M-Learning:
A New Paradigm of Learning ICT in Nigeria

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Abstract—**Mobile learning (m-learning) is the study and practice of using mobile devices, such as smart phones, mobile phones, tablets, PDAs, MP3s and pocket PCs in learning and teaching. M-learning has become paramount for developing countries such as Nigeria, as many of these countries have the required infrastructure and a rapidly increasing amount of mobile device users. In addition, mobile devices are able to support a variety of learning activities and learners are generally willing to use the devices for learning. In this article, we have enumerated the possibilities and challenges of implementing m-learning in a developing country context, specifically in Nigeria, and identified potential m-learning solutions to support learning of ICT in Nigeria. We administrated a questionnaire to find out primary and secondary school students readiness in Nigeria to adopt m-learning, their preferences to use specific m-learning devices and solutions in learning situations, as well as their opinions regarding the suitability of m-learning for learning ICT-related subjects. We also propose a cloud-based m-learning model for learning ICT topics in Nigeria.**

Index Terms—**Cloud-based learning, Computer studies, ICT in Nigeria, m-learning**

I. INTRODUCTION

Mobile learning (*m-learning*) is considered to be the simplification of learning and access to educational content through the use of mobile devices [2]. The advent of mobile and Wi-Fi technologies has abetted innovations in m-learning, and Ting [1] has enumerated different mobile communication devices that support the multipurpose facets of m-learning. New digital learning environments are created to support these advances in order to make learning more flexible and engaging, potentially by anyone, anytime and anywhere. Learning materials are designed and compacted into chunks and consumable formats before releasing them to learners. The convergence of audio, visual, web, internet and mobile technologies into a single platform shows the strength of m-learning. Facilitation of learning through mobile devices has many advantages including supporting communication and increasing learner-to-learner interactions [3]. Also, large number student intakes, poor infrastructural facilities, inadequate time and opportunities for staff due to tight working schedules are reasons for developing nations to implement m-learning [4]. In addition mobile devices are more easily accommodated in the classroom than desktop computers. The lightweight nature of mobile devices in comparison to computer science textbooks is a huge source of attraction to learners [5]. Thus, m-learning offers exceptional possibilities in the field of ICT education specifically in African context.

The Nigerian government has put in place several *ICT* (Information Technology & Communication) initiatives to make m-learning accessible to students. Nigeria being the most populous African nation has the highest number of mobile network access subscribers in Africa, which contributes massively to its potential for managing m-learning facilities. According to The Nigerian Communications Commission 2014 online statistical editorial on mobile markets, Nigeria is listed among the world top 8th mobile markets with over 170 million mobile subscribers [6]. The reasons for m-learning expansion in Nigeria include, for example, low cost of devices, availability/accessibility, cheaper maintenance cost, lower energy requirement, and easy mobility [7].

However, teaching and learning of ICT on m-learning platforms is also facing many challenges in Nigeria as a result of teaching methods, government policies or learners participation. Basically, there are numerous problems in the existing learning system in Nigeria that impact the ability to implement mobile learning solutions in Nigeria, such as, poor infrastructural development, youth unemployment, lack of instructional materials, high cost of private schools, inadequate teacher professional development, and the lack of materials to support special education - physically challenged individuals [8], [9], [7].

In our study, we elaborate the prospects of implementing m-learning as a new paradigm for learning ICT subjects in Nigeria. We analyse potential motivations, benefits, necessary infrastructure, user perceptions, readiness and identified challenges for applying m-learning to study ICT topics in the context of a developing country. Our study contributes to the design and development of a novel m-learning platform for learning ICT in Nigeria. This is a continuous research work and part of first author's doctoral studies.

In our study, we seek answers to the following research questions:

1. Does developing country such as Nigeria possess the required infrastructure to implement m-learning?
2. What are the benefits and challenges of m-learning implementations for primary and secondary school students in developing country such as Nigeria?
3. What are the required features of a typical m-learning platform for learning ICT?
4. What is the level of readiness and suitability of m-learning to support learning of ICT among primary and secondary school students in Nigeria?

In addition, we propose a cloud-based framework for m-learning ICT subjects in Nigeria among basic school and senior secondary level education. The framework is comprised of remotely deliverd ICT lessons, mobile quizzes - where students are presented with exercises for continuous assessment, SMS notifications for updates and information regarding the subject, school activities diary for keeping records, social collaboration features, and student progress tracking which provides an opportunity for teachers and parents to monitor students' progress.

