Towards a Topology for ICT & E-learning in Nigerian Rural Public Primary Schools.

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Abstract
This study attempts to evaluate possibilities and paradigms, in underdeveloped rural milieus, of using ICT in primary education in Nigeria. The study view rural schools in Nigeria as generally sharing critical factors that may affect learning prospects and strategy implementations. The study under a proposed topology examined five crucial aspects. ***E-Strategy****: that comprise educational policies, pedagogy, and teacher training,* ***E-content****: that deals with learning materials production, on-line resources and syndication,* ***E-transmission****: by examining how learning materials are delivered to learners, and* ***E-site****: discussing how the various target sites are managed to receive and utilize learning materials and technology. In the end, a clear topology is proposed based on a rational review of data gleaned from available educational statistics, plans, policies and various studies and reports already carried out on the subject.*

Keywords: *Educational Technology, Topology, E-learning, Rural Primary Education, ICT in Education.*

Introduction

According to the Global Competitiveness Report GCI (Schwab: 2016), Nigeria ranks 138th in health and primary education, ahead of only nine countries from the bottom. Primary school enrolment still remains comparatively low (less than 70%) and this is compounded by a prospect of demising future workforce with suitable skillset, due to poor introduction of ICT and the quality and quantity of education which makes Nigeria to remain behind African countries like Kenya and Rwanda. In essence, the risk factors are increasing and solutions may not depend only on increased investments and enrolments in education, but will depend as well on planning the quality of education to support a workforce in a highly uncertain future.
In general therefore, several complications combine to challenge a successful provision of modern primary education in Nigeria. Central to the low ranking of Nigeria in primary education is the increasing figure of children who don't have primary education, who drop out or are victims of displacements due to various kinds of conflicts.

Statistics gleaned from the Federal Ministry of Education (2016) and UNESCO (2016) show that although at the beginning of the Universal Basic Education in 2007, primary school enrolment rose, however between 2014 to 2016 there was a decline of enrolment if compared to population rise. Although some experts point to the non-inclusion of private school enrolments in the statistics as the cause, still the marginal increase since 2014 and a looming decline as from 2016 is an indication of a serious challenge, thereby giving credence that Nigeria has the highest number of under 15 out-of-school in the world.

To worsen the grim statistics, it is suggested (UNESCO: 2016) that girls form 60% of the estimated large number of out of school children and the same percentage are children from Northern Nigeria. The out-of-school challenge may pose a huge challenge for Nigeria as a society but also a potential for reconsideration of the pedagogical and philosophical basis of basic education in Nigeria in the sense of possibilities for innovative approaches to tackle the out-of-school and drop- out phenomena outside the school walls.

Added to the above challenges, is the increasing number of children forced out of the educational system by conflicts in various parts of the country. Over 1.5 million children are estimated to have fled conflict in the north east and the middle belt of Nigeria, thereby increasing the demand for funding and interventionist plans in basic education. Although donor agencies and the Federal Government are supporting initiatives to give displaced children basic education, the enormity of capital required is overwhelming. UNICEF (2015) alone had estimated N182,5000,000 for its North East education strategy for the year 2015. If this is multiplied as an average for all NGOs involved, a huge capital outlay can be anticipated.

Funding therefore, will remain the most repeated challenge to universal basic education in Nigeria. With a growing population that is above 170 million and increasing, the youth form 45% of the population and therefore the burden on public education is overwhelming. Resources are spread thinly and standards are continually declining especially in the rural areas. Despite UNESCO/MDG recommendations for higher budgetary allocation to education, the combined allocation by both the national, state and local governments to education still is lower than 10% in the past two decades. The private sector participation is not fully documented and may therefore affect overall picture in funding and enrolment.

Infrastructure for basic education is also abysmal both in terms of quantity and quality. Generally, all studies agree that the school environment for basic education in Nigerian public schools are learner-unfriendly. The enrolment has far surpassed the provision of buildings, classes, toilets and learning materials. In addition, in most locations schools are located far from settlements creating access problems.
The cumulative effect of the above quandaries: lack of universal enrolment, dilapidated infrastructure, the problem of drop-outs and out-of-school children, lack of investment in basic education resulted in Nigeria not meeting the Millennium Development Goal of universal primary education by 2015. There are serious social and economic implications of such failure. As Watkins (2013) succinctly puts it, "Africa cannot build economic success on failing education systems. And it will not generate the 45 million additional jobs needed for young people joining the labor force over the next decade if those systems are not fixed".

The role of educational technology, especially IT, in such a predicament is both daunting and encouraging at the same time. Daunting because of the enormity of capital expenditure it requires and encouraging because of the potential leap and the enticing nature that ICT can provide to children and even adult learning. ICT can provide the magical leap by stimulating learning among children with poor background, out-of-school children, drop-outs and children of conflicts in Nigeria. It might also provide a completely new platform for informal education as a recipe for remedying educational damages inflicted on communities.

Methodology

This study used available educational data from various international reports and national agency reports. Most significantly, the study used the data from a recent study carried out by

the Universal Education Commission of Nigeria (UBEC), titled: The Conduct of National Personnel Audit (NPA) of all Basic Education Institutions in Nigeria, 2018.
Although the survey is mainly focused on authenticating the number of children (5-15 years of age) in school and out of it, by this time laudably ensuring the inclusion of private schools, it also assess the quantity and qualifications of teaching staff and some aspects of facilities in schools. A number of fields in the questionnaire relate to this study. They are:

Table 1: some of the valuable fields included in a recent survey (2018) by Universal Basic Education Commission (UBEC) of Nigeria.

