Identifying potential design features of a smart learning environment for programming education in Nigeria

Author

Address

Abstract: Smart learning environment (SLE) has been researched to enhance teaching and learning by providing personalized learning, quick feedback, motivation, and learning support. This study discusses the features of SLE that are relevant to programming education and the general design features for developing SLEs. In addition, the study provides insights into the level of awareness and use of the SLE for programming education in the Nigerian higher education institutions (HEI). In this study, mixed research method was employed to conduct a survey among the teachers and students of computer science at HEI in Nigeria. Data were collected through questionnaire and interview instruments. The study showed that the students and teachers have no experience of SLEs but indicate strong willingness to embrace the use of the SLE for programming education. Besides, tentative features of SLE such as learning guides, personalized learning, quick feedback mechanisms, and automatic task scheduling were identified and presented.

Keywords: smart learning environment; programming education; design principles; Nigeria context

Reference to this paper should be made as follows: Author. (xxxx) 'Title', *Int. J. xxxxxxxxxx xxxxxxxxxx*,

Biographical notes:

1 Introduction

A smart learning environment (SLE) is relevant in programming education since it supports ubiquitous and personalized learning. Features of smart learning environments include adapting to learner's preferred ways of learning, context awareness, ubiquity, and intelligent feedback mechanism (Laine and Joy, 2009). Intelligent feedback mechanism can improve the learners' programming experience. For example, an intelligent tutoring system, Ask-Elli (Gerdes et al., 2016), helps the students learning functional programming to incrementally learn, receive feedback whether they are right or wrong, and present a hint to the solution when they are stuck. Besides, SLE considers affective aspects of the learner such as motivation and emotional states at all times (Self citation). This kind of environments have the potential of producing professionals that may contribute positively to the societal growth of the developing countries; economically, socially, and technologically.

However, higher percentage of the Nigerian graduates applies a theoretical method to the learning of computer programming and do not own good practical skills Okebukola (2003). As reported by Kamba (2009), the awareness of the technology-enhanced learning environment among the Nigerian Universities is very high but the investment and commitment to developing such tools are poor and below expectation. Several other challenges facing programming education in Nigeria have been identified (Self citation, Kamba, 2009). They include inappropriate teaching methods, poor ratio of teachers to students, lack of adequate computers and laboratories, and inability to afford the cost of learning materials. Besides, from personal experience, computer science students in Nigeria can barely afford a laptop to practice programming skill. These students, however, possess smartphones, which is affordable and possess necessary features to support smart learning.

Studies on how to help the students and teachers to learn or teach programming has been conducted in the past. For example, Kordaki (2010) conducted a pilot study on LECGO, a learning environment for programming education. This environment helps the beginners of C programming to learn the concept of problem-solving through the drawing of simple geometrical objects. Similarly, other interventions such as IPRO have been provided to enable students learn programming on their smartphones (Chao et al., 2013; Martin et al., 2013; Self citation). Although these studies exist, but ability to integrate smart features of the mobile technology to enhance learning experience in programming education have not been given much attention.

As a way of providing a solution that allows practical programming knowledge in Nigeria, we ideate on designing a smart learning approach that present the opportunity for anywhere, anytime, and anyhow learning experience. Besides, the study leverages the diffusion of smartphone technology, and integrating its features for programming education. The SLE aim to achieve flexible, accessible, and efficient learning and teaching. To this end, this research work investigates the awareness and perception of students and teachers of computer science in Nigerian higher education institutions (HEI). Besides, the study also finds whether they have the experience of SLEs for programming education. This investigation provides insight into the identified problems and creates the roadmap towards designing and developing a smart learning environment for programming education in Nigeria context.

This study is significant because computer programming expertise has become essential for 21st century students irrespective of the level of education and course major (Fessakis et al., 2012; Verdú et al., 2012). Besides, learning computer programming entails comprehending the much-needed theoretical and practical aspects, which are usually boring and not motivating for most learners (Yeh et al., 2010). The study envisage SLE to transform programming education by providing the following to individual learner: content adaptation, tailored feedback, intelligent support, and personalized recommendations.

Research Questions (RQ)

This study considered the following research questions:

RQ1: To what extent is the awareness of the smart learning environment among computer science students and teachers in the HEI in Kogi State, Nigeria?

RQ2: Has smart learning environment been used in computing courses at HEI in Kogi State, Nigeria?

RQ3: What are the potential general design features of smart learning environment in Nigerian HEI context?