II. MAPPING THE TERRITORY: ICT EDUCATION AND MOBILE INFRASTRUCTURE IN NIGERIA

A. ICT Education in Nigeria

Several regional governments in Nigeria are embarking on m-learning initiative projects to provide ICT education. For example, Lagos and Osun state governments recently launch "Tablet of Knowledge" initiative for all primary and secondary school students to support m-learning across the states. In these projects, tablet PCs are provided free of charge to teachers and students to aid learning. The initiative delivers tablets with text books, tutorials and practice questions in order to convey fascinating, flexible, and interactive learning environment to support anytime anywhere learning for the teeming student population. The initiatives are relevant to ICT education since ICT subjects are compulsory in the curriculum. Even though these initiatives are good, there exist numerous institutions of learning and schools that do not make use of the provided mobile technologies to support the drive for digital learning environment [10].

Nigeria has a new 9-year Compulsory Basic Education Curriculum which commenced operation in September 2008 [11]. The new curriculum comprises of a three level structure as follows:

i. Lower Basic Education (Primary 1-3) (Age 6-8years) Basic 1-3
ii. Middle Basic Education (Primary 4-6) (Age 9-11years) Basic 4-6
iii. Upper Basic Education (Junior Secondary 1-3) (Age 12-14years) Basic 7-9

In all the three levels of this basic education, Computer Studies/ICT is a compulsory subject. During the Basic Education Certificate Examinations (BECE) at the end of the 9-year basic education schooling, pupils undertake a placement examination for Post Basic Education (Senior Secondary School).

Pupils in the compulsory basic school normally sit for computer studies in their Basic Education Certificate examinations [11], [12]. IT education is confronted with similar challenges of the Nigerian educational system as identified in [12], [13], [9], [7]. The challenges mentioned are poor infrastructure, insecurity, poor funding, poor implementation and management strategy, inadequately trained computer science teachers, poor maintenance culture, institutional readiness, teachers and learners competence. Therefore, the current learning environment is not fully suitable for computer studies/ICT, however with continued effort in research, stakeholder's enlightenment about the relevance of m-learning, increased government
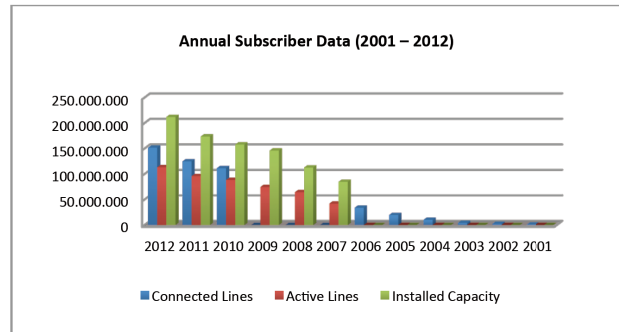

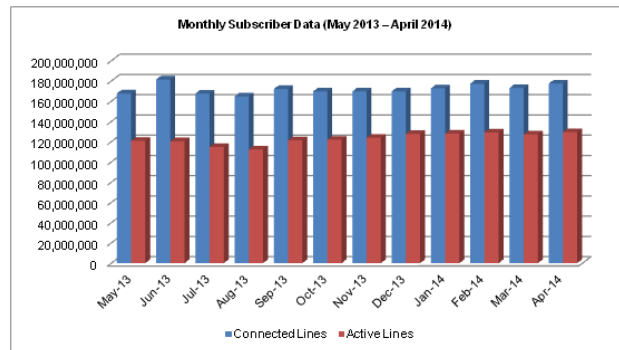Figure 1.   Annual Subscriber Data (2001 – 2012) –Source: [6]

Figure 2.   Monthly Subscriber Data (May 2013 –April 2014) – Source: [6]

funding and sunstantial infrastructural improvement, these problems are surmountable.

B. Mobile Infrastructure in Nigeria

In Nigeria, telecommunications comprises television, radio, fixed and mobile telephones, and the Internet. There is a new facet to internet connectivity in Nigeria allowing millions of people to now access the internet on their mobile phones. As provided in Fig. 1, Nigeria experienced a dramatic upsurge of connected lines between 2001 and 2012. Also in May 2013 to April 2014 there was a rise in number of active lines as shown in Fig. 2. This sudden rise has paved way for increased access to the Internet and a massive shift to learning online by all people irrespective of age, gender, social status and academic profile.

Students can access internet services with their mobile devices using either a data plan from network operators such as Globacom Limited, Etisalat Limited, Airtel, MTN Nigeria Communication, Visafone Limited, and Multilinks Telkom or Wi-Fi networks provided by educational institutions' computer centers, cyber cafés and private/home network installations.

There has been no significant increase in mobile subscription lately, possibly due to militancy, terrorism, and insecurity experienced in some part of Nigeria. Mobile (GSM) has the highest percentage of subscriptions in Nigeria, providing an opportunity for the huge population to access the Internet. Even masses in remote areas can boast of data and internet network coverage. With this new paradigm in place, it appears that m-learning can succeed in Nigeria since the right atmosphere is provided in terms of mobile phone penetrations, telecommunication network availability, and interest from stakeholders.