1.	20.	COMPUTER LITERACY: Shade yes, if you have the ability to use computer and NO if you do not.
	22.	WORKSHOPS/SEMINARS/TRAININGS YOU ATTENDED IN THE LAST FIVE YEARS: Shade a circle number that is applicable to you from the options provided.
2.	18.2	NUMBER OF USEABLE AND UNUSEABLE FACILITIES (Computers, laboratories, library, play grounds, incinerator)
	18.3	SOURCE OF POWER: Identify source of power (PHCN/NEPA, generator, solar, etc.) available in school and tick as appropriate.
3.	18.6	LEARNING MATERIALS: Show whether the school has learning materials (charts, posters, toys, word puzzle box, care giver guide and audio-visual as radio, TV, DVD) for ECCD by ticking all that apply.

The above pointers (Table 1), although not exhaustive, can give at least a glimpse of the enormous challenges that may be faced in deploying ICT in primary education setting in Nigeria.

Analytical Discussions
A number of interconnected imperatives will have to be discussed regarding the possibilities of deploying ICT in rural primary schools, solving out-of-school and drop-out problems in Nigeria. Some of the most essential considerations are: National policies and plans, funding basic education, infrastructure, education curricula, source of electric power, appropriate educational technology, provision of internet in rural enclaves, and teacher training.

National Policies and Plans
Although ICT policies and plans themselves cannot guarantee effective implementation of ICT and e-learning in rural education, they can provide a preparatory pedestal to connect with curriculum planning, teacher training and project evaluations. Most national policies are broad and lacking in details (NERDC, 2013). Even the NATIONAL INFORMATION and COMMUNICATION TECHNOLOGY (ICT) POLICY (2012) by the Ministry of Communication Technology, Abuja, only make recommendations and point to potentials:

- To integrate ICT into the national education curriculum;
- Introduce mandatory training and appropriate courses for ICT at all tiers of education;
- Promote ICT awareness and proficiency in mass and non-formal education with emphasis on children, youth, women, and the physically challenged;
- Promote the incorporation of ICT within the education curriculum at all levels.

In general concrete and more detailed policies and plans can help in articulation and evaluation of projects. However broad policies like the ones in Nigeria, should not prevent stakeholders from designing educational projects that are informed by detailed plans that can make it easy

for donors and sponsors to appreciate the nature of a project and the enormity of funding required.

Funding

Funding is a major challenge in implementing educational initiatives in Nigeria. Since 2012 when national budgetary funding dipped, allocation has still hovered between 7-8% of National budget, 2018 being 7.07% only. Primary education is funded by the states and local government authorities in Nigeria with 2% of national annual budget dedicated to basic education. The Universal Basic Education Commission administers the fund on a counterpart funding basis, where contributing states can draw on the funds. The various recommendations of national budget percentages (UNESCO, MDGs) to fund education has remained a tall order in Nigeria which ranks low in educational expenditure even by African standards.

Some studies (Nwoko, 2015, Hinchliffe (2002) point to the intricacies of the three tier system of federal, state and local governments' involvement in the responsibility and abdication of roles. The state governments are mostly figured as culprits in the triangle of roles regarding basic education. Yet the essence of funding basic education especially in Nigeria where out-of-school children and children of conflicts abound, cannot be over-emphasized because educational damages cannot be repaired if ever.

The above milieu makes funding technology-based initiatives doubly difficult, no matter how pertinent. Another aspect of funding that need to be considered is coordination. Most initiatives by international organizations, private corporations and NGOs are disparate. Getting a unified ICT and e-learning plan with concrete framework will make it easier to source for funding from donor agencies and stakeholder communities than waiting for donor agencies, vendors and international projects to formulate their visions.

Physical Infrastructure

In the same vein, infrastructure also poses a challenge to introducing educational technologies in primary education in Nigeria mainly in relation to project priorities and the creation of secured ICT labs in remote rural schools. Preliminary assessment of 282,049 (not final) classrooms in Nigeria's public primary schools (UBEC. 2018) shows that over half of the classrooms are dilapidated, especially for primary 1-3 as figures 1&2 show. Unfriendly learning environments can be devastating for learners in their formative periods and might be a factor in the increasing drop-out rates in rural schools.