The remaining part of this article is as follows. Section 2 introduces the concept of the smart learning environment and highlights of the features of the smart learning environment relevant to programming education. Section 3 focuses on the research design, context, and methodology. Section 4 presents the results of the study regarding the awareness and use of the smart learning environment among students and teachers in Nigerian HEI. Section 5 discusses the findings, presents the potential features to guide the modelling of the smart learning environment for programming education as a reflection of the findings from the survey. Finally, the section 6 presents the concluding remark regarding the findings from this study, recommendations to the stakeholders and future researchers in smart learning environment.

2 Definition of smart learning environment

The emerging field of the smart learning environment began to show up in the research domain from 2012 when Huang et al. (2012) proposed the concept of the smart learning environment as the highest level of digital environment for a learning system. Since then, many authors, including Hwang (2014), Spector (2014), have made a tremendous contribution to the concept. The advancement of technology, in addition, has caused the transition in the educational learning environment, from the mobile learning environment to the ubiquitous learning environment, and now, to a smart learning environment (Taisiya et al., 2013). Accordingly, the building block of learning technology, that focus on the technology-enhanced system, learning is progressing from web-based learning to wireless mobile-based learning, and from mobile-based learning to context-aware ubiquitous learning Yeonjeong (2011), and from context-aware based to socially aware learning technology (Liu and Hwang, 2010).

Though previous research has shown that the concept of the smart learning environment is still new and there is no unanimity of its definition (Abtar and Hassan, 2017), some researchers (Abtar and Hassan, 2017; Hwang, 2014; Sahar et al., 2016; Spector, 2014), have tried to define it as the application of technology to making pedagogy seamless, flexible, and efficient. According to Spector et al. (2014), the smart learning environment can be referred to as an adaptive technology designed to include innovative features that improve understanding and performance. The innovation as stressed by Spector et al. (2014) includes features that make a smart learning environment adaptive, context-aware, and motivating for learners. Similarly, Sahar et al. (2016), define the smart learning environment as a technology-enhanced learning environment that incorporates the criteria and roles of intelligent learning systems and context-aware ubiquitous learning. The intelligent feature of the smart learning environment includes the learning analytics and learner's performance evaluation functionalities. Hwang (2014) defined the smart learning environment "as the technology-supported learning environments that make adaptations and provide appropriate support" (pp. 5). The supporting features include; "guidance, feedback, hints, and tools in the right places and at the right time based on individual learners' needs. These needs might be determined via analyzing their learning behaviors, performance, and the online and real-world contexts in which they are situated" (Hwang, 2014). The smart learning environment is the form of an intelligent, adaptive and personalized learning intervention that can be integrated with a diversity of devices (Huang et al., 2017).

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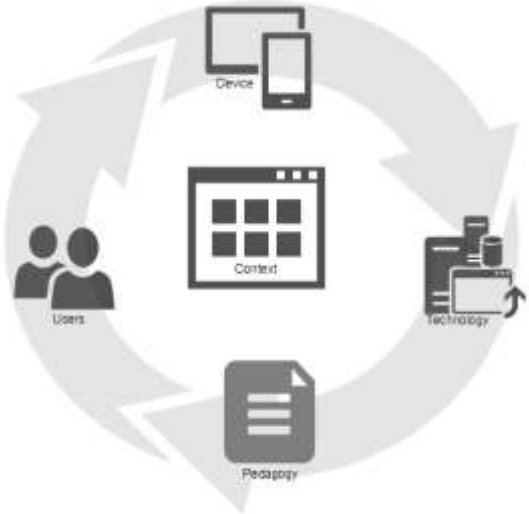
From the array of definitions of different authors, we define the smart learning environment as an enhanced context-aware ubiquitous learning system that leverage the social technologies, sensors and wireless communication of mobile devices to engage the learner for a hands-on experience and presenting the contents in a motivating form. It is capable of connecting learning community, awareness of the physical environment, tracking and rendering of support to users as a learning guide.

2.1 Components of the Smart Learning Environment

Based on the literature that has discussed the concept of the smart learning environment, we have realized key components that play a vital role in the realization of the design of the smart learning environment. These components are shown in Figure 1, which include the user, device, technology, context, and pedagogy, have helped in outlining the proposed guiding principles for the design of the smart learning environment for programming education, which we presented later in Table 7.

