

Research Article An Estimation of Digital Learning Culture Index of Secondary Education in Nigeria

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The socioeconomic vulnerability of youths in developing economies is a challenge that can be mitigated by quality education and digital learning skills. However, it is increasingly demanding for developing economies still struggling with universal access to preadult education to provide their youths with quality education. Mitigating this challenge, therefore, will require a social reengineering of the educational system of developing economies. Critical to this, reengineering is a comprehensive appraisal of their educational system's support for digital learning. We set two objectives for this study: (i) examine the digital learning culture (DLC) of secondary education in Nigeria—a typical developing economy and (ii) estimate the digital learning culture index (DLCI) of secondary education in readiness for a lifelong learning skill among the Nigerian youths. Data were collected using the questionnaire survey and the stratified random sampling technique. A total of 2,107 students' questionnaire feedback and 666 secondary schoolteachers' questionnaire feedback at all secondary education levels across communities in the six geopolitical zones of Nigeria were analyzed. The DLCI of secondary education in Nigeria has been estimated to be 0.21. The results revealed two key findings: (1) evidence of sharp divides in DLC of secondary education among the communities in Nigeria and (2) statistical evidence that secondary education in the North-East zone of Nigeria has a higher DLCI than all other zones in the country except for the South-East zone.

1. Introduction

The developing economies are characterized by socioeconomic vulnerability and a youthful population [1]. Ensuring inclusive and equitable quality education and the promotion of lifelong learning skills opportunities for all as enshrined in the United Nations Sustainable Development Goal 4, SDG-4 [2] are key enablers of the SDGs [3] designed to mitigate the socioeconomic vulnerability of all people globally [4]. With the emerging global digital economy, quality education must be transparently encapsulated in digitalization to support a digital culture of lifelong learning skills [5–10]. However, this is a challenge to developing economies still struggling with universal access to quality education [5, 11–13] and have low frontier technology readiness for digital lifelong learning [14]. Thus, education in developing countries without the digitization of traditional institutions and systems may not position their youthful population for socioeconomic emancipation and productive participation in their social life and the emerging global digital economy. Studies have shown that a nation's readiness for frontier technologies is knowledgebased and requisite for growth and competitiveness in the emerging technology-driven social life and the emerging digital economy [15, 16].

To curb youth socioeconomic vulnerability, it is incumbent on developing economies to intentionally invest in new technologies and digitalization—the adoption, integration, and diffusion of advanced digitization of analog traditional sectors and institutions in the way of life of their citizenry. This transformation ambition, however, may only be adequate if their educational system is at the epicenter of the national digital socioeconomic and reengineering agenda. Otherwise, attempting to institutionalize technology into the system may be futile without a proper understanding of its present integration and diffusion state [15–17].

In Nigeria, as in most countries, formal education is categorized into primary, secondary, and tertiary. However, tertiary education is optional and centered on advanced knowledge. Secondary education is imperative for literacy and numeracy, sufficient for one to acquire the skills needed to function in the global environment of new and advancing technologies. Hence, a significant number of studies on digital learning culture (DLC) have focused on primary and secondary education [5, 18-23] which is the preadult education after which citizens usually become socioeconomically independent and responsible for themselves. Besides, Costa et al. [9] and Cukier et al. [24] affirmed that such innovative culture is better imbibed in pretertiary education. A DLC in secondary education defines the adoption, transparent integration, and diffusion of information and communication technologies (ICTs) in all its aspects of teaching and learning [9, 25–28]. In the past, technologies and facilities dominated discussions on digital learning, but it has become evident that digital learning should imbibe how the technologies are integrated into teaching and learning in educational institutions and organizations [15, 21]. This approach puts digital learning within educational institutions and organizational context and considers the ability of users to take advantage of the technologies as a tool for development in social life and the emerging global economy. As a result, integrating digital learning as a culture in educational institutions and organizations became an area of renewed interest for technical development in most recent studies [5, 19, 20, 29].

Based on relevant findings from previous studies [5, 12, 19, 30], the intervention to prepare developing countries for digital learning can only be achieved through investments in new technologies for digitization and digitalization. In this regard, European countries, Australia, North American countries (United States and Canada), Japan, Israel, China, and Singapore, are regarded as developed countries because they are in the "high" score group of the frontier technology index [1, 14, 15]. These regions and countries are on the cutting edge for new technologies and digitalization, and most breakthroughs in technology and digitalization originate in those regions or countries. Globally, technology and digitalization drive the wave of access to the global market, economy, products, social and essential services, public goods and utilities, education, healthcare, and technologies for development. Therefore, developing countries need to invest heavily in frontier technologies to step up and catch the wave of new technologies and digitalization [12, 30, 31].

Our study, therefore, aimed to (i) examine the DLC of secondary education in Nigeria and (ii) estimate the digital learning culture index (DLCI) of secondary education in Nigeria—in readiness for digital lifelong learning skills of the youths needed to maintain a strong link between technical skills and the development of the digital environment that affect their future roles in the global world of new technologies and digitalization [17, 32]. Nigeria being a typical developing economy with socioeconomically vulnerable youths, large youthful population, low frontier technologies readiness index, and fragile democracy is an appropriate demography for this study.

2. Literature Review

Based on the development and advances in digital technologies, studies have focused on imbibing a DLC among students with a view to making it a lifelong learning skill for their social life and global economic development [23, 33]. Faraj and Sharabi [17] and Anthony [34] opined that the ideal stage for students to imbibe digital culture in their learning process and connect it to their other cultural values is through educational institutions. This is not questionable since the DLC encompasses the ability to use and adapt new technologies, digital devices, and ICT facilities to perform services in the society that will adhere to the society's cultural and ethical standards of digital communication and interaction [17, 23, 33].

However, both Schmid and Petko [23] and Joo et al. [33] drew attention to the present reality that education in the twenty-first century requires students not only to adapt to the DLC but also to develop skills for the readiness to use digital technologies for lifelong learning skills and problem-solving. This new approach to learning in recent years clearly defines how education is acquired with the use of digital technologies to reshape the concept of personalized skills for a lifelong digital culture. In this regard, the 2030 development strategy included many ambitious and effective programs aimed at development and sustainability, including the orientation to technology [28]. As a result, previous studies have focused on the advantages of digital learning in education but not as a culture for lifelong learning skills required for development and problem-solving [5].