III. MOBILE LEARNING FOR ICT EDUCATION IN DEVELOPING COUNTRIES: OPPORTUNITIES AND CHALLENGES

A. Potential Motivations and Benefits of Applying M-Learning

According to [17] the main benefits of m-learning are prospects of ubiquitous learning and raising usability of pervasive learning. Opportunities for lifelong and continuous learning without constraints of time and space are opened. M-learning implementation offers students the chance to enjoy absolute flexibility, collaboration, freedom, just-in-time learning, and focused self-centered learning [4]. Another clear advantage of mobile learning is to support communication and increasing learner to learner and learner to teacher interactions [3]. For example, teacher's comments are easily communicated to the students and possibly to their parents or guardians. Monitoring of learners progress is carried out online in real time. Students are provided opportunities to make amendments to their performances and teachers assist in this direction [14].

Some learners are especially attracted to technological innovations, exciting features and learning applications found on mobile devices. When the learning medium is appealing, students become curious and desirous of getting immersed in the process of learning. Thereby, increasing engagement and overall output of positive learning [7]. Besides, learners are able to use their mobile devices at any place anytime: in the classroom, library, restaurant, café, home, and the bus in order to continuously learn and remain active. Another advantage of m-learning is time management and tracking features. Learners as well as their instructors regularly face messy time plans. This could undermine their confidence in achieving daily academic targets and expectations. M-learning implementation which consists of a feature for automatic tracking of learners' progress could be a reliable solution to messy time schedules. The progress of learning activities can be monitored when learners attempt quizzes via their mobile devices. Also mobile devices are more easily accommodated in the classroom than desktop computers. The lightweight nature of mobile device in comparison to computer science textbooks is a huge source of attraction for learners [5].

Cost related problems for m-learning are minimal given that the implementation of m-learning systems are encouraged on open source software platforms, technologies and operating systems such as Android. Students can explore this opportunity to learn and create custom-made applications free of charge [14]. Young people are fond of playing computer games as a form of educational and entertainment medium. The application of educational computer games in computer science courses has been found to be effective in stimulating learners' understanding of ICT concepts and further motivating them to learn. This learning model can be exploited for m-learning implementation since they are found to improve the knowledge of subject matter and increases learners' fun, engagement, concentration and focus during the course of learning. It has also been shown that educational computer games increased educational success and enthusiasm when compared to a traditional classroom scenario in subjects such as computer science education, science and mathematics [15], [16]. Socially disadvantaged and physically challenged individ-

TABLE I.
CHALLENGES OF M-LEARNING [4], [5], [7]

Category of challenges	Identified challenges
Technical challenges	Network connectivity and bandwidth, Battery life, small screen size and key size, Limited memory size, Layout of content when viewed on emulator compared to on real device, File format support, Several developer proprietary
Security challenges	Device content security, Piracy and copyright infringement, Theft of device, Misuse, virus and malware
Social challenges	End users' inability to access and afford the cost, Lack of basic skills, Training and support, Negligence of socially disadvantaged and physically challenged individuals, Lack of self-confidence in ICT use and application
Pedagogical challenges	Adaptation of present e-learning resources for m-learning, Capability to execute content of m-learning, Conversion from teacher centered to learner-teacher method, Assessing learning content outside the schoolroom, Suitable learning model and learning theory, Coping with theoretical dissimilarities between e-learning and m-learning, Planning and implementing of innovation for lifelong learning, Assessment of outcomes of m-learning implementation, Lack of constraint on learning schedule, Lack of demographic border, possibility of getting distracted
Peculiar challenges in developing country scenarios	Poverty and affordability, Lack of infrastructure and Network issues, Insecurity and Political instability, Government inadequate policy plan and implementation, Issues relating to poor acceptability, Stakeholders negligence of education, Limitation to technology accessibility, Poor awareness among teachers

uals in the society could be catered for through learning via mobile devices. These groups of people mostly lack self-confidence in the use and application of ICT and they are commonly found in developing countries such as Nigeria. Stead [18], confirmed that learning via mobile applications helps to eliminate the obstacle faced by young and disadvantaged people in information technology related areas. It creates a huge paradigm shift and a bridge in independence, enthusiasms, and confidence towards working with information and communication technology offered by the use of mobile device in learning.

Mokeira, et al. [19], studied the educational challenges confronting African youth and educational systems. A proposal was provided for the application of m-learning as a practical and coherent means of conveying education to African youths. Azi, Nkom, and Schweppe [20], considers recent ICT advancements such as Intellimedia, New Partnership for Africa's Development (NEPAD) e-School, One Laptop Per Child (OLPC) and Intel Classmate projects as successful and proposes the provision of digital contents to Africa that showcase the rich African cultural perspective. A scheme for the Interactive Child Learning Aid Project (i-CLAP) model was introduced to provide resources for improving pre-primary instruction in Nigeria. It has been observed that there is a need to integrate ethnic or native contents in order to improve the efficiency and motivation of indigenous students. M-leaning, an existing technology is advocated to strengthen the Massive Open Online Courses (MOOC) in Africa as a means of reaching the rural areas with education [21].

