective education in universities. This implies that the more electronic learning resources are utilized in institutions, the more learning effectiveness is attained among students and vice-versa.

Research Questions

This study provided answers to the following questions:

1. What is the extent of e-learning infrastructure usage in universities for learning purposes?
2. To what extent are e-communication infrastructures used for learning by university students?
3. How much are e-library infrastructures utilized by university students for learning purposes?
4. To what extent is learning effective among students in universities?
5. To what extent does the use of e-infrastructures (such as e-learning, e-communication, and e-library) impact students' learning effectiveness in universities?

Materials and Methods

This study adopted a descriptive survey research design. The design was deemed most appropriate for the study because the phenomena observed were current and ongoing practices in the institutions. The researchers studied them as they existed in the institutions at the time of the investigation. The population of the study comprised 14,897 students, including undergraduates (N = 9,683; 65%) and postgraduates (N = 5,214; 35%), from the University of Calabar (UNICAL) and the University of Cross River State (UNICROSS). A total of 9,820 respondents (irrespective of academic level) were from UNICAL, and 5,077 were from UNICROSS. The researchers used stratified proportionate random sampling to select 9.75 percent of the population from each institution, making a total sample of 1,452 students. The study's population and sample distributions are presented in Table 1 for clarity.

Table 1: Crosstab of the Population and Sample of the Study

Institution	Population (N)			Sample (n)		
	Undergraduates	Post-graduates	Total	Undergraduates	Post-graduates	Total
UNICAL	6383	3437	9,820	622	335	957
UNICROSS	3300	1777	5,077	322	173	495
Total	9,683	5,214	14,897	944	508	1452

Source: Owan and Ekpenyong

Usage of Electronic Infrastructure Scale (UEIS) and Learning Effectiveness Questionnaire (LEQ) were used for data collection. The UEIS was designed with forty-seven items organized into a six-point Likert-type scale. Response options ranged from Very High Extent (six points) to Very Poor Extent (one point) for positively worded items. The LEQ was designed with ten items placed on a modified four-point Likert-type scale, with response options ranging from Strongly Agree (four points) to Strongly Disagree (one point) for positively worded items. However, all the items in both the UEIS and LEQ were reverse-coded for negatively worded items. The face and content validities of the instruments were established by psychometric and Educational Technology experts, all in the University of Calabar. The internal consistency of the questionnaire was determined using the Cronbach reliability method of internal consistency and was found reliable at a 0.83 alpha value.

In collecting data, letters were given to all the participating students with detailed explanations of the purpose and implications of participating in the study. A total of 1,490 students voluntarily accepted participating in the study; hence, copies of the UEIS and LEQ were administered. The aim was to measure how students have utilized electronic learning infrastructures and their learning effectiveness in their institutions. The researchers requested that the subjects responded objectively to the items and gave two weeks duration for respondents to do so without interference. Out of the 1,490 copies of the instruments administered, 1,452 were retrieved successfully, while the remaining thirty-eight could not be recovered due to attrition. The return rate on the distributed copies of the tools represents 97.45 percent, while 2.55 percent was due to attrition.

Mean and Standard deviation were used to answer the research questions. In the decision-making process on the scale of electronic learning infrastructures, scores below the mean value threshold of 3.5 implied low scores, scores equal to 3.5 were considered average, and those above were deemed to be high scores. Similarly, for learning effectiveness, scores below the criterion mean of 2.50 were understood to imply low extents, values equal to 2.50 were taken as average scores, and those above it were regarded as high extents. These formed the decision rule for all the research questions. The hypothesis of this study was tested at the 0.05 level of significance using the Polytomous Logistic Regression Model.

Results

Research Question One

What is the extent of e-learning infrastructure usage in universities for learning purposes? Table 2 shows that all the items have mean scores below the criterion mean of 3.50. Given that the observed overall mean is 2.4, there is a low degree in the use of e-learning infrastructure for university learning purposes. This means that e-learning infrastructures are not adequately used for university learning purposes.