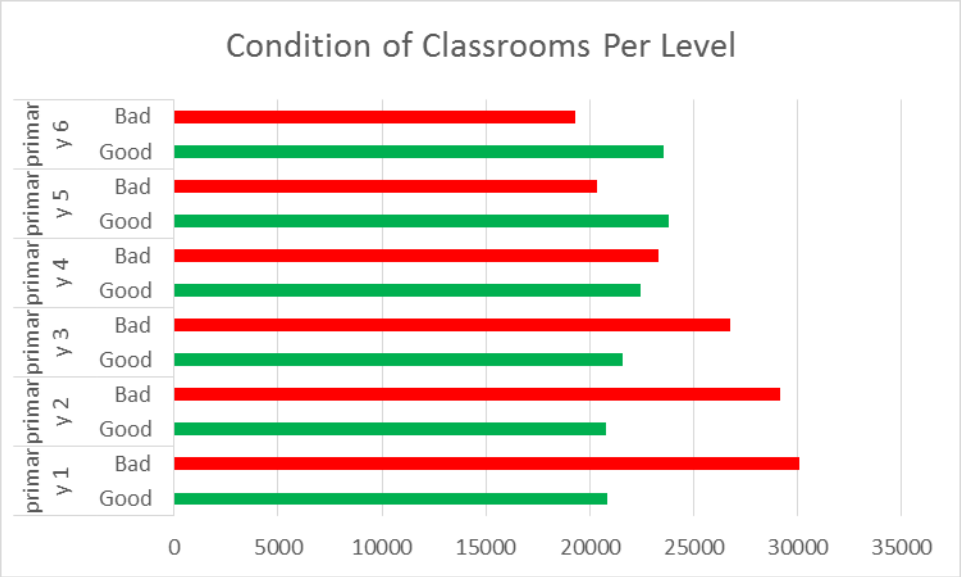

Figure 1: Condition of Classrooms in Public Primary Schools, UBEC 2018

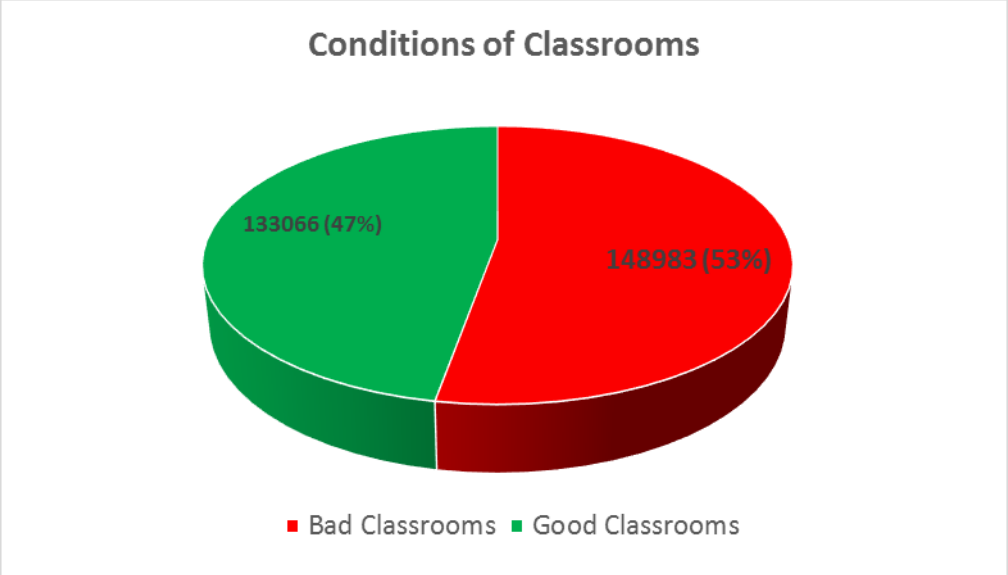

Figure 2: Percentages of Good and Bad Classrooms

Teacher Training

So also is the quality of teachers. The consideration of getting children to be IT literate at an early stage and enshrining ICT as a vehicle and enhancer of learning is also complicated by the overarching need for their teachers to be also well-trained. As several studies show, this requirement can be a debacle to a full implementation of ICT in education. Swig (2015) who studied the Latin American case observe that, "Teachers entering the workforce are not adequately prepared to use ICTs as resources to teach and improve student learning". UBEC (2018) survey reveals that the situation in Nigeria is not disappointing as will be expected given the situation of primary education in the country. Of the 252,992 rural public school teachers polled in 25 states of the federation, over 40% are computer literate. The percentage is not as disappointing as the chart (Figure 4) that shows the absence of computers in 87% of the rural schools. This could mean that many teachers are ready for the introduction of ITC in their

respective schools. It is yet to be clear if their literacy is a result of their college training, personal endeavor or in-service training.

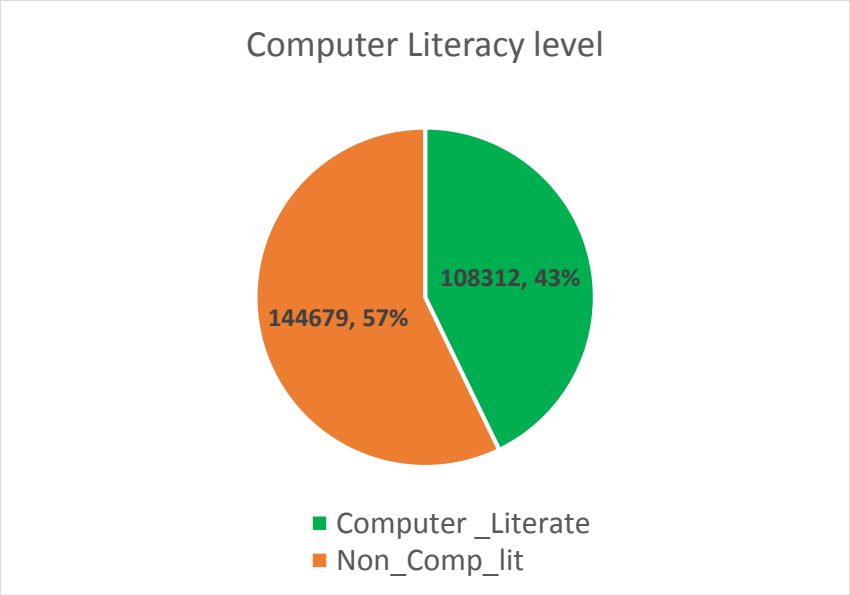

Figure 3: Computer literacy Among Public Schools' Teachers (UBEC, 2018)

It is obvious without ascertaining proficiency levels, that retraining is required based on a planned pedagogy for ICT and e-learning in primary schools. The general competences that capacity building programs normally address include hardware literacy, skills in applications, integrating ICT in learning, and instructional design.