Our study, unlike most previous studies on the use of digital technologies for teaching and learning, focused on the use and access to digital technologies as the culture of learning and teaching in secondary education by students and teachers respectively in Nigeria. It is of note, however, that some research works have asked for more studies of the reality of digital culture toward reaching an appropriate vision in the global society first, before activating DLC among students in educational institutions [17]. Therefore, our study aimed to estimate the culture index of digital learning in secondary education across the communities of Nigeria—in readiness for a digital lifelong learning skill.

2.1. Related Works. Muhaimin et al. [35] examined teachers' integration of digital resources in the teaching activities of secondary education in an Indonesian province. The survey questionnaire method was adopted, and the questionnaire was designed based on the integrative model of behavioral prediction framework. The research targeted only factors affecting digital integration, science education, and rural communities. The research exposed that the developed countries have a well-implemented integration of digital resources for secondary education. They showed no significant difference between digital integration, gender, and school levels of respondents.

Naykki et al. [36] also investigated technology integration for both fundamental aspects of learning—cognitive and affective—using the empirical research method. Four case study experiments capturing digital education were used. The key finding from the work is that digital technology can provide multiple opportunities for learning across age groups.

Ihmeideh and Alkhawaldeh [37] investigated the role of technology and digital media (TDM) in the early years of a developing child. They employed the survey questionnaire and interview methods with the parents and teachers of preschool-age children. The study reported a statistical difference between parents and teachers in the role of TDM in developing a child learning culture, both sets of respondents agreed that TDM improves academic learning in early childhood education.

Molto et al. [38] focused their attention on the implementation of DLC in analogical institutions (primary and secondary schools) using interview and document content analysis methods. While their interest was to understand the implementation issues in transforming preadult education from an analogical learning culture to DLC, our work attempts to understand the DLC level and pattern of preadult education. Specifically, our investigation was on secondary education because they identified that the digital–analog gap is stronger in secondary schools.

Skillen [39] investigated whether the integration of ICT into teaching and learning in secondary education can promote higher level thinking and learning, and the result was in the affirmative. A mixed-mode survey research method was employed with a 9th/10th-grade teacher and 15 students. Our work is more holistic than the five afore discussed related studies whose focus was basically digital technology integration, for digital integration is only an aspect of DLC [25]. The remaining related studies are concerned with the diffusion aspect of DLC.

Beblavý et al. [15] investigated the Index of Readiness for Digital Lifelong Learning (IRDLL) of 27 Europe countries (dubbed E-27). The premise of the study was that three broad categories are most relevant to understand the digital lifelong learning readiness: learning outcomes and participation, institutions and policies, and the availability of digital learning. According to the study, the index presents a combined qualitative and quantitative assessment of each current situation in those countries to help policymakers, social partners, media, and the public understand the IRDLL and what needs to be done, and in what direction.

Moreno-Morilla et al. [8] investigated the digital literacy of primary school pupils within and outside a school using the survey questionnaire and categorical principal component analysis. Their results showed that outside schools favored digital literacy while inside schools favored analogical literacy; supporting a similar position of Williams [40] for secondary school students. The work did not attempt to estimate the digital literacy levels of these pupils.

Ramírez-Correa et al. [16] study was to validate the Technology Readiness Index (TRI) 2.0 instrument in a less technologically mature country of Chile and explore the perceptions of Chilean users of new technologies to classify and compare them with users from the USA. Data were collected in two Chilean regions through a face-to-face survey with a sample size of 788 respondents. Latent class analysis was used as a segmentation tool to obtain five groups of users: pioneers, hesitators, avoiders, explorers, and skeptics. Their study helps expose the relative technology readiness of a developing economy against that of a developed economy, USA.

The United Nations [14] report estimated the "frontier technologies readiness index" of 158 countries. The work covered national capacities to use, adopt, and adapt these technologies. Overall, no prior attempts have been made to estimate or understand the DLCI of preadult education in developing countries toward quality education in readiness for digital lifelong learning skills in the emerging global digital economy and social life. Consequently, this study dedicates itself to estimating the DLCI of secondary education in Nigeria, as a basis to understand the readiness for digital lifelong learning skills in developing economies.

3. Materials and Methods

The questionnaire survey, stratified random sampling particularly, was adopted for this study. This section discussed the study participants and instruments as well as the data collection and data analysis techniques employed.

3.1. Study Participants. The study respondents were students and teachers of secondary schools across the six geopolitical zones in Nigeria and the Federal Capital Territory (FCT), Abuja. The age bracket of secondary school students in Nigeria is typically from 11 to 18 years of age. A total of 2,220 students and 740 teachers across 111 secondary schools participated in the study from 1 to 28 February 2022. Other participants were the field assistants, N=26. The teachers and field assistants were adults. The selected schools (via their school head), teachers, students, and field assistants understood the study and their individual roles. They freely consented to participate, however, on the condition of anonymity.

3.2. Instruments. Two sets of questionnaires were designed and administered: one set for secondary school students (Appendix A) and the other set for secondary school teachers (Appendix B). Both questionnaires were aggregated from standard validated questionnaires for (i) the technology acceptance model [41–43], (ii) the unified theory of acceptance and use of technology model [44], (iii) United Nations Educational, Scientific and Cultural Organization (UNES-CO)'s Model of ICT maturity [45, 46], (iv) technological, pedagogical, and content knowledge (TPACK) framework [47], and (v) e-readiness assessment models. These standard digital adoption and diffusion models were chosen because they are questionnaire based, popular, and particularly effective for estimating ICT adoption, integration, use, and diffusion in the educational sector.

The aggregate questions from these questionnaires were streamlined and specifically tailored to the DLC for the student questionnaire and the digital teaching and evaluation culture for the teacher questionnaire. The resultant questionnaires were vetted and approved for the survey by the research advisor (last author). Both questionnaires consist of three sections: Section A captures the respondent's educational demographic data, Section B consists of a set of indicators (35 for the student questionnaire and 55 for the teacher questionnaire) weighted on a 5-point Likert scale from strongly agree to strongly disagree, while section C captures the respondent's school details.