B. Challenges, Risks and Potential Problems of M-Learning

Technological innovations such as m-learning are not immune to challenges, and m-learning has its limitations. Since this is a new learning paradigm and it's still in infancy or at the experimental stage in developing countries such as Nigeria, m-learning is faced with the hurdles encountered by most technological novelty of this nature. Boyinbode, Bagula, and Ng'ambi [22] opined that lack of persistency of face-face lectures is a challenge to learning in South Africa, and they proposed an m-learning platform for students in self-paced learning. This could be seen as a step to automate a learning scenario but might not be completely persistent, enduring and reliable considering the large number of students and lack of infrastructure in an average Africa society.

We have summarized the identified challenges, risks and problems related to m-learning in Table 1. The challenges are categorized into five types: Technical, security, social, pedagogical and challenges related to the developing country context. In our work, we aim to overcome some of the identified challenges by designing and implementing m-learning solutions for IT subjects.

C. Examples of Mobile Learning Solutions for ICT Education

In this section, we give five examples of concrete mobile learning solutions for ICT education. The examples are selected to show that there are different types of solutions to support learning of ICT via mobile devices.

1) Example 1: Mobile games for programming

Games programming on mobile devices is a promising solution when teaching and learning ICT/programming. Problem-based learning and games development to learn programming for school students was implemented in [25]. The game platform allows touch input devices for coding and learning conditional programming and algorithm sequence ordering. Students in Nigeria could be attracted to indigenous games for ICT education (Figure 3).

2) Example 2: Programming on mobile devices

TouchDevelop by Tillmann, et al. [26] is another solution for programming on mobile devices. It provides a programming platform and code editor on mobile devices. The platform enables the teaching of computer programming directly on mobile devices and thereby serves as an instant support to students' learning. Their study showed the feasibility and possibility of learning programming on mobile devices, and the experience of middle and high school students confirmed the viability of learning programming on mobile devices (Figure 4).

3) Example 3: Teaching programming languages with mobile devices

In order to teach programming languages on mobile device, Fenwick et al. illustrate using tablet PC mode of Entourage Edges to implement logical microlabs in logical programming language (Prolog) and functional programming language (F#) [28]. An application which supports students to run programs on their mobile devices was developed (Figure 5).

Figure 3. Gameplay Screen. Source: [25]

Figure 4. Two screenshots illustrating the TouchDevelop programming environment on mobile devices. Source: [26]
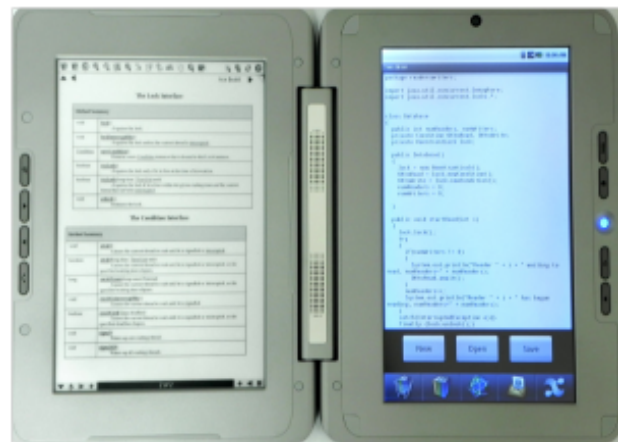

Figure 5. Solving a Microlab on the Entourage Edge. Source: [28]

4) Example 4: Pearson problems in mobile devices

A mobile application for Parsons Problems, which facilitates the learning of programming was presented in [29]. Learners could build programs through small tasks of ordering and aligning program codes. Parson problems are appropriate for mobile learning since the small tasks help learners develop programming skills (Figure 6).
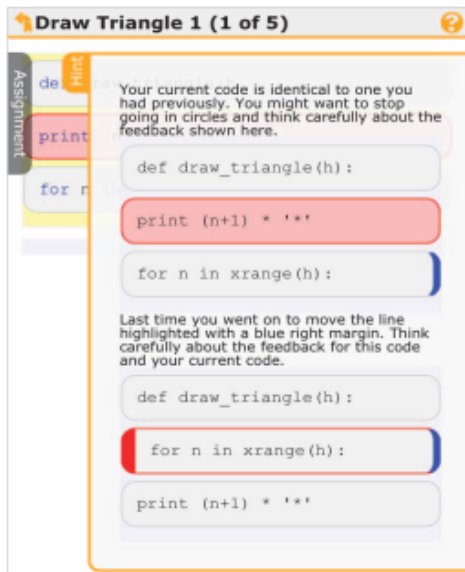
Figure 6. MobileParsons environment showing hints, blue highlights to show changes made by learners, and red highlights to show errors. Source: [29]

5) *Example 5: Scaffolding construction of programs*

Scaffolding construction of programs was proposed and developed in [31] to support novice programmers who intend to use mobile phones to program outside the classroom settings. An Android platform with five-level scaffolding framework was used for the design (Figure 7).