IT Curriculum

That is why it is very important to reconsider and revise the curricula. The National Educational Research and Development Council (NERDC) have IT syllabus from Primary 1 – 6 and subsequently Junior and senior secondary schools. The syllabus significantly is techno-centric, covering mostly the history of computing, computer parts, hardware and software and storage devices. Computer applications are generally delayed until JSS 3 and SS levels, focusing mainly on basic database, spreadsheets, graphics, basic programming and the internet. It is not clear how IT is effected in teaching other subjects and how school administration is computer-aided. Wallet & Melgar (2015:9) discuss how a curriculum should specify the computer skills to be acquired and how ICT can be utilized in learning process to crucially prepare students for their future education, especially for children who don't have IT tools at home. Again, the philosophy behind basic education in Nigeria and the digital skills demanded in the society must be reflected on the curriculum.

Educational Technologies

No matter the curriculum, to boost digital skills and aid learning, there is need for the availability of computers, tablets, smartphones, screens and various audio-visual teaching aids in schools. Ideally their availability need to be sufficient in both density and efficiency in terms of maximizing utility and learner – to – computer ratio. Access to tools must be ensured for learners, for content delivery and administration. All these imperatives require specific capabilities like teacher proficiency, availability of hardware and software, and continuous maintenance of the IT and e-learning facilities. The current educational technology density in rural public primary schools in Nigeria (UBEC, 2018) is abysmal. Of the 50,324 located in

rural areas, only 13 percent have useable computers, 87% of rural schools have not computers at all (fig 4).

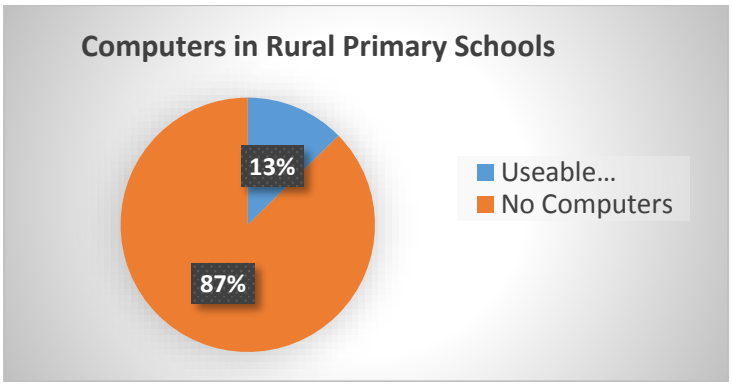

Figure 4: Available Useable Computers in Rural Primary Schools (UBEC, 2018)

This is very low even by African standards. In fact audio-visual tools form only 3% of the whole gamut of learning aids available in the surveyed rural primary schools, where 33% have actually no teaching aids of whatever kind as figure 5 below shows.

Digital interactive tools have expanded, probably making the obsession with learner-to-computer ratio obsolete. With the increase of portable digital tools like phones and tablets, delivery platforms have expanded giving possibilities of leaping beyond the traditional computer lab. In addition it makes not starting with pre-primary and early grades inexcusable. The ICT lab despite many new innovations however, remains central to deploying ICT in schools especially when considering equipment security and situations where other classes are dilapidated.

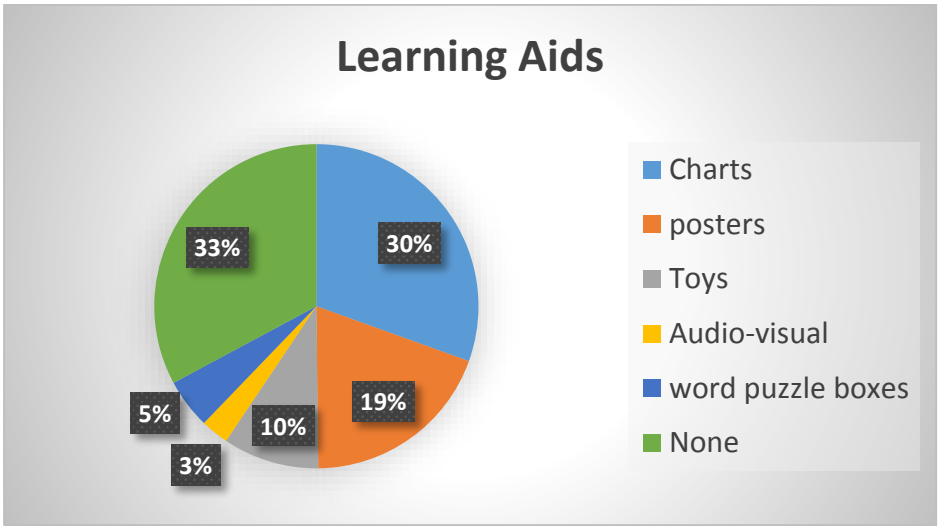

Figure 5: Available Learning Aids in Rural Public Schools for Early Children Care and Development Education (ECCDE)

Source of Electric Power

Another important imperative is power supply. Stable electricity supply is mandatory for a successful implementation of ICT in primary schools. However electricity supply is a huge challenge in both urban and rural areas of Nigeria. So far, the national grid paradigm has not merited any accolade and the prospect of linking rural areas to a functional grid is dim as the recent surveys have shown. Of the 50,324 public primary schools surveyed (UBEC, 2018),

92% have no power supply and there is a near total absence of solar energy in the ecosystem (fig 6). The grid system as the national paradigm for electricity supply is contended by many experts (e.g Bahai, 2013) due to the enormity of its connection expenses, territorial expansiveness, and notorious unreliability. Only 4% of surveyed public schools are currently connected to the national grid (fig 6). Most experts promote a decentralized model that is off-grid, revolving around self-generation and maintenance.