3.3. Data Collection. The questionnaires were physically administered to secondary school students and teachers across the six geopolitical zones in Nigeria and the FCT by a team of field assistants under the supervision of the authors. Nigeria (9.0820°N, 8.6753°E) is a popular West African country of about 923,769 km² area with a current estimated population of about 225 million. About half of this population is aged less than 19 years [48]. Nigeria consists of 36 states and the FCT, Abuja. These states are grouped under six geopolitical zones, namely: South-South (Edo, Delta, Bayelsa, Rivers, Cross-Rivers, and Akwa Ibom States), South-East (Anambra, Imo, Ebonyi, Enugu, and Abia States), South-West (Oyo, Ekiti, Osun, Ondo, Lagos, and Ogun States), North-Central (Niger, Kogi, Benue, Plateau, Nassarawa, Kwara States, and the FCT), North-East (Bauchi, Borno, Taraba, Adamawa, Gombe, and Yobe States), and North-West (Zamfara, Sokoto, Kaduna, Kebbi, Katsina, Kano, and Jigawa States). Each of these states apart from FCT is further subdivided into three senatorial districts. Broadly, Nigeria is divided into two regions, namely: the northern region and the southern region. The northern region consists of North-Central, North-East, and North-West zones including the FCT while the southern region consists of South-South, South-West, and South-East zones.

Each geopolitical zone and region is culturally and economically homogenous. Thus, the questionnaires were administered across the senatorial districts of selected states in each geopolitical zone. Two states were randomly selected from each geopolitical zone including the FCT so that a good spread is realized across the country. The selected states were Edo and Akwa Ibom states (South-South), Oyo and Lagos states (South-West), Imo and Abia states (South-East), Kwara and Niger states (North-Central), Taraba and Bauchi states (North-East), and Kebbi and Jigawa states (North-West) and the FCT. In each of the selected states, nine secondary schools were randomly selected; such that in each senatorial district, three secondary schools (private or public) were randomly administered questionnaires: one urban, one suburban, and one rural.

Two field assistants from each selected state and FCT who are indigenes and residents of selected states and FCT with at least a bachelor's degree in computer science, education, or mathematics were recruited and trained to administer the questionnaires in their respective states. Living within a state and being able to speak some of their local languages is a requisite to ease communication with the locals and even school administrators and as well guide the random selection of schools and navigation to and from school and homes. This was particularly necessary considering the insecurity due to insurgency in Nigeria at the time of the survey. A total of 180 student questionnaires and 60 teacher questionnaires were administered per state. For the FCT, 60 student questionnaires and 20 teacher questionnaires were administered. The FCT is like a senatorial district, hence there are 109 senatorial districts in Nigeria.

The field assistants were virtually monitored via WhatsApp video calls by the authors with not less than two unscheduled visits to each team while in the field. The lead author at different unscheduled times was part of one field team or the other. Each team spent up to 2 days per secondary school. The first day was for protocol and briefing students and teachers. The briefing was usually during their daily school break period. Many times, the questionnaire administration proper was done the following day; and on whichever day, in the presence of the field assistants. While it took the students about 20-30 min to complete the questionnaire, the teachers spent about 15-20 min. In each secondary school selected for the survey, not more than 20 student questionnaires and seven teacher questionnaires were randomly distributed among students and teachers across the six levels of secondary education in Nigeria-three levels in the junior secondary school and three levels in the senior secondary school.

3.4. Data Analysis. After the collation of administered questionnaires by the field assistants, the questionnaires were examined, and some were rejected for incomplete responses or multiple responses to indicator questions. Each accepted questionnaire was coded and analyzed under various strata (zones and regions). Each indicator question, all on a uniform Likert scale, was assigned a numeric value during coding in the range of +2 to -2: strongly agree (+2), agree (+1), undecided (0), disagree (-1), and strongly disagree (-2). For each stratum, the cumulative points from each questionnaire were aggregated under rural (ru), sub-urban (su), and urban (ur), and their sum was divided by the number of respondents and thereafter, the results were divided by the number of indicator questions, k which is 35 for the student questionnaire and 55 for the teacher questionnaire.

Mathematically, this process is succinctly captured in Equations (1)-(4). Since the maximum possible value is 2, the overall index in Equation (4) was gotten by dividing the computed value in Equation (3) by 2, to keep the norm of indexes being in unity:

$$\operatorname{VSum}_{s,r,c} = \left(\sum_{j=1}^{n} \sum_{i=1}^{k} V_{i,j,s,r,c}\right),\tag{1}$$

$$VQ_{s,r,c} = VSum_{s,r,c}/n,$$
(2)

$$V_{s,r,c} = \mathrm{VQ}_{s,r,c}/k,\tag{3}$$

$$I_{s,r,c} = V_{s,r,c}/2,$$
 (4)

where VSum is the cumulative indicator point, VQ is the average cumulative indicator points per respondent, V is

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Survey strata	Administered questionnaire	Accepted questionnaire (n)	Accepted questionnaire (%)
South-South zone (SS)	360	360	100.00
South-East zone (SE)	360	350	97.22
South-West zone (SW)	360	352	97.78
North-East zone (NE)	360	347	96.39
North-West zone (NW)	360	360	100.00
North-Central zone (NC)	360	298	82.78
FCT (FCT)	60	40	66.67
Northern region (NR)	1,140	1,045	91.67
Southern region (SR)	1,080	1,062	98.33
Nigeria (NGR)	2,220	2,107	94.91

TABLE 1: Accepted student survey questionnaires.

TABLE 2: Accepted teacher survey questionnaires.

