Smart learning environment for computing education: readiness for implementation in Nigeria

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Abstract: This study examined the readiness and prospect of implementing the smart learning environment (SLE) for programming education in the context of Nigeria. An overview of design science research as the methodology for implementing SLE was introduced. Data collection was conducted through a questionnaire, and a descriptive statistic was adopted to analyse the data. The result showed that students placed a high expectation on SLE features such as location and social awareness, pedagogy and adaptivity to learning preference. Besides, the study investigated whether the implementation of SLE in Nigeria is possible. Consequently, issues regarding basic requirements such as the inadequate supply of electricity, low memory and battery capacity of the smartphone, and inadequate cloud infrastructures were identified as potential challenges that may affect the implementation of the SLE in the context. Taken together, these findings do support strong recommendations to stakeholders regarding the use of smart learning technology as mainstream for programming education, and provision of basic infrastructures needed for the implementation of SLE at higher education institutions.
Keywords: Smart learning environment, programming education, infrastructure, Nigeria

INTRODUCTION

The implementation of a smart learning environment (SLE) is capable of improving programming education. The SLE is a new concept in the digital learning space created to make learning more adaptive to context and content, providing instant feedback, and engaging learners anytime and anywhere. The SLE is envisioned to make the developing of programming and problem-solving skills a flexible experience. This new paradigm of learning can also make learning accessible to everyone irrespective of location, learning status, and preference (Abtar & Hassan, 2017; Hwang, 2014). Learning of computer programming remains one of the challenges facing the students and educators (Kazimoglu, et al., 2012; Maleko, et al., 2012; Williams, et al., 2002). Computer programming is the actual transcription of abstraction into a computer understandable language. The stages of computer programming involve writing, testing, debugging and running a set of codes using different programming languages (Renumol, et al., 2009; Ahmed, et al., 2018). These stages can be tasking and complex, especially for novices. Previous researches (Renumol, et al., 2009; Stamouli, et al., 2004; Oyelere, et al., 2017) have shown that often, programming is relatively considered difficult among other science-related courses, and building the skill takes time and commitment (Maleko, et al., 2012).

Computing education have been researched over the years and fundamental issues regarding the teachers, students, resources, and teaching methodology have been topical (Sentance & Csizmadia, 2016; Dasuki & Quaye, 2016). Some of those studies identified the potential challenges that confronts the computing education and provided recommendations or solutions (D'Souza, et al., 2008; Oyelere & Suhonen, 2016). In Nigeria context, the challenges are obvious from the resource's perspective, although not too many researches have studied the specific challenges. However, one that has been reported is the use of traditional approach towards teaching and learning of programming and problem-solving skills (Dasuki & Quaye, 2016; Oyelere, et al., 2017). This method is already archaic and should be overhauled by providing innovative technology approach to improve teaching and learning experiences.

Efforts to ease the task of learning how to develop problem-solving skills and programming education exist. Some authors applied approaches such as visualization, games, puzzles, and computational thinking to motivate students and increase interactions between learners and educators (Kazimoglu, et al., 2012; Oyelere, et al., 2017;

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D'Souza, et al., 2008; Stamouli, et al., 2004; Williams, et al., 2002). For instance, Oyelere, et al. (2017), developed a mobile learning system for computing education with puzzles to motivate students' learning experience in Nigeria context. The emergence of smart learning technology such as personalized and self-regulated learning system, adaptive, context and location-awareness leaning tools with timely feedback mechanism, provides ways to learn in an efficient and motivating form (Kim, et al., 2012). Previous research on SLEs has shown the theoretical and conceptual design and how this approach allows for enhanced learning experience (Zhu, et al., 2016). This is evident in the survey conducted by Agbo & Oyelere (2019), where different solutions developed with SLE features to enhance programming education were presented.