Solar energy, due to its abundance in tropical Africa, is the favorite. Again, the question of cost is no less a challenge even in decentralized models. Assembling a solar system of 5 Kva to support an IT lab will require not less than N3 million (as of 2018) per school. If cost is considered, the least expensive method could be a standby generator (5Kva) which uses fuel. Such an alternative although less costly than a solar system, has the down side of less durability and the continuous need for fueling and troublesome maintenance.

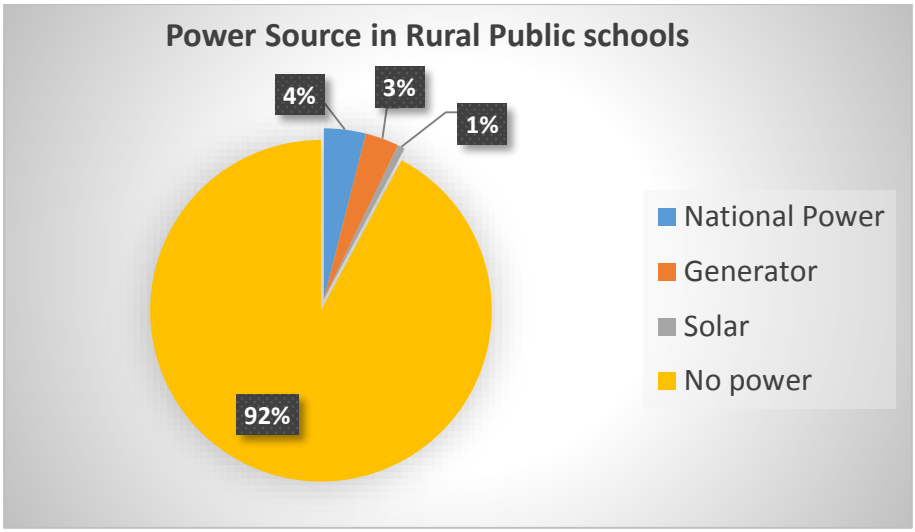

Figure 6: Sources of power in Rural Primary Schools (UBEC, 2018)

Deciding on the off-grid power source model will depend on a meticulous study that is comparative and penchant on cost – effectiveness, considering the project is nationwide.

Source of Internet

Accessing internet is another fundamental aspect of ICT in education. Familiarity with the procedures of harnessing its wealth of resources not only ensure a large percentage of digital literacy but also a potential indicator that a learner would benefit from a modern platform where many services are converging. Providing internet access to rural areas is as daunting as providing electricity. Both have to overcome and balance challenges of cost and model. There are several models for providing internet access to rural enclaves including many experiments like Google Balloons which was conceived in 2013 and Facebook drones. Broadly speaking, there are still three notable ways of providing internet access to rural areas in Nigeria: terrestrial (e.g fibre), Wireless (GSM) and increasingly satellite (especially VSAT). Tremendous innovations, improvements and hybridizations are taking place in the sector necessitating the need for expertise in choice and planning.

Proposal

Having generally considered the daunting challenges that could face the introduction of ICT and e-learning in rural public schools in Nigeria, it is important to elucidate why its introduction

is important in a milieu that is apparently hostile to its domiciliation. The enticing luminosity of a phone, a tablet, or a computer, together with its audio-visual engagement, can be vouchsafed by every parent who had watched his ward grapple with its mastery. Not only do children have fun in learning using IT gadgets but actually show remarkable speed in acquiring navigational skills, subject identification and recall of content. The potential of this enticement in encouraging learning and early skills among children with no access to ICT gadgets at home, and out-of-school children, could be tremendous. In addition the use of ICT to augment subject learning promise equally beneficial outcomes. If the objective of the 9-year schooling in Nigeria is to ensure that children acquire adequate "basic competences and life skills", then ICT should play a significant role in such an undertaking.

I propose to discuss a topology (fig 7) that have pertinent interconnected segments that deal with **E-Strategy** (educational policies, pedagogy, and teacher training), **E-content** (learning materials production, on-line resources and syndication), **E-transmission** (how learning materials are acquired or delivered to learners), and **E-site** (discussing how the various target sites are managed to receive and utilize learning materials and technology).