Survey strata	Administered questionnaire	Accepted questionnaire (<i>n</i>)	Accepted questionnaire (%)
South-South zone (SS)	120	119	99.17
South-East zone (SE)	120	85	70.83
South-West zone (SW)	120	118	98.33
North-East zone (NE)	120	119	99.17
North-West zone (NW)	120	117	97.50
North-Central zone (NC)	120	96	80.00
FCT (FCT)	20	12	60.00
Northern region (NR)	380	344	90.53
Southern region (SR)	360	322	89.44
Nigeria (NGR)	740	666	90.00

the DLC value, and *I* is the DLC index (DLCI). The "*s*," "*r*," and "*c*" in Equations (1)–(4) denote the stratum, respondent, and community as defined in Equations (5)–(7), respectively. We may have variables without the "*c*" a subscript element, and this implies the variable overall value. Moreover, *n* denotes the number of respondents from a stratum, and *k* denotes the number of indicator questions in the questionnaire:

$$s \in \{ \text{ ft, ss, se, sw, nc, ne, nw, nr, sr, ng} \},$$
 (5)

where ft denotes FCT, ss denotes South-South (SS), se denotes South-East (SE), nc denotes North-Central (NC), ne denotes North-East (NE), nw denotes North-West (NW), nr denotes northern region (NR), sr denotes southern region (SR), and ng denotes Nigeria (NGR):

$$re\{teacher(t), student(d)\},$$
 (6)

$$ce\{urban(ur), sub-urban(su), rural(ru)\}.$$
 (7)

To compute the overall strata DLC index $I_{s,r}$ for a given stratum *s*, and respondent class *r*, the specific community where the secondary school is resident is ignored. However, to compute the overall DLC index *I* for each stratum for both classes of respondents with and without specific community consideration, Equations (8) and (9), respectively, hold:

$$I_{s,c} = 2(I_{s,d,c} \times I_{s,t,c}) / (I_{s,d,c} + I_{s,t,c}),$$
(8)

$$I_{s} = 2(I_{s,d} \times I_{s,t}) / (I_{s,d} + I_{s,t}).$$
(9)

Equations (8) and (9) are simply the harmonic mean of teacher and student indices for the various strata with and without community consideration, respectively. The harmonic mean is particularly suitable to mitigate the effect of outliers [49, 50]. Thereafter, the two-tailed type two Student's *t*-test probability value (*p*-value) was computed for zone pairs, resulting in ${}^{6}C_{2} = 15 p$ -values computation, and between the two regions to establish statistical significance of computed DLCIs among related strata. The choice of the Student's *t*-test [51] is because we have only two regions in the study besides the independence of the strata DLCIs across communities, and for consistent use of statistical tool and simplicity of analysis across strata. These computations across strata were done using Microsoft Excel spreadsheets. This package was sufficient as the computations were basic arithmetic operations, repeated across the stratum or strata pairs.

4. Results

Tables 1 and 2 capture the number and percentages of accepted and analyzed student and teacher questionnaires for each survey strata. In all, the study has a total of 10 strata, as shown in Tables 1 and 2. In Tables 1 and 2, it is evident that the valid

			Community (c) index (I)				
Strata (s)	Respondents (r)	Rural (ru)	Sub-urban (su)	Urban (ur)	index (I)		
	Student (d)	0.20	0.35	0.34	0.31		
North-West zone (NW)	Teacher (t)	0.12	0.07	0.15	0.11		
	Overall	0.15	0.11	0.21	0.16		
	Student (d)	0.31	0.32	0.41	0.35		
North-East zone (NE)	Teacher (t)	0.41	0.32	0.44	0.40		
	Overall	0.35	0.32	0.42	0.37		
	Student (d)	0.15	0.17	0.22	0.18		
North-Central zone (NC)	Teacher (t)	-0.25	-0.05	0.37	0.02		
	Overall	-0.05^{*}	0.06*	0.28	0.04		
	Student (d)	_	-0.40	0.22	0.18		
Federal Capital Territory (FCT)	Teacher (t)	—	-0.45	0.27	0.15		
	Overall		-0.42	0.24	0.16		
	Student (d)	0.04	0.22	0.28	0.20		
South-East zone (SE)	Teacher (t)	0.16	0.29	0.32	0.28		
	Overall	0.06	0.25	0.30	0.23		
	Student (d)	0.25	0.16	0.30	0.25		
South-West zone (SW)	Teacher (t)	0.21	0.24	0.15	0.19		
	Overall	0.23	0.19	0.20	0.22		
	Student (d)	0.05	0.08	0.09	0.08		
South-South Zone (SS)	Teacher (t)	0.28	0.11	0.21	0.18		
	Overall	0.08	0.09	0.13	0.11		
	Student (d)	0.24	0.27	0.33	0.28		
Northern region (NR)	Teacher (t)	0.18	0.08	0.32	0.19		
	Overall	0.21	0.12	0.32	0.23		
	Student (d)	0.11	0.16	0.22	0.18		
Southern region (SR)	Teacher (t)	0.23	0.19	0.21	0.21		
	Overall	0.15	0.17	0.21	0.19		
	Student (d)	0.18	0.22	0.27	0.23		
Nigeria (NGR)	Teacher (t)	0.20	0.13	0.26	0.20		
	Overall	0.19	0.16	0.26	0.21		

TABLE 3: Computed result summary of DLC index across strata and communities.

*Arithmetic mean used instead due to the extraneous solution from harmonic mean.

feedback from the survey was remarkable across the regions and geopolitical zones of Nigeria. The overall computed indices for individual stratum and across communities for both categories of respondents, as well as their harmonic means, are summarized in Table 3. For better comprehension and analysis, the results as summarized in Table 3 have been visualized with a chart as shown in Figure 1. Furthermore, Figures 2 and 3 capture the computed *t*-test *p*-value between the DLCIs across communities of zone pairs and regions, respectively.

Table 3 holds the computed DLC/readiness for lifelong learning indices of the respondent types under their various strata. It further holds their harmonic means with and without community considerations, computed using Equations (8) and (9).

Figure 1 combines the clustered column chart of the DLC indices for the various communities, the line chart of the overall DLC indices and the linear trend of the overall DLC indices across strata. While the horizontal axis of the clustered

column chart holds the various strata in the clusters of their communities: rural (ru), sub-urban (su), and urban (ur), the vertical axis indicates the DLC index level. The light blue bars denote the DLC index of the rural community; the red bars denote the DLC index of the sub-urban community, and the gray bars denote the DLC index of the urban community. While the solid yellow line denotes the overall DLC behavior across the strata, and the broken yellow line denotes the linear trend of the DLC index across the strata.