This study is explicating the challenges of computing education in Nigeria as part of the goal of the authors toward designing and implementing a smart learning solution for programming education in the context. To achieve this goal, the authors employs the design science research method, which is later introduced in this study. Consequently, this study and other previous research deals with the problem explication phase of the design science research. For instance, a study on the awareness and use of SLE in Nigeria shows that teachers and students have no experience of SLE but are eager to enhance their programming education by embracing it (Agbo, et al., 2018). Therefore, this study discusses the potential of using SLE to make learning and teaching problem-solving and programming education more interesting. SLE personalizes student's learning experience, motivates the student, and provides the teachers with the opportunity to give feedback to develop students' confidence. This study also aims to explore the possibility of implementing SLE as a new paradigm for developing problem-solving skills and enhancing programming education in Nigeria. In addition, the use of the smart technology such as smartphone and other wearable devices in education is an emerging area in the learning ecosystem. One of the ways to achieve the aim of implementing SLE for computing education in Nigeria is to leverage the diffusion of smartphones in the country (Oyelere, et al., 2016). Smartphones are affordable and can be useful within and outside the classroom for enhanced learning experience. With the intended intervention of using SLE for teaching and learning problem-solving and computing education in Nigeria, it is possible to have many learners participating in a course at the same time without converging in a physical location. This kind of learning paradigm reduces the dependence on the limited infrastructure to accommodate large numbers of students at the higher education institutions (HEI) as commonly practiced in traditional classrooms. Thus, the following research questions would be addressed in this study.

RQ1: What are the expectations from students regarding the implementation of the smart learning environment for programming education in Nigeria?

RQ2: What are the potential challenges that may confront the implementation of the smart learning environment for programming education in Nigeria?

LITERATURE REVIEW

The concept of smart learning in computing education

Smart learning has recently been researched to allow learners to be wholly immersed in the learning itself. The concept of smart learning is based on certain features: context awareness, adaptivity, ubiquity, and social awareness. Although this concept is still new, and no unanimity exists on its definition (Abtar & Hassan, 2017), some researchers defined it as the application of technology to make pedagogy seamless, flexible, and efficient (Hwang, 2014; Zhu, et al., 2016; Spector, 2014). According to Spector, SLEs can be referred to as an adaptive technology designed to include innovative features and capabilities that improve understanding and performance. This innovation, as stressed by Spector, includes features that make SLEs adaptive, context-aware, and motivate learning. Similarly, Yassine, et al. (2016) defined such environments as a technology-enhanced learning environment that integrates the intelligent learning systems and context-aware ubiquitous learning. The intelligent feature of smart learning environments includes learning analytics and learner's performance evaluation functionalities. Hwang (2014), defined such environments as the technology-supported learning environments that adapt and provide appropriate support. Examples of learning support features include guidance, feedback, hints, and tools provided in the right places and at the right time based on individual learners' needs. These needs might be determined by analysing student's learning behaviour, performance, and online and real-world contexts in which they are situated. These definitions stress the attributes that relate to technologies and learning scenarios of the SLE. However, it is essential also to consider the input needed for the SLE to determine learner's scenarios. Hence, we define the smart learning environment as an enhanced context-aware ubiquitous learning system that leverages social technologies, sensors, and wireless communication for inputs; determine the characteristic of the learners for a personalized learning experience.

Smart learning is an enhancement in mobile learning; thus, one of its aims is to provide users with a learning environment that is not restricted to a single location (Laine & Joy, 2009). According to Gwak (2010), smart learning is focused on learners and content more than on devices; it is effective, intelligent, and tailored learning based on advanced information technology infrastructure. In other words, the focus of SLE should consist the

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learners and context also, but not only on the utilization of smart devices. Examples of tools designed for computing education with embedded smart features are shown in Table 1.