The above examples are applicable to developing countrys' learning context because learners could be attracted to the possibilities of learning programming on their mobile devices. Features such as learning apps, learning games, collaboration, automatic assessment, multimedia contents, learning content sharing, and visualization are relevant solutions that will facilitate learning on m-learning platform. Some identified learning theory that could form the basis for m-learning solutions in ICT education are social learning, active learning, collaborative learning, project-based learning and problem-based learning.

IV. RESEARCH DESIGN

We follow a design research approach in the work, which is part of the doctoral studies of the first author. Design research method proposed by [32], [33] consists of two emphases: development of novel products and creating operational guidelines for successful decision making. Design research creates artifacts and innovations through rigorous process of iterative fine-tuning of problems, solutions and grounded scientific methods. One of the principal benefits of design research is that it necessitates researchers and specialists to work in partnership and collaborate to solve problems and create innovations [34]. It involves the following phases: identify problem, design a solution based on prevailing ideologies, create a prototype, evaluate and test, while iteratively refining the problems, solutions and approaches until a desired outcome is achieved. The overall aim of our research work is to design a novel m-learning solution to support ICT education in the Nigerian context. The study reported in this paper is the first phase of the process, called problem identification. The phase is conducted parallel with a literature re-

(a)

(b)

Figure 7. Two screenshots indicating (a) full program & (b) executed program of a completed problem. Source: [31]

view related to mobile learning in the developing country context. During the problem identification phase, we are looking for results that will help in the designing of a solution for m-learning platforms for ICT education. It is possible through a survey and critical review of existing m-learning platforms.

We used questionnaire to collect data and to obtain responses from the participants regarding the use of mobile devices for learning. The study was conducted between February and May 2014. Twelve (12) primary and secondary schools in Adamawa State of Nigeria were included for questionnaire coverage. A total of 1000 questionnaires were distributed among the 12 selected schools. 980 questionnaires were returned completed, representing 98% response rate. The consent to carry out this research work was given by the school principals. The following statements were used to obtain respondents views about the

various subjects addressed in this research work (see the questionnaire in Appendix A):

i. Identify your type of device
ii. Estimate how much you use various functions of your device
iii. Are you ready for m-learning?
iv. Select the feature(s) you feel is appropriate on m-learning platform
v. It is suitable that I can learn on my mobile device anywhere anytime

Replies were mostly entered on a five-point Likert-scale: Strongly disagree, Disagree, Unsure, Agree, Strongly agree except for mobile device identification and frequency of usage of mobile device functions.

V. RESULTS

The features of mobile devices and their usage frequency are depicted in Fig. 8. Most of the primary and secondary students engaged in the use of social media, chatting, playing educational games, making phone calls, sending SMS and browsing the internet several times a day while most student rarely download documents.

The second aspect of the study was to find out about the ownership and type of mobile devices used by the students. The results derived from our questionnaire are presented in Fig. 9. We can see that most of the students in primary and secondary schools own a mobile phone compared to smart phones and other mobile devices. The result confirmed that the students have experience with the use of mobile devices.

Not more than 12% of students who participated in the survey are yet to own a mobile device which could be attributed to a lack of finance to own a device or parental disapproval. The idea of learning through mobile devices might not be completely accepted in developing nations because of a lack of awareness on the application of these devices in the learning of ICT. Most students indicate their readiness to embark on learning via mobile devices as shown in Fig. 10. Less than one fifth of the respondents are unsure whether to commence m-learning, while only 6 % of the respondents are completely unprepared for m-learning.

On the features supported by the students to be implemented on m-learning platforms, as presented in Fig. 11, the students are strongly in support of blog and social media forums, course materials available on m-learning platforms, task feature, and a timetable for learning activities.