In Figures 2 and 3, the zones and regions are depicted as nodes while the edges hold the Student's *t*-test *p*-value between associated strata. Specifically, the green sedges depict statistical significance of association (higher or lower) between the paired strata DLCIs across communities, and the red edges depict no significance of association, based on 0.1 level of significance. The threshold of 0.1 significance level, i.e., 90% confidence limit is fair enough considering the fact that the computed *p*-values are two-tailed, and the study is a social research.



FIGURE 1: Clustered column and line charts of DLC index across strata communities.



FIGURE 2: Graph weighted with *p*-value of DLCIs between pairs of geopolitical zones in Nigeria.



FIGURE 3: Graph weighted with *p*-value of DLCIs between the regions in Nigeria.

5. Discussion of Results and Findings

We commence this result discussion with the national results, through the geopolitical zones to the regions in Nigeria.

5.1. Research Results and Findings (#1): Evidence of Sharp Divides in DLC of Secondary Education among the Communities. In Table 3, it is evident from the student's perspective that the DLCI of secondary school education in Nigeria is 0.23. From the same perspective, the rural and suburban secondary school education was below the national index, with that of the rural secondary students being 0.18 and that of the sub-urban students being 0.22. However, the urban secondary students' response led to an estimated DLC index of 0.27; a clear indication of digital literacy and DLC divide between urban secondary school students and their sub-urban and rural counterparts. From the teachers' perspective, Table 3 shows that the DLC of secondary education in Nigeria is 0.20, while the urban teachers think it should be 0.26, the sub-urban teacher's opinion resulted in 0.13 and their rural counterpart responses gave an estimate of 0.20. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through sub-urban to rural communities, while for that of the teachers, the decline is from urban through rural to suburban. This trend in DLC as supported by teachers across communities in Nigeria is in tandem with the literature [52] that basic education is worse in sub-urban than rural communities, particularly in developing countries where the suburbs are urban slums. The downward urban, sub-urban, and rural trend from the students' perspective is of no surprise because these students are digital natives [37, 40] and exposed to outside school experiences that favor digital literacy which enhances DLC in schools [8, 40]. Thus, the proximity and interaction of sub-urban children with their urban counterparts may have influenced the higher DLC index of secondary education in the suburbs over that of the rural communities in Nigeria.

Overall, as shown in Table 3, the DLC indices for the rural, sub-urban, and urban communities in Nigeria were calculated to be 0.19, 0.16, and 0.26, respectively, showing a DLC divide. This DLC divide between the communities of Nigeria (urban, sub-urban, and rural) is consistent with the finding of Muhaimin et al. [35] that digital integration divides exist between schools in rural and urban communities of Indonesia.

Table 3 and Figure 1 make it evident that the overall DLC index of secondary education in Nigeria is 0.21. Though this is slightly higher than the 0.20 frontier technology readiness index of Nigeria in the United Nations' [14] report, the slight

difference in the two figures is expected because our population sample is mostly secondary school students who are by classification digital natives, compared to the UN's general sample mix of both digital natives and digital immigrants. Moreover, in Figure 1, Nigeria's overall level of DLC sophistication in secondary education (the overall linear trend) is stable across the country at an index of 0.19, a little lower than the 0.20 index estimate by United Nations [14]. The United Nations' [14] estimate therefore corroborates our results within ±0.01 error margin, which is tolerable. This low DLCI of Nigeria shows that across its communities and geopolitical demographics, its youths are socioeconomically vulnerable, and not positioned for the emerging global digital economy through a quality education system and DLC in secondary education.

5.2. Research Results and Findings (#2): Statistical Evidence that Secondary Education in the North-East Zone of Nigeria Has a Higher DLCI Than All Other Zones in the Country Except for the South-East Zone. This subsection further strengthens the first research finding of DLC divides across communities in Nigeria and specifically shows statistically that the North-East zone of Nigeria has the most advanced DLC in Nigeria. Further discussion of DLC divide in this subsection is expedient to expose the pervasive and entrenched nature of DLC divide in Nigeria.

5.2.1. North-West Zone DLCI Analysis. For the North-West Zone of Nigeria, it is evident in Table 3 that the DLC index of secondary education in the zone is 0.31 from the student's perspective. From the same perspective, the indices of urban and sub-urban secondary education are higher than the zonal index, with that of the urban secondary students being 0.34 and that of the sub-urban students being 0.35. However, the rural secondary students' response led to an estimated DLC index of 0.20; a clear indication of the digital literacy and DLC divide between the rural secondary school students and their sub-urban and urban counterparts in the North-West geopolitical zone of Nigeria. From their teachers' view, Table 3 shows that the DLC of secondary education in the North-West zone of Nigeria is 0.11, while the urban teachers think it should be 0.15, the sub-urban teachers' opinion resulted in 0.07 and their rural counterpart's responses gave an estimate of 0.12. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban/sub-urban communities to rural communities, while for that of the teachers, the decline is from urban through rural to sub-urban. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the North-West geopolitical zone of Nigeria was calculated to be 0.15, 0.11, and 0.21, respectively, showing a similar divide trend as the teachers of the zone submitted. Table 3 and Figure 1 make evident that the overall DLC index of secondary education in the North-West zone of Nigeria is 0.16. The result of the zone follows a similar pattern as the national (see Figure 1) and therefore similar discussions are held. Statistically, as evident in Figures 1 and 2, the DLCI of this zone is lower than that of the North-East zone.