Table 1 Example of SLE solutions for computing education

Sources	Tool and technology	Pedagogical features
Liew & Xhakaj, (2015)	RedBlackTree Tutor	Help students to learn algorithm for building data structure
Shamsi & Elnagar, (2012)	eGrader	Graph-based grading system for Java programming courses
Grawemeyer, et al., (2017)	LIBE VLE	Personalisation and adaptation features for enhanced learning
Go´mez, et al., (2013)	Units of Learning mobile Player	Adaptation to learners' need—feedback and support, navigation to location, context-aware of educational scenarios
Tillmann & Halleux, (2011)	TouchDevelop	Task-based learning with a little guide in Java or C++
Tillmann, et al., (2013)	Pex4Fun	Game-based, fun-filled learning, and teaching of programming in computer science programming and software engineering class
Oyelere, (2017)	MobileEdu	Puzzle-based learning environment for programming courses
Martin, et al., (2013)	iPro	Game-based tool to learn basic programming
Renny, et al., (2017)	Minerva	Programming educational game that adapts learning content & gameplay
Figueiredo & García-Peñalvo, (2017)	Lightbot	Learning of fundamental programming concepts using Puzzles-based learning platform (JavaScript and Python)
Fabic, et al., (2018)	PyKinetic	A Python tutor mobile tool

Mapping the study context

a. ***Challenges of computing education in Nigeria HEIs***

In Nigeria, students and teachers at HEIs are faced with specific problems that have limited computing education over years (Dasuki & Quaye, 2016; Oyelere, et al., 2016; Agbo, et al., 2018). Similarly, a study by Kamba (2009) had reported that Nigerian universities, for instance, are aware of the technology-enhanced learning environment but are not willing to invest resources for developing such environment to enhance learning. Hence, previous studies' position regarding the state of computing education at HEI in Nigeria remained unclear. Although these issues may not have been studied, but personal experience has shown that teachers find it difficult to teach the subject for comprehensive understanding, and students have also been finding it difficult to comprehend the topics. One of the problems is attributed to a large number of students admitted into a computing degree every year. Hence, it is difficult for teachers to provide intensive tutoring and assessment for their students to identify those with special learning need and provide timely support. Besides, limited number of teachers employed for computing education courses have affected the ratio of students to teachers where teachers are overwhelmed, such that it is impracticable to conduct proper coaching. Sometimes, the number of subjects that are allocated to each teacher in a semester is beyond what the hours available for teaching can allow for effecting course design, which is highly required for programming topics. On the part of students, lack of resilience has caused some students to be discouraged and withdraw from completing computing degree. After failing in a programming course, some students do not have the courage to continue. In addition, the majority are not motivated since the method of teaching is not engaging to arouse their interest to continue the learning (Oyelere, et al., 2016). Sometimes, the period allowed for students to practice in the laboratory is usually inadequate. From personal experience, students, especially in public universities hardly can develop problem-solving skills, understand and read codes, practice and debug errors. Regarding the learning resources, the institutions and government try to provide some infrastructure for learning, but they are not enough. Many of the students cannot afford the cost of learning materials and gadgets such as personal computers or laptops in order to engage themselves in practicing programming skills.

Most of the reported global challenges of computing education (Sentance & Csizmadia, 2016), are viewed from the teachers, students, and resources' perspectives. These challenges as highlighted from the different perspectives by researchers (Dasuki & Quaye, 2016; Kamba, 2009; Ibanga, 2016; Ngene, et al., 2018) are predominant in Nigeria context. The teachers' aspect includes: (i) lack of professional topic knowledge to teach the students; (ii) dry (uninteresting) method and approach of teaching; (iii) limited time spent on designing the course and inadequate preparation. On the students' side, the following are common challenges: (i) low cognitive ability; (ii) lack of problem-solving skills; (iii) poor mathematics understanding; (iv) lack of motivation to learn the topic; (v) limited time for a hands-on practical session. From the resource's perspective, physical infrastructures are the major challenge, which includes: (i) inadequately equipped computing laboratories; (ii) insufficient number of computers for many students admitted into a class; overstressing of the limited resources, which causes them to breakdown. Although these challenges exist, the use of an innovative approach, however, to aid programming education, such as the smart learning environment that comprises of features of computational thinking could reduce these challenges by making the learning experience personalized, adaptive, motivating, and contextualized. For instance, the aspect of assessment and feedback by the teachers can be solved by modelling SLE features that allow automatic feedback

mechanism. In addition, students can be motivated to learn through the social-aware features of SLE. Besides, these students, however, possess smartphones, which are affordable, portable, and can allow learning to take place anywhere, anytime, thereby turning computing education from a localized classroom learning to ubiquitous learning.