Other features agreed by the students are push notifications, assessment and grading features, and learner's progress monitoring tools. The last aspect of the survey investigated the suitability of m-learning for computer studies/ICT in primary and secondary schools as depicted in Fig. 12. It is worth noting that most students agree that m-learning is appropriate for learning ICT subjects. M-learning is believed to ease the difficulty of delivering learning to people in remote areas and offers the much yearned for transformation of the educational sector of developing countries. Most especially in the aspect of student populations in any ICT class, m-learning has the potential of enabling access to more students at a lesser cost for institutions.
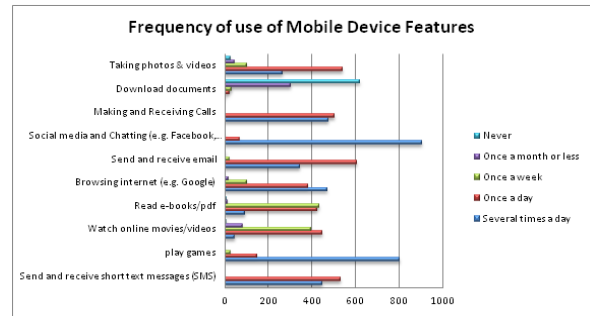

Figure 8. Mobile devices features & frequency of use by primary and secondary school students
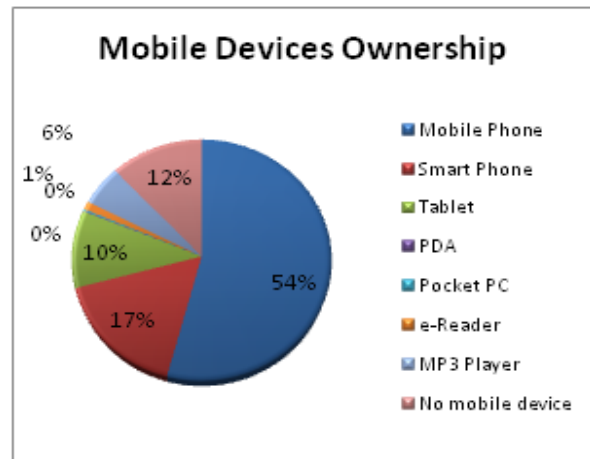

Figure 9. Mobile devices owned by primary and secondary school student
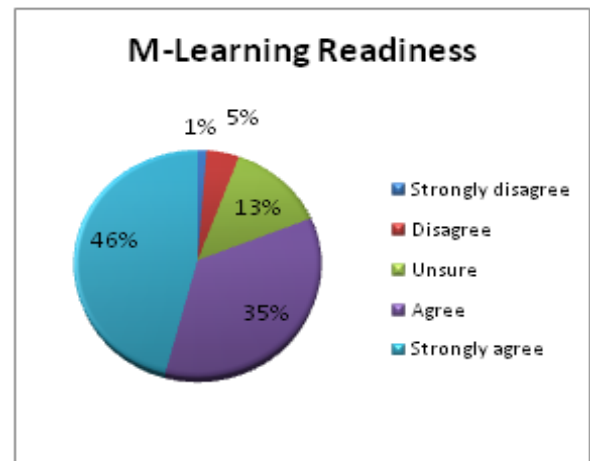

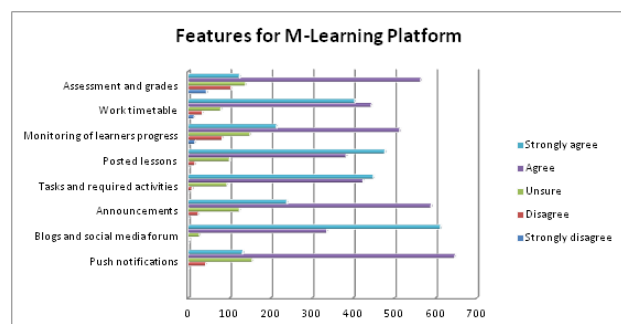Figure 10. Readiness to commence m-learning by primary and secondary school students

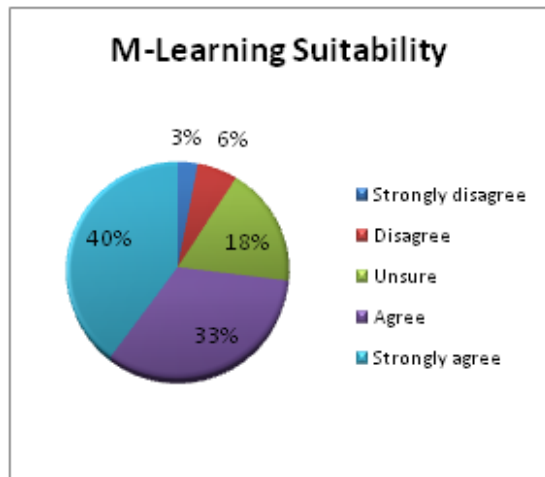Figure 11. Recommended M-Learning System Features

Figure 12. Suitability of M-Learning for IT studies in primary and secondary schools