5.2.2. North-East Zone DLCI Analysis. In Table 3, it is evident that the DLC index of secondary education in the North-East geopolitical zone of Nigeria is 0.35 from the student's perspective. In this same vein, the indices for rural and suburban secondary education slightly fall below the zonal index, with those of the rural secondary students being 0.31 and that of sub-urban students being 0.32. However, the urban secondary students' response led to an estimated DLC index of 0.41; a clear indication of the digital literacy and DLC divide between urban secondary school students and their sub-urban and rural counterparts in the North-East zone of Nigeria. From the teachers' point of view, Table 3 shows that the DLC of secondary education in the North-East zone of Nigeria is 0.40, while the urban teachers think it should be 0.44, the sub-urban teachers' opinion resulted in 0.32 and their rural counterpart's responses gave an estimate of 0.41. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through urban, sub-urban to rural communities, while for that of the teachers, the decline is from urban through rural to sub-urban. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the North-East geopolitical zone of Nigeria was calculated to be 0.35, 0.32, and 0.42, respectively, showing a similar divide trend as the teachers of the zone submitted although less steep. Table 3 and Figure 1 make evident that the overall DLC index of secondary education in the North-East zone of Nigeria is 0.37. The results from the zones follow a similar pattern of the national (see Figure 1); therefore, similar discussions suffice. Statistically, as evident from Figures 1 and 2, the DLCI of this zone is higher than those of every other zone in Nigeria with the exclusion of the South-East zone.

5.2.3. North-Central Zone DLCI Analysis. Table 3 shows that the DLC index of secondary education in the North-Central geopolitical zone of Nigeria is 0.18 from the student's perspective. From the same perspective, the indices for rural and sub-urban secondary education slightly fall below the zonal index, with those of the rural secondary students being 0.15 and that of the sub-urban students being 0.17. However, the urban secondary students' response led to an estimated DLC index of 0.22; a clear indication of the digital literacy and DLC divide between urban secondary school students and their sub-urban and rural counterparts in the North-Central zone of Nigeria. In the teachers' opinion, Table 3 shows that the DLC index of secondary education in the North-Central zone of Nigeria is 0.02, while the urban teachers think it should be 0.37, the sub-urban teachers' opinion resulted in -0.05, and their counterpart's responses gave an estimate of -0.25. From the students' and teachers' perspectives, there is a decline in digital literacy and DLC index as one moves from the urban communities, through sub-urban to the rural communities. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the North-Central geopolitical zone of Nigeria was calculated to be -0.05, 0.06, and 0.28, respectively, showing a similar divide trend across communities. Table 3 and Figure 1 make it evident that the overall DLC index of secondary education in the North-Central zone of Nigeria is 0.04. The result from the zone is particularly disturbing as the rural and sub-urban communities of the zone are completely disconnected from their urban counterparts. The DLC of the zone is unfairly skewed toward urban secondary school students. The pattern, however, is like the pattern of the students' response nationally; therefore, similar discussions suffice. It is however important to note that it is statistically evident in Figures 1 and 2 that the DLCI of this zone is lower than that of the North-East zone.

5.2.4. South-East Zone DLCI Analysis. For the South-East geopolitical zone of Nigeria, it is evident in Table 3 that the zone's DLC index of secondary education is 0.20 from the student's perspective. From the same perspective, the DLC index of rural secondary education, which is 0.04, greatly falls below the zonal index. However, the sub-urban and urban secondary students' response led to an estimated DLC index of 0.22 and 0.28, respectively, above the zonal index. There is a clear indication of digital literacy and DLC divide between urban secondary school students and their sub-urban and particularly their rural counterparts in the zone. In the teachers' opinion, Table 3 shows that the DLC of secondary education in the South-East zone of Nigeria is 0.28, while the urban teachers think it should be 0.32, the sub-urban teachers' opinion resulted in 0.29, and their rural counterpart's responses gave an estimate of 0.16. From the students' and teachers' perspectives, there is a decline in digital literacy and DLC index as one moves from the urban communities, through sub-urban to the rural communities. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the South-East geopolitical zone of Nigeria was calculated to be 0.06, 0.25, and 0.30, respectively, showing similar divide trends across communities. Table 3 and Figure 1 make evident that the overall DLC index of secondary education in the South-East zone of Nigeria is 0.23. The result from the zone is also disturbing as the rural communities of the zone are completely disconnected from their sub-urban and urban counterparts in the DLC index. The DLC index of the zone is unfairly skewed toward urban and sub-urban secondary school students. The pattern however is like the pattern of the students' response nationally; therefore, similar discussions suffice. It is, however, important to note that the zone's DLC in the sub-urban and urban communities is the highest, though not statistically evident, in the southern region. However, statistically, as evident in Figures 1 and 2, the DLCI of this zone is lower than that of the North-East zone.

5.2.5. South-West Zone DLCI Analysis. For the South-West Zone of Nigeria, it is evident in Table 3 that the DLC index of secondary education in the zone is 0.25 from the student's perspective. From the same perspective, that of the urban secondary students is 0.30, and that of the rural students is 0.25. However, the sub-urban secondary students' response led to an estimated DLC index of 0.16; an indication of digital literacy and the DLC divide between the rural secondary school students and their sub-urban and urban counterparts in the South-West geopolitical zone of Nigeria. From

their teachers' view, Table 3 shows that the DLC of secondary education in the South-West zone of Nigeria is 0.19, while the urban teachers think it should be 0.15, the sub-urban teachers' opinion resulted in 0.24 and their rural counterpart's responses gave an estimate of 0.21. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through rural to suburban communities, while for that of the teachers, the decline is from sub-urban through rural to urban. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the South-West geopolitical zone of Nigeria was calculated to be 0.23, 0.19, and 0.20, respectively. Table 3 and Figure 1 make evident that the overall DLC index of secondary education in the South-West zone of Nigeria is 0.22. The result from the zone follows a similar pattern as the nation except that the index of the rural communities is now higher than that of the urban communities. This notwithstanding, though not statistically evident, the zone's digital index is higher than the national in both rural and sub-urban communities. This is indeed interesting and an indication that better digital secondary education is located outside of urban communities in the South-West zone of Nigeria. Statistically, as evident in Figures 1 and 2, the DLCI of this zone is lower than that of the North-East zone but higher than that of the South-South zone.