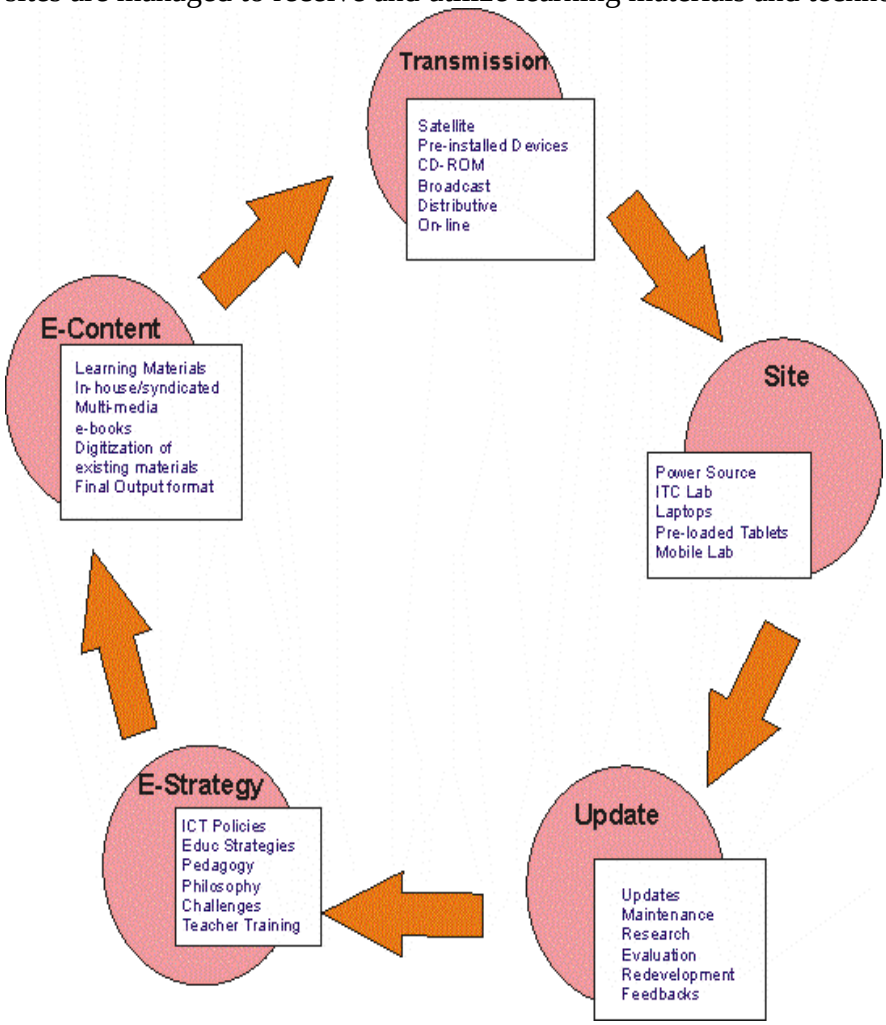

Figure 7: Proposed Topology for the deployment of ICT & E-learning Rural Primary Schools in Nigeria

E-Strategy

Starting with e-strategy is vital because policies and concrete plans that will address general philosophy of the undertaking, curricula, and teacher training will ensure a concrete base for

venturing into implementations and even inviting donor agencies and other non-governmental financing. Investment into thinking and planning is extremely important in education especially as hardware can no longer determine how projects are implemented. The day when a cumbersome monstrous machine can determine how people plan and work is long gone. Technology today is componential that fit into plans and targets according to objective choices. A Choice like what tool to use - workstations, laptops or tablets given a specific learning situation for example.

Beginning with philosophical basis for modelling ICT in rural basic education can illuminate and justify a national project. Fundamentally, as has been documented by various reports and studies, there is the need to ensure that as early as possible young learners start on skills and competencies that will ensure they become capable in partaking in the digital milieus of their society. But most importantly there is a need to break the cleavage between children from a very poor background and those in urban areas who have access to digital tools at home.
Although a general policy like the ones enunciated by the Ministries of Education and Communications like "Introduce mandatory training and appropriate courses for ICT at all tiers of education" may be a starting point, albeit in a nebulous way, pertinent stakeholder organizations like UBEC need to take that as a mantle to create detailed plans and incubation centers for curricula, content generation, training and evaluation.

Essentially both teacher training and primary school ICT curricula should share a matrix of digital competencies and skills currently demanded by the society. As Kalas et al (2012) observes, training should focus on "effective ways to develop the knowledge and skills to strive in an increasingly complex and digital world". Taking word-processing for instance, the skill matrix will, (starting from tertiary level) be advanced word-processing skills to Alphabets learning and verbalization (phonological awareness) at nursery and early primary levels. It appears skills' need analysis, even if not guaranteed to be permanent, should be taken to reflect the current digital competences and skills required in Nigeria. At the universal level, a project to revise curriculum for ICT in primary education need to cover ITC aspects of *digital literacy*, which mostly will come from usage, *information technology*, involving the use of ICT in the acquisition, processing and delivery of knowledge, and *computer science*, the promotion of logic and computational thinking in problem-solving.

The detail areas of digital skills and competencies may include: using technology, using the internet, creating and publishing, communication and collaborations, digital media, using data, programming and control, modelling and simulation. Much will depend on approach and grouping of skills and competencies, especially as IT-aided subject teachings like mathematics, English and science must also be part of the project. Kalas et al (2012) see three distinct approaches to deploying ICT in primary education - 1) incorporating ICT in subjects like science, mathematics to enhance learning outcomes, 2) focus on ICT to develop basic computer literacy mainly focusing on productivity applications like word-processing, data processing and multimedia, and 3) teaching informatics as a distinct subject that cover constructionist aspects of ICT, e.g computational thinking. Knierzinger et al (2002) therefore considers training teachers for ICT competence to include, 'ICT as a subject for teaching, utilization of ICT as tools and ability to teach with ICT as tool and learning material'

E-Content

Learning has expanded beyond the level of text to include the possibility of enhanced interaction in both aural and visual dimensions. Learning about a concept or phenomena cannot

be restricted to verbal descriptions alone. Progress in multimedia communication is a boon to children learning by making digital – based content superior to the mundane textual pedagogy. While teachers have tons of materials to draw from on the internet, the materials themselves depend on the ingenuity of the teacher in wielding them into his lessons. This again signify the need for higher IT proficiency and versatility from teachers who can, given the e-learning tools available, be able to create their own contents. But given the current level of ICT literacy of teachers in public schools, e-learning materials production and adoptions will have to be taken on an enormous scale pending the development of proficiency among teachers.