Figure 13. Proposed Cloud-Based M-Learning Model

VI. DISCUSSION

In our study, we have examined the prospects of m-learning implementation for learning computer studies in primary and secondary schools in a developing country scenario. First, we have enumerated the benefits of m-learning to developing countries such as Nigeria; assessed the availability of network and telecommunication infra-structure, and identified the challenges of implementing m-learning platform in Nigeria. Second, we have intro-duced several concrete examples of using mobile technol-ogies in ICT education. Finally, we carried out a survey in order to investigate the user perceptions in terms of avail-ability of mobile devices, readiness of students for m-learning and suitability of m-learning for teaching com-puter studies/ICT. According to the survey conducted, it is now confirmed that students possess the mobile devices required for carrying out m-learning. We therefore rec-ommend that since most of the students already own a mobile device, opportunities are available for formal and informal learning. Moreover, it will reduce the impending cost of m-learning implementation [5], [7]. Mobile devic-es features and frequency of usage by primary and sec-ondary school students was another relevant area covered by this research work. This is an effort to identify those activities regularly carried out by students with their mo-bile devices. While we found that social media, chatting and playing games are the most engaged activities, a good percentage of students are also involved in other m-learning related activities such as browsing the internet, watching online videos, and reading e-books/pdfs. The inference from these results is that the students are already conversant with the technical procedures of learning con-tent and material access from their mobile devices.

A large percentage of the students that participated in the survey indicated strong interest to commence m-learning. The implication of this result is that the students are willing to enjoy the benefits accruing from m-learning such as flexibility, mobility, collaboration, learning any-time, anywhere and other benefits most especially to de-veloping African scenarios as provided in [7], [4]. The features supported by students for implementation on m-learning platform are reasonable enough to cater for their basic learning needs and provide for online collaboration, progress assessment as well as the critical success factors [35].
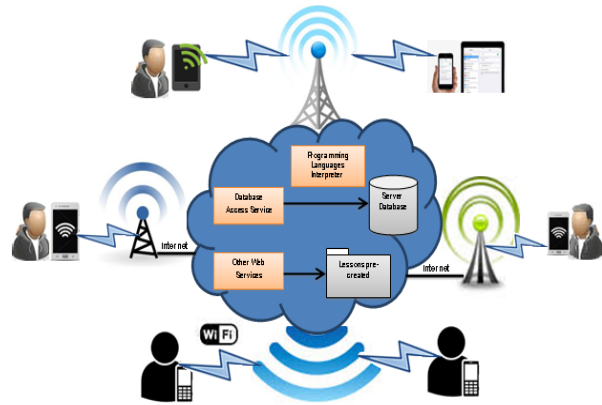
A. Proposed M-learning Model for Learning ICT in Nigeria

In order to implement m-learning platform for learning ICT in developing countries such as Nigeria, a cloud-based model is proposed (Fig. 13). The concept is to ena-ble students to learn ICT subjects on their mobile phones and tablets while on the cloud. At the same time, it will enable teachers to create their own classrooms where they can post new lessons and quizzes while also allowing interactions with the students. There are several noticeable issues with implementing a learning system model such as the one proposed in this research work. One relevant benefit is learner mobility which allows freedom to the student to learn anywhere anytime at own pace without interruption using their mobile devices. The proposed m-learning model will support students' mobility and flexi-bility [5].

B. Adopted Solutions from Previous Examples

Some of the examples of mobile learning solutions pre-sented in the background section would be relevant in the proposed model: a function for video animations of ICT topics such as algorithms, and sorting techniques would be provided for students. This will support ICT learning on mobile devices as realized in [23]. Multimedia learning through contents like audio, images and video will be supported as proposed by [30]. Experimenting with this model will be undertaken to find out if the known limita-tions of mobile device such as small battery capability and small screen size affect students learning.

The aspect of learning ICT through playing of games is another solution which the proposed cloud-based model will address as opined by [25]. Students can learn ICT concepts such as algorithms and conditional programming on mobile devices. The platform will provide code editor interface, and feedback on programming assignments [27]. It will be possible for learners to assemble program-ming codes through small tasks such as the Parson prob-lems [29] and also scaffold the construction of programs [31]. These functions are meant to support novice and expert ICT learners to use mobile devices inside and out-side classroom settings.

Besides mobility, there will be a reduction in the cost of learning when this system is implemented. Students can use their mobile device directly to learn with the aid of a cloud based system. Asabere, [4] noted tight budgets and poor funding as the principal problem encountered by institutions interested in m-learning implementation in

developing nations. But cloud computing is proposed as a possible solution for this problem.

Contextually, the proposed system will address issues of large number of students attending classes in a small classroom due to lack of infrastructure. Leveraging on the apparent broad ownership of mobile devices in Africa to convey education, the problem of disadvantaged youths in the society can be reached through m-learning. The identified solutions would work directly in Nigeria but games programming solution could be tailored to include indigenous games.