a. ***Infrastructure to support smart learning environment in Nigeria***

The availability of information and communication technology (ICT) infrastructure at universities and other HEIs in Nigeria varies from one to another. Some privately own institutions make use of the contemporary ICT infrastructure such as strong Wi-Fi internet connections; well-equipped laboratories with modern smart visual displays; sophisticated computers, smartphones, and tablets; cloud server infrastructure and services customizable for educational use within the campuses. On the other hand, most of the public universities are only able to use moderate infrastructure. This has limited the staff and students at the public HEI in Nigeria where there is more number of student ratio to staff. Considerable improvement has been reported in the aspect of cloud infrastructure (Matthew, 2016; Gital & Zambuk, 2011). Statistically, the study shows that 82% of Nigerian public universities have adopted the use of cloud computing for educational purpose (Matthew, 2016). Some institutions have installed campus area network supported by wireless connectivity at strategic offices for limited users (Gital & Zambuk, 2011). Besides our experience shows that internet connection has improved at the urban areas leaving the rural areas to weak internet connection due to poor services by the internet service providers (ISPs).

Nigeria is yet to deploy the much-needed infrastructure to support state-of-the-art technologies for education. For instance, strong internet required for such technology is lacking in schools. Besides, other generic challenges that have limited the technology-enhanced learning from penetrating HEIs includes high cost of the implementation of ICT laboratories, cost of computers and internet facilities, inadequately qualified teachers, poor incentives and motivation for the educators, government inability to provide the funding needed for the installation, and insufficient electricity supply (Ibanga, 2016). These challenges can inhibit the implementation of SLE in Nigeria if concrete steps are not taken to resolve the fundamental requirements necessary for such implementation. Recently, the online reports of the Nigerian Communications Commission (NCC)—the body that regulates ICT related matters in Nigeria —shows that there are over 169 million mobile telephone subscribers as at November 2018, and over 108 million active internet data subscribers (Commission, 2018) (See Figure 1 & 2).

This statistic indicates that Nigeria has massive mobile phone and internet users with over 60% of its population being active users, which forms a strong base to make mobile learning possible. It is also an enabler for the implementation of SLE HEI in the context. This report is consistent with the result of one of the recent studies regarding the number of students that possess smartphones and have used it to engage learning in Nigeria (Agbo, et al., 2018). The study discovers that most of the students in tertiary institutions in Nigeria possess smartphones compared to the laptop computer.

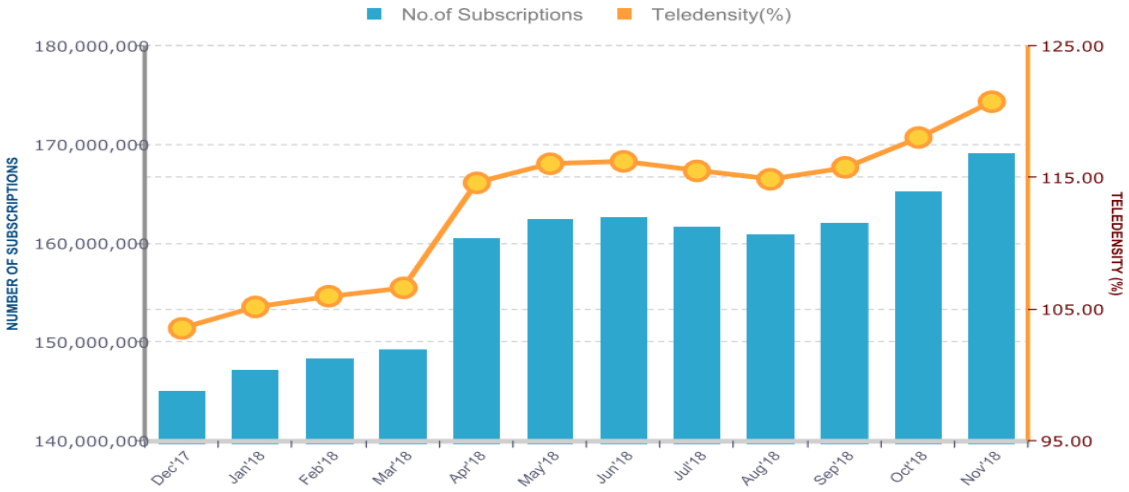

Figure 1 Mobile telephone subscribers in Nigeria as at November 2018: Source (Commission, 2018)