5.2.6. South-South Zone DLCI Analysis. For the South-South geopolitical zone of Nigeria, it is evident in Table 3 that the zone's DLC index of secondary education is 0.08 from the student's perspective. From the same perspective, the index for the communities greatly falls below the zonal and national indices. The rural, sub-urban, and urban secondary students' responses led to an estimated DLC index of 0.05, 0.08, and 0.09, respectively. This is a very low digital literacy and DLC with little or no divide among the communities in the zone. Their teachers, however, differed in their position. In the teachers' opinions, Table 3 shows that the DLC of secondary education in the South-South zone of Nigeria is 0.18, while the urban teachers think it should be 0.21, the sub-urban teachers' opinion resulted in 0.11, and their rural counterpart responses gave an estimate of 0.28. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through sub-urban to rural communities, while for that of the teachers, the decline is in the reverse order. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the South-South geopolitical zone of Nigeria was calculated to be 0.08, 0.09, and 0.13, respectively, showing a slight divide trend across communities. Table 3 and Figure 1 made it evident that the overall DLC index of secondary education in the South-South zone of Nigeria is 0.11. The pattern however is like the pattern of the students' response nationally; therefore, similar discussions suffice. It is, however, important to note that the zone's DLC in the sub-urban and urban communities is the lowest in the southern region and far lower than the national indices in all communities as evident in Figure 1, though not statistically evident. Statistically, as evident in Figures 1 and 2, the DLCI

of this zone is lower than that of the North-East and South-West zones.

5.2.7. Regional DLCI Analysis. In Table 3, it is evident from the student's perspective that the DLCI of secondary education in the northern region of Nigeria is 0.28. From the same perspective, the indices for rural and sub-urban secondary education fall below the regional index, with those of rural secondary students being 0.24 and that of sub-urban students being 0.27. However, the urban secondary students' response led to an estimated DLCI of 0.33. From the teachers' view, Table 3 shows that the DLC of secondary education in the northern part of Nigeria is 0.19, while the urban teachers think it should be 0.32, the sub-urban teachers' opinion resulted in 0.08, and their rural counterparts' responses gave an estimate of 0.18. From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through sub-urban to rural communities, while for that of the teachers, the decline is from urban through rural to sub-urban. Overall, as shown in Table 3, the DLCI for the rural, sub-urban, and urban communities in the northern region of Nigeria was calculated to be 0.21, 0.12, and 0.32, respectively, showing a similar divide trend as the teachers of the region submitted. Table 3 makes it evident that the overall DLC index of secondary education in the northern region of Nigeria is 0.23. The results from the northern part of Nigeria follow a similar pattern as the national and similar discussions therefore hold.

The southern region of Nigeria shows a slightly different pattern from the north. As shown in Table 3, the DLCI of secondary education in the southern region of Nigeria is 0.18 from the student's perspective. Also from the students' perspective, the indices for rural and sub-urban secondary education fall below the regional index, with that of the rural secondary students being 0.11 and that of the sub-urban students being 0.16. However, the urban secondary students' response led to an estimated DLCI of 0.22; an indication of the digital literacy and DLC divide between urban secondary school students and their sub-urban and rural counterparts in the southern part of Nigeria. However, from the teachers' perspective, as shown in Table 3, the DLC of secondary education in the southern part of Nigeria is 0.21, which happens to also be the outcome of the urban teachers' response. Their rural and sub-urban outcome, however, differs considering the sub-urban teachers' position of 0.19 and their rural counterpart's responses, which gave an estimate of 0.23.

From the students' perspective, there is a decline in digital literacy and DLC as one moves from urban communities, through sub-urban to rural communities, while for that of the teachers, the decline is in the reverse order. The pattern of responses from the students of the southern part of the country is like the national pattern for students and to that extent, similar discussion holds. For the teachers, we have a similar pattern to that of the teachers' the national pattern only that the rural and urban communities swapped places we had a downward trend as we move from rural, through urban to sub-urban. Overall, as shown in Table 3, the DLC index for the rural, sub-urban, and urban communities in the southern region of Nigeria were calculated to be 0.15, 0.17, and 0.21, respectively, showing a similar divide trend as the students of the region submitted. Table 3 and Figure 1 make evident that there is an obvious DLC divide in secondary education across communities in the southern region of Nigeria. The overall results from the southern region of Nigeria follow a similar pattern as the students' national position and similar discussions also held. Though the DLC divide is more pronounced in the northern region than in the southern region, this is not statistically corroborated as evident in Figure 3.

6. Conclusion

A study of the DLC of Nigerian secondary school education has been carried out as a foundation toward an effective digital social reengineering of the sector. This is critical as the global economy drifts into full digitalization and the country's population surges. The study has shown a national DLC index of 0.21 with a national sleeping trend of 0.19. This low DLC index is a serious source of worry for Nigeria in the emerging digital global economy. This will make the youths of the country more socioeconomically vulnerable. The Nigerian youths may be of little or no significant economic value in developed countries unless there is a total social reengineering of its preadult educational system and digitization of traditional institutions and sectors. The overall DLC index of 0.21 from this study is within a ± 0.01 error margin to the 0.20 of a similar index of a study reported by the United Nations [14]. Also, in tandem with a similar study [8, 53], there are evidence of a digital culture divide between urban, sub-urban, and rural schools in Nigeria. Secondary education in Nigeria and other developing countries in general should therefore be digitalized and digitally reengineered for enhanced DLC.

6.1. Implications of Study. The implications from the study results and discussions are: (1) the socioeconomic

a global nuisance as the youthful population lack the requisite DLC for lifelong skills and participation in a digitalized global economy; (2) the inequitable DLC in Nigeria's secondary education causes a digital learning divide throughout its regions, geopolitical zones, and communities; and (3) the index similarity between this study result of DLC and the United Nations [14] frontier technology readiness for Nigeria being in the same neighborhood of 0.20 ± 0.01 does not only validates the results of this study but also exposes that a country's readiness for frontier technologies requisite for participation in the global digital economy is roughly same as the level of sophistication of its population's preadult DLC.

6.1.1. Specific Recommendations. From the results of the study, the government of developing economies should make frantic and genuine efforts to digitally reengineer its secondary education equitably across communities to reduce the DLC divide and improve the DLC in schools.

6.2. Limitations. Although the results of the study revealed DLC indexes in Nigeria's secondary education from both teachers' and students' perspectives across its regions to the geopolitical zones, the results are not enough to generalize for the developing economies until similar studies are carried out in more developing economies. Other limitations of the study include assuming equality of all students and teachers that participated in the research, regardless of age, gender, qualifications, and socioeconomic background.