Generally, the proposed cloud-based learning model is envisaged to support pedagogical developments, increase teachers output and reinforce good practice in computer studies especially in developing country such as Nigeria. The much yearned for illumination into theoretical concepts required for successfully transfer of ICT knowledge and skills are reinforced. The implementation of the proposed model requires educational policy makers to be conversant with innovations in educational technology. Opinions of stakeholders in both ICT and education sector should be indulged in the entire process of this m-learning implementation.

C. Features of Proposed Cloud-Based M-Learning Framework

The followings are the proposed features to be implemented in the m-learning system for learning computer studies/ICT:

1) Social media features

Social forum/media, blogs and chatting are important features identified in both student responses and consulted literature [30]. These features will be implemented in the proposed model so as to create opportunity for collaboration and activeness in learning. Students are provided with the functionality to facilitate free expression of their views on topical issues especially regarding their programming learning to teacher and peers.

2) Learning material repository

The component which supports uploading and downloading of learning materials, personal content sharing such as photos, and multimedia learning contents such as video will be implemented with the aim of supporting students learning aspirations as identified in [23], [30]. This will create a distinctively engaging and fun learning experience for students.

3) Open source solutions and identification of learners

In order to reduce the cost of m-learning implementation, a cloud-based model will be adopted. Moreover, since we identified that mobile network infrastructure is adequate and up-to-date in Nigeria, there is need to leverage the existing network infrastructure to create a cost effective platform for students and parents. Open source technologies and operating systems proposed by [14], [24] will be applied in the development of the m-learning system for ICT education. An authentication feature which will help to ensure the safety of the learning materials, protect against identity theft and guard security challenges will be implemented on the proposed cloud-based model [7].

4) Posting quizzes and tasks

Features for posting quizzes and tasks to support problem-based learning opined in [25] will be implemented on the proposed cloud-based model. Prospects for monitoring learners progress will form part of the implementation. Functionality for push notifications, announcements, creation of groups to support collaborative activities will also be part of the proposed system [36].

VII. CONCLUSION

M-learning is envisioned to make learning accessible to everyone irrespective of class, social status, academic qualification and societal strata. Moreover, the use of mobile devices in several contexts is considered an emerging ICT landscape within the eAccessibility 2020 study [37]. People in remote areas are most especially expected to feel and reap the benefits provided by m-learning. The convenience of mobile phones and the penetration of telecommunication into African economy is a sign of hope for education through mobile devices. Moreover, the ownership of mobile phones by many students and familiarity with mobile device features such as social media forums, chatting, browsing the internet, e-book reading exhibited by students in primary and secondary schools in Nigeria are good indicators to students readiness for the new learning paradigm. The new paradigm is fundamentally the shift or concepts of using mobile devices for learning ICT.

Nigeria as a developing country possesses the required infrastructure to implement m-learning. Telecommunication operators are continuously improving their services to world class standard. The benefits of m-learning to any society are enormous, most especially with the cloud-based model proposed in this research work. The challenges facing m-learning in developing countries can be overcome when all the stakeholders in the education sector collectively push for policies that will favor m-learning. There is need for infrastructural development and increased awareness about the benefits of m-learning to people in remote areas. A typical m-learning platform requires features that will make learning interactive and fun to the students. The outcome of the survey indicate that mobile devices are useful in learning computer studies/ICT subjects as most of the primary and secondary school students already use them in their learning activities. We argue that m-learning is therefore a new paradigm of learning ICT in developing countries. In the future, we plan to implement and deploy the proposed cloud-based m-learning model as part of a PhD research process. We will further study the impact of the m-learning model and critically examine the teacher's position on learning through mobile device in Sub Saharan Africa.

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APPENDIX A

1. Identify your type of device: Mobile Tablet ⬜ Mobile Phone ⬜ Smartphone ⬜ PDA ⬜ Pocket PC ⬜ Other mobile device (please specify)

_____

2. Estimate how much you use the following functions of your device:

Mobile Devices Features & Frequency of Use	Several times a day	Once a day	Once a week	Once a month or less	Never
Send and receive short text messages (SMS)					
play games					
Watch online movies/videos					
Read e-books/pdf					
Browsing internet (e.g. Google)					
Send and receive email					
Social media and Chatting (e.g. Facebook, Twitter, 2go, WhatsApp)					
Making and Receiving Calls					
Download documents					
Taking photos & videos					

3. Readiness to commence M-Learning:

Are you ready for m-learning?	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Response					

4. Select the feature(s) you feel is appropriate on m-learning platform

Features for m-learning platform	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
Push notifications					
Blogs and social media forum					
Announcements					
Tasks and required activities					
Posted lessons					
Monitoring of learners progress					
Work timetable					
Assessment and grades					

5. M-learning suitability:

m-learning Suitability	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
It is suitable that I can learn on my mobile device anywhere anytime					