The possible reason for this vast number of smartphone users and mobile subscribers in Nigeria could be due to the affordability of the device, low cost of maintenance, portability and a small amount of power it requires to function. Many of the students regularly subscribe to internet data from their smartphone for online activities such as chatting, messaging, voice and video calling, and accessing learning materials on the internet through social media.

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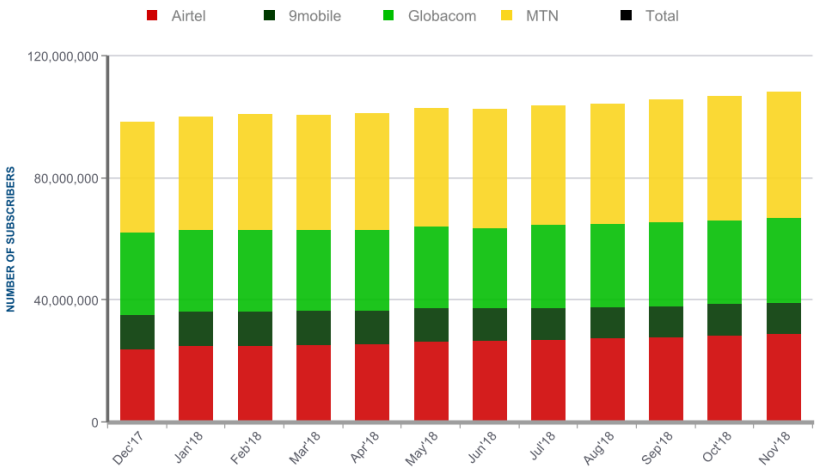

Figure 2 Internet data subscribers in Nigeria as at November 2018: Source (Commission, 2018)

The primary telecommunication firms in Nigeria have internet data bundle subscription plans that are affordable to different categories of users. Even though the internet coverage in Nigeria has not reached the remote rural areas, but the status of coverage is sufficient to encourage the implementation of SLE in Nigeria.

RESEARCH DESIGN AND METHODOLOGY

The methodology of the first author's doctoral research utilizes the design science research (DSR) approach. DSR (Perjons, 2014), comprises of two crucial aspects: developing innovative artifacts and creating practical guidelines for successful decision-making (Oyelere, et al., 2016). DSR creates products and interventions through a rigorous process of iterative refinement of problems, solutions, and concrete scientific methods. One of the unique features of DSR is that it allows the use of feedforward and feedback from the stakeholders to validate the design, development, and evaluation, of research artifacts (Oyelere & Suhonen, 2016). Another benefit of DSR is that it requires researchers and specialists to work in collaboration towards solving problems identified and create innovations (Hevner, et al., 2004). DSR involves the following phases: problem explication, requirements definition, prototype design and development, prototype demonstration, and artifacts evaluation and testing. It iteratively refines problems, solutions, and approaches until the achievement of the desired outcome. The overall aim of our research is to design a novel SLE to support programming education in the context of HEIs in Kogi State, Nigeria. This paper is part of the first phase of the DSR process—problem explication, which investigates the possibilities and readiness for the implementation of SLE in the context in terms of the available infrastructure and stakeholders' perceptions.

In this study, we employ the quantitative analysis of data obtained through a questionnaire. A questionnaire was administered to collect data from students who major in computer science (n=197). Before administering the questionnaire, the first author held a brief session with the students to explain the meaning and concept of SLE as learning aid to support the students learning to program. During the discussions, the participants were informed that choosing to participate in the survey is voluntary. A portion of the questionnaires sought for the consent of the students either to agree to participate or decline. One hundred and sixty-five (83.8%) of the students were from Federal University Lokoja, while thirty-two (16.2%) were from Federal Polytechnic Idah. Moreover, responses were entered according to a five-point Likert-scale as explained by Joshi (Joshi, et al., 2015): Strongly Disagree (SD) to Strongly Agree (SA).