Table 2: Mean and Standard Deviation of the Responses on the Extent to which e-Learning Infrastructures are Used for Learning Purposes in Universities

S/N	e-Learning Infrastructures	$\bar{x}$	SD	Remark
1	Virtual laboratories	3.40	1.32	Low
2	Webinars	2.90	1.22	Low
3	Zoom	2.75	1.38	Low
4	Google Meet	2.85	1.11	Low
5	MOOC	2.30	1.01	Low
6	Socrative	2.55	1.29	Low
7	EduClipper	2.15	.91	Low
8	Edmodo	2.15	.91	Low
9	Kahoot	2.30	.84	Low
10	Google Classroom	2.95	1.11	Low
11	Seesaw	2.20	1.03	Low
12	ClassDojo	2.40	.97	Low
13	Podcasting	2.30	1.01	Low
14	Prezi	2.75	1.18	Low
	Average	2.41	1.03	Low

Source: Owan and Ekpenyong

Research Question Two

To what extent are e-communication infrastructures used for learning by university students? The results in Table 3 show that apart from items 16 and 24, other items have mean scores below the criterion mean of 3.50. Given that the grand mean is 2.98, there is a low degree of using e-communication infrastructures for university learning purposes. This means that e-communication infrastructures are not adequately used for learning in the universities except for phones and WhatsApp.

Table 3: Mean and Standard Deviation of the Responses on the Extent to which e-Communication Infrastructures Are Used for Learning by University Students

S/N	e-Communication Infrastructures	$\bar{x}$	SD	Remark
15	Emails	3.35	1.10	Low
16	Phones	3.50	1.25	High
17	Skype	2.95	1.06	Low
18	YouTube	3.05	1.29	Low
19	Text messaging	2.90	1.09	Low
20	Instant messaging	2.75	1.22	Low
21	Instagram	2.45	.67	Low
22	Facebook	2.65	1.19	Low
23	Snapchat	2.65	1.35	Low
24	WhatsApp	3.60	1.16	High
25	Twitter	2.75	1.05	Low
26	Flash share	3.00	1.30	Low
27	Video calls	2.80	1.47	Low
28	Telegram	3.20	1.45	Low
29	Blogs	2.90	1.30	Low
30	Flickr	3.10	1.30	Low
31	Pinterest	3.00	1.26	Low
32	Wikis	3.30	1.35	Low
33	Google+	2.85	1.15	Low
34	Myspace	2.75	1.26	Low
	Average	2.98	1.15	Low

Source: Owan and Ekpenyong

Research Question Three

How much are e-library infrastructures utilized by university students for learning purposes? The evidence in Table 4 shows that except for items 44, 45 and 46 (which have mean scores above the criterion mean), all others have mean values below the criterion mean of 3.50. Given that the grand mean is 2.94, there is a low degree of acceptance among the students in using e-library infrastructures for learning purposes in universities. This means that e-library infrastructures are not adequately used for learning purposes in the universities except for e-references, databases, and e-portals.

Table 4: Mean and Standard Deviation of the Responses on the Extent to which e-Library Infrastructures Are Used for Learning Purposes in Universities

S/N	e-Library Infrastructures	x̄	SD	Decision
35	e=Books	2.70	1.35	Low
36	e-Journal	2.85	1.35	Low
37	e-Thesis	3.05	1.02	Low
38	e-Newspapers	2.35	1.28	Low
49	Websites	2.20	1.03	Low
40	e-Conference Proceedings	2.75	1.38	Low
41	e-Reports	2.85	1.02	Low
42	e-Maps	2.65	1.15	Low
43	e-Magazines	2.75	1.18	Low
44	e-Reference	3.60	1.32	High
45	Database	3.60	1.07	High
46	e-Portals	3.90	1.37	High
	Average	2.94	1.24	Low

Source: Owan and Ekpenyong

Research Question Four

To what extent is learning effective among students in universities? Table 5 indicates that all the items have mean scores below the criterion mean of 2.50. Given that the average mean is 1.94, students learning effectiveness in universities is low. This means a low level of learning among students in universities.