Apart from on-line materials that can be adopted, abundant CD-ROM materials that were generated in the 1990s can be re-purposed for primary education in Nigeria, this, in addition to new materials that can be designed in-house or syndicated to professional producers. The foregoing will necessitate the creation of a new national incubation center in addition to upgrading educational resource centers all over the states. Centers where teacher trainings, curricula development, technology adoption and maintenance is carried out on a continuous basis. At the beginning much will depend on centralized materials production and guidelines for using them, but hopefully after a period, teachers will be proficient enough to be versatile and highly resourceful in IT-assisted teaching.

One of the complimented topics regarding ICT in early education (Kalas, 2012) is the constructionist approach of teaching early learners using computational thinking. The method which was popular since the 1990s (e.g. the logo experiment in the US and UK) teaches young learners early skills in step-wise approach to problem solving and constructing solutions to problems in a logical way. While this can be taught as a separate subject e.g. informatics, it can also be added as a component to their mathematics curriculum.
In subject teaching, attempt could be made in exploring multi-media supplementation to class textbooks where there is a possibility of enriching them. If tablets are used, they could be pre-loaded with such supplementary multi-media materials for teaching. However converting textbooks into PDFs alone as an exercise in digitization should be avoided, unless such PDFs are highly interactive and enriched with multimedia.

Another aspect that requires digital content production is the provision of basic education for out-school and adolescent education. Ways must be found to include ICT in complementary approaches to teaching out-of-school children and adolescents. Pease (1995) who studied some cases in South Africa, suggests that "methods and materials should conform to the cultural milieu of learners and as close as possible to real-life experiences. The joint development of materials with learners, and the use of indigenous learning materials, associated with cultural songs, dances and toys, local festivals and other cultural events, are found to be highly motivating and empowering". The implication of the above is that in Northern Nigeria for instance, enticing multi-media content that include Arabic and Islamic knowledge should be design in addition to digital, numeric and verbal competencies. In the north east region, this will probably provide a good basis for religious re-education.

E-Transmission

Modelling the delivery of digital services and internet connections to rural areas, a prime requirement in e-learning, is no less problematic than the other imperatives discussed earlier. The challenges primarily are cost and efficiency, especially in the 'last mile' or the backhaul (the means of connection to the wider network). A lot of innovations and changes are taking place in the sector that necessitate careful and through planning before settling on any internally designed paradigm or vendor proposal.

Recently tech giants like Google (2013) and Facebook (2014) announced innovative ways of bringing affordable broadband internet connection to African rural areas. Google intend to use inflatable balloons that float 20 kilometers above the earth surface to deliver internet services to phones and other devices. Kenya is reported to partner with goggle to cover its vast rural areas by 2019, it will be a project worth assessing for replication in Nigeria.

However three possibilities remain open for internet connections and digital transmissions in Nigeria – the satellite, the fiber optic, and mobile telephony. Of the three, satellite appears to be the most promising because of its total coverage when available. But latency problem and its 'last mile' is still cumbersome and very expensive especially if 2-way interactive services are envisaged. Rapid developments are happening in the sector however, necessitating the need for more specialized professionals to be involved in both planning and selection of models (Wang, 2006). Two parastatals that should be consulted to find out what provisions and assistance they could provide are **NigComSat-1R** and **Galaxy Backbone**. NigComSat-1R (2018) promise to 'work with stakeholders in the education sector to deliver unprecedented innovations in the area of tele-education', how this has been achieved is not clear from their website or any other public report.

Similar uncertainty trails the **National Broadband Plan (2013 -2018)** a submission by a presidential committee to the Communication Ministry (2018). The plan had promised 'pervasive broadband deployment, adoption and usage - five times increase in internet and broadband penetration'. Recent newspaper reports of stakeholders meetings, show that the plan has not been achieved, despite fiber-optic cable laying being one of the fastest and most reliable broadband internet connection to the rural areas. As the golden standard of broadband connections, fiber technology promise to delivery more services like TV and other multimedia in addition to internet connection.

The third alternative is GSMA mobile services that have of recent achieved a modest penetration in Nigeria's rural areas. If there is to be an award among the three alternatives for 'who reached the village first?' mobile telecommunication companies could be the first. However the roll out of base stations have slowed down in the past two years allegedly due to the difficulty of getting foreign exchange for imports. Oludimu (2017) who summarized the various reports on recent GSM developments, reports that according to NCC, Nigeria require 60,000 base stations to achieve a universal coverage across the nation.

The fluid nature of the telecommunication situation will necessitate any project to embark on a serious evaluation of the available alternatives in a tabulated form using significant fields like: Type of broadband, cost, prospects, constraints and the 'last mile'. But while such serious planning is going on, the good old way of delivery like pre-installed devices, CD-ROM, broadcast, and other distributive techniques could be used to delivery learning materials, from National, State and Zonal resource centers.

E- Site

The IT lab is still indispensable in deploying ICT in rural schools in Nigeria because it can serve the multi-purpose function of housing adequate workstations, laptops and for storing and charging tablets. It can also be equipped with a display unit for full classroom sessions.