RESULTS

This section is divided into two according to the research questions in the study. The first aspect will present a descriptive analysis of the expectation of students regarding the implementation of the smart learning environment for programming education in Nigeria. While the second part will present findings regarding the readiness of students towards the implementation of the SLE in Nigeria and the presumed challenges it may encounter.

The expectation of students regarding the implementation of a smart learning environment

After the students became aware of the fundamental knowledge of the SLE (including SLE features and potential benefits), the questionnaire that sort for the students' expectations regarding the implementation of SLE to support teaching and learning of programming was distributed to the students. The questions were categorized into two groups as shown in Table 2. The first category includes constructs that are specific to the technical features of SLE— context-aware, location-aware and ubiquity. Similarly, the second category contains constructs that border on the pedagogical components of SLE—adaptivity, pedagogy, and social-awareness. The categorization of these constructs makes it easier to view the outcome of the study concisely from the technical and pedagogical aspects of learning technology.

Regarding context-aware, location-aware, and ubiquity, the students have responded positively to them. For instance, most of the students (M=3.95; SD=1.19) expects a SLE that allows for connecting learners within the same geolocation through the GPS and wireless connection. Even though the students maintain a moderate positive disposition in their responses regarding the ubiquitous operation of SLE, the result shows that the item has the highest standard deviation value in that category (SD=1.48). This, perhaps, shows that the opinion of the students regarding the ubiquity of SLE is scattered across the Likert scale, hence the result falls between positive and neutral.

Table 2 Students' expectations of a smart learning the environment in Nigeria (n=197)

Categories	Constructs	M	SD
Expectation regarding technical features of SLE (adaptivity, context-aware, location-aware. and ubiquity)	I expect a learning platform that will allow access anywhere anytime.	3.73	1.24
	I like to enable the GPS feature on my smartphone when connected to the internet.	4.01	1.19
	I expect a learning platform that displays the location of learners.	4.01	1.07
	I like to connect with learners within the same location through Bluetooth or Wi-Fi.	3.95	1.14
	I expect the ubiquitous feature of the smart learning environment to supports my learning outcome.	3.24	1.48
Expectation regarding pedagogical features of SLE (Pedagogy and social-aware)	I prefer to study programming in a group.	3.66	1.33
	I learn to programme with practical example and tasks than theoretical ones.	3.72	1.31
	I expect a smart learning environment that support and adapt to my ways of learning.	3.93	1.17
	During a programming course, I feel fulfilled when I am able to solve a difficult problem.	3.24	1.51
	My teachers DO NOT encourage me to try out new ideas - think independently.	2.38	1.59
	I expect an achievement badge as a feature of the smart learning environment to motivate my learning.	3.89	1.21
	I expect the social features of the smart learning environment to allow for social networking among friends.	3.70	1.30

Regarding the adaptive feature of the SLE, students have expressed positive to the constructs in this category. For example, the majority of the students (M=3.66; SD=1.33) are expecting a SLE that allows collaborative learning. Collaborative learning is an approach that has been utilized at different educational levels to allow the students to learn from each other (Yassine, et al., 2016; Hayashi, et al., 2015). The result also shows that students preferred to learn with examples (M=3.72; SD=1.31). This shows that the practical session is very relevant during the learning of computer programming. Similarly, the students expect a SLE that can adapt to their preferred ways of learning because 67% of the students (M=3.93) responded positively. This is evident in the students' responses to constructs regarding adaptivity of SLE, which received low standard deviation (SD=1.3), making their responses tilted to the positive side of the scale rather than being scattered. In addition, results in the second category show that students are more interested in features that motivate their learning experience. For instance, most of them (M=3.89; SD=1.21) have expressed that using a SLE with achievement badge will motivate their learning. In another vein, they also expect SLE with features that allow for social networking among learners. However, one of the constructs in this first category that seeks to know whether the students are encouraged to think independently did not present a clear result. This construct (M=2.38; SD=1.59) received the lowest mean and the highest standard deviation in this category. One analysis that is obvious from this result is that the students have a varied opinion on whether there are encouraged to think undependably or not. Again, it can be seen that they are between the negative and neutral. Lack of understanding of the construct by the students may be the reason behind the sparser nature of their responses and hence unclear result.