Table 5: Mean and Standard Deviation of the Responses on the Extent of Learning Effectiveness among Students in Universities

S/N	Items	x̄	SD	Remark
1	I have access to learning materials with less difficulty.	2.15	.573	Low
2	There is a high level of collaborative learning among students in my institution.	2.10	.769	Low
3	Students have easy access to their colleagues at any time for instructional purposes.	1.95	.591	Low
4	Students' learning process is not always interrupted by a lack of lecture venues.	2.10	.539	Low
5	There is no platform for students to access their lecturers outside the classroom.	2.60	.663	Low
6	Many students in my institution have been carrying out group research work with students in other institutions.	2.05	.670	Low
7	In my institution, students have unlimited access to information resources.	2.05	.494	Low
8	Sometimes, students receive lectures online in my institution.	2.45	.669	Low
9	In my institution, students submit their assignments online.	2.45	.777	Low
10	There are institutional platforms for students to publish their research work in my institution.	1.75	.765	Low
	Average	1.92	.651	Low

Source: Owan and Ekpenyong

Research Question Five

To what extent does the use of e-infrastructures (such as e-learning, e-communication, and e-library) affect students' learning effectiveness in universities? The results of the analysis showed that 799 respondents (55%) demonstrated a high level of learning effectiveness; 290 students (20%) had average learning effectiveness, while 363 students (25%) maintained a low

level of learning effectiveness. A polytomous logistic regression analysis was performed to examine the relative effects of three continuous predictors (usage of e-learning, e-communication and e-library infrastructure) on the three ordinal levels (high, average, and low) of the response variable—students' learning effectiveness. The result further revealed that the criterion model, which contained only the intercept, was significantly improved when the three independent variables were added to it χ^2 (6, N = 1452) = 147.730, Nagelkerke R^2 = 0.112, p < 0.05. As shown in Table 6, the three predictor variables significantly made unique contributions to the response variable generally. This implies that there are significant partial effects of using e-infrastructures (such as e-learning, e-communication, and e-library) on the levels of students' learning effectiveness (high, average, and low) in universities. The deviance and Pearson goodness of fit indices were significant at the 0.05 alpha level.

Table 6: Partial Contributions of the Three Predictors on the Dependent Variable Holistically

Predictors	χ^2	Df	p
e-Learning infrastructure	37.492	2	.000
e-Communication infrastructure	91.249	2	.000
e-Library infrastructure	6.211	2	.045

Note: Chi-square statistics are the gap in -2-log similitudes between the final and a reduced model. The reduced model consists of the final model's inability to achieve a response. Both parameters of the effect are 0, which is a null presumption.

Source: Owan and Ekpenyong

To assess the partial effects of the independent variables on the different levels of students' learning effectiveness, the average level of students' learning effectiveness was set as the reference category. Consequently, each predictor variable has two parameters in predicting students' high and low learning effectiveness. The results presented in Table 7 revealed that using e-infrastructures such as e-learning, e-communication, and e-library tools significantly predicted students' high level of learning effectiveness in universities. In the "low" category of students' learning effectiveness, the results indicated that students' usage of e-learning and e-communication infrastructures were significant predictors. However, students' usage of e-library infrastructure did not significantly predict their learning effectiveness in the "low" category.