6.3. Future Research. It is recommended for future work to extend the study to more developing economies. Another important area of interest is to determine the relationships existing among the various research variables. Future research can also focus on the extent to which DLC in secondary education in one or more countries is affecting the digital culture of the country and the emerging global digital economy.

Appendix

A. Questionnaire on "The DLC of Secondary Education" (Student Questionnaire)

Section A: Tick this $(\sqrt{})$ for the right option **Location of school:** urban () sub-urban () rural () Grade or class level: SS3 () SS2 () SS1 () JSS 3 () JSS 2 () JSS 1 ()

Section B:

S./no.	Question	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1.	I can boot and shut down computers.					
2.	I know how to use computers.					
3.	I know how to use the internet.					
4.	I use the internet to source information for assignments.					
5.	I can type and produce documents using computers.					

S./no.	Question	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
6.	I can operate a smartphone.	0				
7.	I have a personal computer at home.					
8.	I have a computer with internet access at home.					
9.	I have a printer at home.					
10.	I can install and uninstall software applications on my computer.					
11.	I can get help with my computer problems at home.					
12.	My school has a standard computer lab for students.					
13.	My school uses computers for teaching and learning.					
14.	My school has broadband internet services.					
15.	My school provides free Internet access for students.					
16.	My school uses paper and pen tests (PPT) only mode of exams.					
17.	My school uses computers for exams.					
18.	My school train students for computer-based test (CBT) mode exams.					
19.	There are internet services in my community.					
20.	There are computer cafés to train for CBT mode exams in my community.					
21.	There are computer repair technicians in my community.					
22.	We have a regular electrical power supply in my community.					
23.	We use alternative electrical supplies in my community.					
24.	We have computer teachers in my school.					
25.	My school is committed to supporting students' efforts to use the Internet for learning.					
26.	I think using computers for learning/assignments is fun and very exciting.					
27.	I like learning to do new things using computers.					
28.	I like using the Internet to find out information.					
29.	My parents are in favor of learning with computers at school.					
30.	I believe computers are useful learning tools in schools.					
31.	There are enough skilled computer teachers in my school.					
32.	I can study on my own with a computer with no support or assistance.					
33.	Online learning is as interesting as classroom learning.					
34.	I can learn, browse, download files, and conduct searches online.					
35.	I think my computer skills from school will prepare me for the future.					
Na LO	Arme of School:Stat	e				-

Thank you for your time

B. Questionnaire on "The DLC of Secondary Education" (Teacher Questionnaire)

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Section A: Tick this (\sqrt{}) for the right option
Location of school: urban () sub-urban () rural ()
Class level of teaching: JSS () SS ()
Your position at school: Class Teacher () Senior Teacher () Asst. Principal () Principal ()
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Section B:

S./no.	Question	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1.	I am a trained ICT teacher.					
2.	I learned ICT by attending workshops outside of formal training.					
3.	I learned ICT through personal efforts online and by taking short courses.					
4.	I use the Internet to research and download materials for teaching.					
5.	I use computers to create materials for teaching and evaluation.					
6.	I use the internet to interact with my students online.					
7.	I create posters and other visual displays with computer software applications.					
8.	I teach in a well-equipped computer lab or classroom.					
9.	I have an internet-connected computer in my office at the school.					
10.	I teach with internet-connected computers.					
11.	I teach ICT with smart Mobile phones provided by the school.					
12.	I use an interactive whiteboard for teaching.					
13.	I use educational software for teaching.					
14.	I track students' progress and completion of individual activities online.					
15.	I am very uncomfortable using computers to teach my students.					
16.	I prepare lessons using digital learning resources.					
17.	I know the teaching and learning strategies to guide student knowledge.					
18.	I use computers to facilitate teaching.					
19.	I use computers to support students' personalized learning styles.					
20.	I use computers to facilitate teaching students with disabilities.					
21.	I use computers to facilitate creativity.					
22.	I use computers to facilitate students' ability to use ICT in learning.					
23.	I use computers to teach my students as often as possible.					
24.	I have the professional teaching skills to make students like learning to use computers.					
25.	I believe learning with computers is fun for students.					
26.	I will continue to use computers to teach my subject.					
27.	I have enough ICT skills to teach my subject.					
28.	I know how to improve my ICT skills.					

S./no.	Question	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
29.	I know how to choose the computer skills that will help students learn the subject.	U				
30.	I can learn technology easily.					
31.	I have sufficient knowledge about my subject.					
32.	I can facilitate my students' use of computers to plan and monitor their learning.					
33.	Without using technology, I can teach my students to understand the subject.					
34.	The school's computers are fully operational for teaching.					
35.	The school library has internet-connected computers for educational purposes.					
36.	The school is connected to the internet.					
37.	The school has computer repairers/technical support staff available.					
38.	The school's internet connectivity/access is free.					
39.	The school's internet connectivity/access is not problematic.					
40.	The school has a stable electrical power supply from the national grid.					
41.	The school uses an alternative electrical power supply.					
42.	There are mobile internet providers in the area.					
43.	The school has a functional website.					
44.	My students can use a digital library for research and learning.					
45.	Most teachers are in favor of the use of ICT at school.					
46.	There are clear professional benefits to using ICT for teaching.					
47.	There are workshops about the pedagogical use of ICT provided to teachers.					
48.	There should be a policy to sustain ICT-based innovations in course teaching.					
49.	Support is available for teachers' pedagogical use of ICT at my school.					
50.	There should be policies on using ICT across the school curriculum.					
51.	Using computers will improve students' performance in CBT mode exams.					
52.	Using computers will make students ICT proficient when they leave school.					
53.	Learning computers will increase students' productivity in the future.					
54.	Computer skills are necessary for secondary students in pursuit of higher education.					
55.	Government should support schools to connect to the main grid of electricity.					

Name of School: _____

LGA: _____

__ State___

Thank you for your time

Data Availability

The research was a questionnaire based research. Data were elicited from primary sources. However, the Excel sheets that codify the sample questionnaires which were attached as Appendices A and B and their computations will be made available upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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