Anticipated challenges of the implementation of a smart learning environment

The data collected also sort for information regarding the expected challenges that may face the implementation of SLE in the Nigeria context. The descriptive results as shown in Table 3 revealed that the cost of subscribing to the internet could not pose a challenge to the users of SLE in Nigeria. However, the majority of the students (M=3.99; SD=0.97) have strongly expressed that lack or rationing of electricity supply would pose a challenge to the implementation of SLE in the Nigerian context.

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Table 3 Anticipated challenges of implementing a smart learning environment

Constructs	M	SD
I feel that the cost of subscribing to internet data would NOT be a challenge for implementing smart learning environment.	3.93	1.22
I feel that the lack of electricity supply would constitute a challenge for the implementation of a smart learning environment.	3.99	0.97
I think that Nigeria DO NOT have the cloud infrastructure to support the implementation of a smart learning environment.	2.76	1.60

On the availability of cloud infrastructure, the result shows that the students seemed to be neutral. Even though the standard deviation value (SD=1.60) being the highest in this list of anticipated challenges, the responses from the students are scattered, with the majority choosing to be neutral. Perhaps, the reason for being neutral is that the students did not understand the detailed meaning of cloud infrastructure or they are not sure of the current infrastructure available in Nigeria. Furthermore, the students in the open-ended part of the questionnaire expressed other perceived challenges. Their opinions form themes that relate mainly to smart devices and government policies. Concerning the devices, they expressed fear about the capacity of its memory, battery strength, and speed. For example, one of the respondents remarked;

> *"I am concerned about the battery capacity of the smartphones since most of them run low very fast when connected to the internet."*

About policies, some of the students nursed the fear of whether SLE would be adopted in the mainstream education for teaching programming at the HEI level. Some respondents further gave reasons for the concern to be based on the manner the government has not reviewed the computer science curricula to introduce the use of 21st century educational technology.

DISCUSSIONS

This study examined the readiness and prospect of implementing SLE for programming education in the context of Nigeria. The study mapped the Nigerian context by presenting the overview of programming education and the teaching methods, exploring the availability of ICT infrastructures, and the potential opportunities for the implementation of SLE for programming education. Next, we carried out a survey where students responded to a list of questions regarding their expectations and presumed potential challenges that the implementation of SLE may face in Nigeria. The participants (n=197) cut across students from two public HEIs in Kogi State, Nigeria. The results from the quantitative survey showed that participants have higher expectations in the technical aspect than the pedagogical aspect. In fact, comparing the results from the technical and pedagogical aspects of the SLE, students' expectation recorded highest positive response in the location awareness using GPS, and allow connecting with friends and other learners within the same geolocation through the wireless technology. The reason for this high level of expectation could be because Nigerian students are very familiar with the social media (Oyelere, et al., 2016), and have used it to connect with friends for messaging or chatting; sharing of files and contents, and many other social network activities, hence would love to embrace such feature in educational solutions. In addition, many of the students were found to respond positively to expectation regarding a SLE that adapt to learning preference. The expectation on adaptive SLE justified that students are more interested in an intelligent, flexible and personalized learning system. The result also revealed that the students' expectation regarding ubiquity and context-awareness features of the SLE is moderate. The authors perceived that since ubiquity and context-awareness are part of the characteristics of smartphone technology, the students expect them to be naturally inherent in the implementation of smart learning systems. On the other hand, a system that allows for a reward such as an achievement badge to motivate learning, received the highest positive response among the items from the pedagogic category. Conversely, while all items in the technical aspect of SLE received a positive response, the result showed that an item in the pedagogical aspect of SLE that discusses the independence of student in solving problem, received a negative response. The authors were wondering whether the students do not understand the construct, or they may not be too sure of their answer. Questions regarding the pedagogic aspect of the SLE may be considered subjective at this stage of the research; hence, students may have varied perception and may not be too quick to place a high expectation on the system they have not utilized.