Table 7: Partial Parameters of the Three Predictors on Students' Learning Effectiveness in the High and Low Category, with the Average Category as the Reference Group

Levels SL Effectiveness [a]	e-Infrastructure	β	SE	Wald	P	Exp (B)
High	e-Learning	.064	.011	33.967	.000	1.066
	e-Communication	.133	.015	74.804	.000	1.142
	e-Library	.019	.008	5.472	.019	1.019
Low	e-Learning	.065	.013	26.838	.000	1.067
	e-Communication	.133	.017	60.511	.000	1.142
	e-Library	.008	.009	.859	.354	1.008

Note: a. The reference category is: Average; SL = Students' Learning

Source: Owan and Ekpenyong

Discussion

This study revealed that the use of EI for learning in universities was considerably low. It was also discovered that the degree of learning effectiveness among students in the institutions was also low. The result highlights that the low extent of learning effectiveness among students in the institutions may be occasioned by the low utilization of electronic learning infrastructures. This is in line with the opinion of different researchers who stressed that learning in twenty-first century higher education is a collaborative, group, and integrative process driven by electronic learning resources (Shava, Chinyamurindi, and Somdyala 2016; Ali 2018; 2020). This result is also in tandem with Vygotsky's sociocultural theory of learning effectiveness, which explains that learning is a collaborative process that occurs within a sociocultural environment through

mediated tools. Vygotsky holds that the employment of mediational tools fundamentally shapes the activities in the learning environment. This implies that learning effectiveness was not maximized among the students in the institutions because e-learning, e-communication and e-library infrastructures were not adequately utilized for learning purposes in the universities.

This study agrees with the findings of various empirical studies, which established that effective use of electronic learning infrastructures in institutions enhanced teaching and learning, thus promoting learning effectiveness among the students (Perera and Richardson 2010; Apuke and Iyendo 2018). Though this study did not directly address educational delivery during an educational crisis, the result has significant implications for the reorganization of university learning experiences, given the emerging need to reform learning practices due to the COVID-19 pandemic. Therefore, administrators of universities should redesign learning content and experiences using electronic tools to match the emerging global-based education delivery practices and boost the learning effectiveness of higher education students.

This study also discovered that using e-learning, e-communication, and e-library infrastructures significantly predict students' learning effectiveness in universities. Students' low and high rates of learning effectiveness were significantly dependent on the usage of EI in universities, other things being equal. This implies that students are likely to be efficient to a high or low extent based on how e-infrastructures are utilized. Consequently, a high level of students' learning effectiveness is attributed to a high level of EI utilization and vice versa. This finding strengthens the results of previous research studies, which documented that various e-library services increase students' learning levels in higher education (Luna-Nevarez and McGovern 2018; Mawere and Sai 2018).

Although previous studies did not explain the category of students that benefited from e-library resources, the present study has shown that students with both high and low degrees of learning effectiveness significantly benefited from e-learning and e-communication infrastructures. However, using e-library infrastructure partially improved students' learning effectiveness in the high but not the low category. An explanation for this result may be due to the cognitive demands required to efficiently deploy e-library resources, which may be problematic for students in the low category. In the high category, students can comfortably search and use relevant materials from the electronic library and databases, boosting their knowledge and understanding.

The limited number of universities surveyed seems to be a major limitation of this work. The scope of related studies may be expanded to cover many universities in Africa and beyond. This would enable us to have adequate knowledge of the extent to which the usage of EI across universities globally or on a larger scale. The study's design did not categorize the independent variables into different nominal classes. Consequently, it is difficult to say whether higher rates of e-infrastructural usage are associated with low or high rates of students' learning effectiveness. In the present study, all the independent variables were treated continuously. Nevertheless, this study has provided the basis for future studies in related areas.

Conclusion

This study was conducted to examine the effect of the utilization of e-infrastructures, such as e-learning, e-communication, and e-library resources, on the learning effectiveness of universities. Based on the results of this study, it was concluded that the extent of usage of electronic infrastructures (e-learning, e-communication, and e-library infrastructures) for learning in universities is low. The extent of students' learning effectiveness generally in universities is low. Students with a high rate of learning effectiveness would significantly benefit from using e-infrastructures for learning in universities. Students with a low level of learning effectiveness in universities would dramatically benefit from the use of e-learning and e-communication but not e-library infrastructures for learning. Based on this conclusion, electronic learning devices were recommended to be fully adopted and applied for university learning to enhance students' learning effectiveness.

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