Figure 1 Components of the smart learning environment



Each of the components is connected to the context of the application. For instance, the users can engage in learning from a different context; the device context varies with peculiar characteristics; technologies also can be discussed from a different context, and pedagogy depends on the context at every instance of learning. The users directly benefit from engaging in the learning process, thereby expecting a better experience in the end.

i. *The context* of the learners, device, technology, and learning contents are also vital to determining the state the solution should assume at any instance (Yaghmaie and Bahreininejad, 2011).
ii. *The types of devices* used to engage learning is important as not all devices have the prerequisite features that can enable smart learning to take place. For example, smartphones, tablets, and other wearable devices are good options (Periera and Rodrigues, 2013). Old generation computer systems such as the mainframe, desktop computers and other premised based computers do not have the technology required to enable smart learning to take place.

iii. T*echnology* has to do with the design architecture, system communication flow, input and output processes, connection and storage facilities of all technical aspects of the learning environment (Periera and Rodrigues, 2013; Roussos, 2002).

iv. *Pedagogy* is the entire goal of developing a smart learning environment, and it entails the expected learning theory, strategy, method, outcome, and feedback to make the learner aware of the progress made after an instance of learning. Pedagogy, as used in this study, is connected to the learning theories since pedagogical principles basically consider the fundamental theories of learning (Ben-Ari, 1998; Jill and Carol, 2004; Quevedo-Torrero, 2009; Self citation).

2.2 Features of smart learning environment relevant to programming education

The concept of adaptivity, context-awareness, ubiquity, preferred ways of learning, and intelligent system are the critical elements of the smart learning system (Laine and Joy, 2009). These elements are referred to as features of the smart learning environment (Zhu et al., 2016), and they are particularly relevant when designing the smart learning environment for programming education. Although Zhu et al. (2016) highlighted ten features of the smart learning environment, with a broader perspective of discipline. However, we have considered seven critical features of smart learning environments that are computer science education specific, because designing a smart learning environment for programming education requires significant components that enhance the cognitive ability and problem-solving skill of the learners. In this section, we have highlighted seven features of the smart learning environment relevant to programming education as depicted in Figure 2.

Figure 2 Features of a smart learning environment

2.2. 1 Location-aware

The smart learning environment is expected to be location-aware (Zhu et al., 2016), that is, it should be aware of all the environments and the situation in a particular environment such that the technology allows the user to learn within any location. The locations of a learner at any point in time can impact on the learner's learning process and level of understanding. For example, when we relate location-awareness of computer programming study, the task that is interesting to a learner at a play garden may not be attractive to the same learner while on the road. Some users may prefer a simple computational arithmetic task, such as addition, subtraction, and multiplication of

numbers while at the shopping mall. Some may even prefer logical problems in the classroom or laboratory than anywhere else. The contextual location of a learner can be acquired from the environment, whether indoor or outdoor, with Global System for Mobile communication (GSM)-based method, Global Positioning System (GPS) based method, both GSM and GPS methods, and Radio Frequency Identification (RFID) method. Amongst these methods, RFID was reported to be commonly used due to its lowest prices, independence of deployment and ease of implementation (Roussos, 2002). For example, a location-based and adaptive mobile learning system, called Multi-Object Identification Augmented Reality (MOIAR) was developed Chang et al., (2010) to improve the learning content adaptability of learners.

2.2. 2 Adaptivity

The adaptivity in the context of the learning environment is referred to an intelligent tutoring system that allows students to learn according to learner's attributes (Laine and Joy, 2009). These attributes can be the learner's characteristics, mood, convenience, learning style, learning progress or status and cognitive abilities. Researchers have described adaptivity in learning environments as the process of transmuting the learning environment (e.g., learning materials and the user interface) in order to match the learner's context, which can comprise different dimensions such as personal context (e.g., learning style, understanding level, emotional state) (Akbari and Taghiyareh, 2014; Renny , et al., 2017). Adaptivity and learning style are two features of the smart learning environment that are intimately connected. The sequence of learning content can be adapted based on learning styles (Yaghmaie and Bahreininejad, 2011). A practical example of this is the work done by Vesin et al. (2012), in their Java tutoring environment; they implemented adaptation of the present method and navigation according to the learning style (Vesin et al., 2012). In the situation where the learner with visual learning styles cannot receive the required grade for a specific concept, the learning environment changes his/her learning style to verbal.

To model adaptivity of the smart learning environment, users can be allowed to specify their learning goals, preferences, styles, and contents. An example of a system that can adapt to the learner's needs in programming education context is Problet (Kumar, 2013). Problet allow users to learn problem-solving exercises in introductory C++/Java/C# programming courses. The mechanism for adaptivity in Problet is achieved by generating problems on only those concepts that the student has not mastered. This adaptive mechanism minimizes the time spent in learning and better engages the interest of the student (Kumar 2013).