Regarding the presumed challenges that may face the implementation of SLE, students have expressed that the cost of subscribing to the internet may not pose a challenge to the implementation of SLE for programming education in Nigeria. This outcome is in line with the efforts of the government towards making ICT thrive in Nigeria. For example, the Nigerian Communications Commission (a government institution responsible for regulating the telecommunications industry in Nigeria) has regulated internet providers to ensure that the cost of subscribing to the internet is affordable for users. This result is also in consonant with the statistics of mobile and

internet subscribers in Nigeria (Commission, 2018), as the government tries to establish policies that would encourage more users to subscribe to the internet. Besides, competitions among internet providers have also contributed to the low cost of services in order to gain more customers. All of these may have contributed to what influenced the responses of the students regarding internet data subscription. Notwithstanding, the government ought to establish Wi-Fi or internet services free of charge to public universities to enable the students to fully utilize the potential of smart learning. Otherwise, in the long run, students might consider it expensive to purchase internet to study in a smart learning environment. However, the study delineated that inadequate supply of electricity in most part of Nigeria is one of the presumed challenges that the implementation of SLE may encounter. Other challenges identified by this study include lack of sufficient memory and battery capacity of smartphones. Creating a smart learning environment would need electricity to power most of the devices including handheld devices. The availability and supply of this basic commodity is still limited in Nigeria and may constitute a major challenge to the implementation of SLE. The last challenge revealed by the study is concerned with the policy formulation. Students are not sure whether SLE would be adopted as the mainstream education for teaching programming at the university level considering the bureaucratic bottlenecks and limited attention given to the education sector by the government.

CONCLUSIONS

The smart learning environment is envisioned to make learning accessible to everyone irrespective of location, learning status, and preference. The concept of SLE is capable of transforming how to gain problem-solving skills and programming education in this 21st century. In addition, ubiquitous users of smartphones and the penetration of ICT into Africa are a sign of hope and an enabler for the advancement of education by exploring these tools. Moreover, the level of mobile subscribers and ownership of smartphones in Nigeria and familiarity with smartphones by students and teachers at HEIs are good indicators towards the readiness for the implementation of the new learning paradigm. This new paradigm in programming education with SLE leverage the smart devices to make the development of problem-solving skill and the acquisition of programming knowledge interesting. This study explicated the problems faced by teachers and students regarding computing education at HEIs in Nigeria and how features of SLE can help to provide an innovative solution. Although, this study has revealed that Nigeria possesses the basic infrastructural requirements for the implementation of SLE, however, some potential challenges have been identified to be capable of impeding its implementation. Nigeria, and indeed the developing countries can overcome these challenges through collaboration between the stakeholders in the education sector and the government to push for the common goal in favour of smart learning. One of the ways this can be achieved is through rigorous infrastructural development by the government and industries, and an increase in awareness and advocacy about the benefits of smart learning for programming education.

The result of this study indicates that learners placed high expectations regarding the implementation of SLE for programming education in Nigeria and that they are eager to have the experience that would impact their learning. Although the low sample size of participants, data gathering technique, and the research method utilized are obvious limitations of this study, the findings suggest that smart learning approach is the new paradigm for programming education in developing countries. Hence, we recommend that designers of SLE for the educational purpose should take into cognizance the identified expectations of the students to have a user-centered solution; developing countries should leverage the opportunities presented by SLE to deploy state-of-the-art learning technology for enhanced teaching and learning of programming education in this 21st century. Government and the school administration should make further effort to provide basic infrastructures needed for the implementation of SLE at HEIs; for example, providing free Wi-Fi for all government universities and ensuring consistent electricity supply across the country. Our future study would be to design, implement, and evaluate a smart learning system to aid the learning of programming in the context of Nigeria.

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