The number one challenge for an ICT lab in a rural school in Nigeria is that of power supply. Power supply like the internet and communication imperative require careful assessment of alternatives and adequate planning that involve outrageous setup and maintenance costs especially considering that 92% of public primary schools have no electric power supply (Fig

6). Off-grid options like solar can address limited appliances that may negate the idea of a centralized multi-purpose lab. An adequately equipped ICT lab may require a solar system that is over 21 kW in addition to the large number of panels as a load calculator (fig 8) shows.

Appliance	Quantity	Watts	Hours On per Day	Watt Hours per Day
Desktop Computer (Standard)	20	200	12	48000
Display screen board	1	200	12	2400
Compact Fluorescent 20 Watt	4	22	12	1056
Smart Phone - Recharge	25	6	24	3600
Tablet - Recharge	25	8	24	4800
TV-LCD	1	150	12	1800
DVD Player	1	15	12	180
Ceiling Fan	4	120	12	5760

System Calculation Results	
Killowatt Hours per Month:	2636.244 kWh
Peak Sun Hours:	5 hours/day
Percentage of Solar:	100%
Solar Panel Watts:	300 W
Number of Panels:	71
System Size:	21.09 kW

Figure 8: A Solar Load Estimation of the proposed ideal Lab

However, the main advantage of solar system is the scalability and the growing efficiency of inverter battery storage. It has been proven that 3 and 5 kVAs systems with inverter battery storage and four solar panels do support up to ten workstations. The Rural Electrification Agency of Nigeria (REA) is a government body that can be approached to find out if they can expand their **Energizing Education Programme** to include a plan for ICT Labs in the rural primary schools in Nigeria. Much again will depend on showing preparedness by providing detailed requirements.

The other alternative, power generators, although will cost less than the initial solar system setup, have the challenges of maintenance and fuel cost. Generators are still the familiar source of off-Grid power in Nigerian rural areas due to the relative availability of fuel and generator's ability to carry heavy loads of appliances for more hours than the solar system. The added advantage of more hours of electricity means more hours of learning and accessibility for both learners and teachers (e.g. the addition of evening classes).
Added to the power challenge on site, is the need to select a classroom to be converted into an ICT lab. A selected room must be refurbished from the roof to the floor to create a well-fortified room that will house computers, tables and other educational technology. Adequate sockets must be planned with the lab totally rewired for connecting appliances. In addition the lab must be renovated to make it burglar-proof but well ventilated. Two indispensable personnel for the ICT lab would be a security guard and a lab attendant who is expert enough to look after the lab.

Another important challenge that must be overcome is accessibility. A plan must be worked out for equitable access by students of all grades. In an ideal situation, all classes should be techno-smart, but since this is far-fetched given the prevailing conditions in rural areas, access to a central lab must be equitable both to learners, teachers and subject teaching. It is no use

restricting a central lab to teaching only ICT as a subject. In general the lab should be a multi-purpose digital hub, a resource center for learning, teaching and even administrative tasks like exam statistics, pupils and personnel data, etc.

Updates, Evaluations & Maintenance

Central to this proposed topology is the essence of continuous evaluation of any emanating project, updating of contents and a general revision of curriculum and implementation strategies. It is significant to establish, even before starting a project, efficient mechanisms of assessing and monitoring, to ensure the enormous expenditure requirement of ICT and e-learning, is effective in preparing children and teachers for a continuously evolving digital age. That is why Wagner et al (2014) in their Conceptual Framework for ICT Monitoring and Evaluation, point to the centrality of both the national development context and the educational context in creating assessment indicators. In Nigeria, this factor is very important because of the lack of synergy among many institutions and parastatals and the disparateness of policies and initiatives.

The primary importance of a component for updates and evaluation in this topology is data gathering and evaluation. Many studies (e.g Nwoko, 2015) lament the lack of data and cohesive monitoring and evaluation of educational development in Nigeria. Hinchliffe (2002) has in fact pointed to a decline since the beginning of this millennium, implying that colonial data on education is more accessible and comprehensive than now. There is nothing worse than working with unknown dimensions, aggregates and factors in social and educational projects. Added to data gathering is a need for a think-tank for the project. The continuous assessment of curriculum, learning materials, and courses for learners, teachers and even administrators should be established within a strategy for integrating ICT and e-learning in primary schools. Training of teachers should include ensuring that they can operate equipment, use software and carry out instructions.

Conclusion

This proposed topology hopes to provide a rudimentary framework that is broad and inclusive of the various components recognized as needed to be addressed in deploying ICT and e-learning in the rural areas of Nigeria. Hopefully the topology will provide a framework for a national planning by any stakeholder. There is no substitute for a detailed framework that is all encompassing and carefully costed. Such a plan makes it easier to scale, giving a good picture of both the enormity of funding required and the specific challenges to overcome. A workable plan that can emanate from an awareness of all the imperatives involved, will eliminate the proliferation of disparate efforts by various stakeholders, agencies, donors and the private sector that quickly dissipate into discontinuous embarkations.

This study in addition, may eliminate the despairing view that the abysmal condition of primary education in Nigerian rural areas negates the need to introduce ICT and e-learning given the more urgent need for infrastructure and qualified teachers. A dogged introduction of ICT in rural primary schools in Nigeria can quickly bridge the digital divide between children in urban areas who have access to ICT tools at home and those in rural enclaves who have not, thereby ensuring all are carried along into the digital future.

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