2.2. 3 Interoperability

Interoperability ensures that solutions can support various technologies in order to enhance information exchange. That is, the system should be able to support and operate on different types of technology such as Android, iOS, Windows and the rest, to reduce the cost of usage (Roussos, 2002). Interoperability is very vital in order to achieve the aim of developing a smart learning environment since the users can be scattered everywhere with a different location and device context. For example, the Fast Health Interoperability Resources (FHIR) prototype (Mandel et al., 2016) was built for interoperability of medical applications. Once built, it can run unmodified across different healthcare IT systems.

2.2. 4 Preferred ways of learning

Learners tend to exhibit different traits when engaged in learning. For instance, some learners would prefer to learn with the audio-visual material; some may prefer when the materials are presented in the form of images or info-graphics, while others may prefer a textual format. All these are different categories of learners with different preferred ways of learning. A smart learning environment for programming education context tries to integrate the feature to detect the mode of teaching that is suitable to each learner with the goal of getting the learner to understand the programming concept and build the skill over time. For example, Minerva, Renny et al. (2017) was developed to aide programming education by adapting learning content and gameplay to the learning and play styles of the player.

2.2. 5 Ubiquitous

Ubiquity has been defined as "a new learning paradigm in which we learn about anything at anytime, anywhere utilizing ubiquitous computing technology and infrastructure" (Peter et al., 2010). Ubiquitous learning is the kind of learning technology that is usually associated with a considerable number of microelectronic devices (small computers), which are capable of performing the functions of computations and communication. Examples of such devices include smartphones, contactless smart cards, handheld terminals, sensor network nodes, RFIDs and many more used in everyday (Peter et al., 2010). The ubiquitous component of the learning environment can further detect learners' conditions and context, including locations, actions, time, and weather (Saadiah et al., 2010). Ubiquitous learning according to Kawahara et al. (2003) has characteristics such as permanency, accessibility, immediacy, and interactivity. With the advancement of mobile technologies, new innovative approaches are employed to achieve ubiquitous context-aware learning. For example, Mobile Learning Support System (MLSS) is a ubiquitous learning system, which was designed to enable students to have access to learning material, leverage on the functions of mobile devices such as the camera for barcode reading and global positioning system for location detection (Huang et al., 2010; Yang et al., 2007).

2.2. 6 Context-aware

The concept of context-aware learning Hwang et al. (2008) was aimed at transmitting proper instructional materials and other information to learners according to their individual needs, and this is done through the available sensors embedded in the medium of transmission (Hwang et al., 2008; Ching-Bang, 2017). Macredie et al. (2006) conducted a systematic survey and analysis of publications in the field of the context-aware mobile learning system to arrive at a classification framework. In order to investigate the content in the field of a context-aware learning system, the authors classified the framework into layers. The hardware architecture layer consisting the device used, system infrastructure and the connection type; the context determination layer consisting the type of content and the type of sensors; evaluation layer, which addresses the methods by which the studies were evaluated and the participants of the studies (Macredie et al., 2006). The components of the evaluation layer are the questionnaire, pre-post-test, and interview. This classification is relevant to the development of the smart learning system by x-raying the components, from the type of devices, context, and sensors during the design process. For example, Laine et al. (2009) surveyed context-aware and pervasive learning environment and identified PDAs, and RFID as the mostly used sensor technology for context acquisition.

2.2. 7 Socially-aware

Social-awareness features of the smart learning environment mean that the system is being aware of its environment, what's around it, as well as being able to accurately interpret the emotions of users with whom the system interacts (Airth, 2018). Social awareness, according to Airth (2018), requires competency in some areas like emotional intelligence and empathy. Theoretically, social awareness is the interworking of multiple concepts which include: Social sensitivity - empathy for others and the ability to infer; Social insight - moral judgment and the ability to comprehend situations quickly; social communication - ability to interact appropriately with others including problem-solving interactions (Airth, 2018). For example, in Self citation, the developed a social-aware learning system, based on Android platform that can be used for teaching and learning programming. For instance the *friends, messages, and blogs* features of the system allows for social interaction between two or more friends using the platform. These features also enhance social awareness and collaboration among learners, which makes it a good example of a learning environment for programming education in context.

3 Research design and methodology

3.1 Research context, methods, and data analysis

The participants of this study were students and teachers of public HEI in Kogi State, Nigeria. In this study, mixed method research (MMR) was used. MMR in this context is a method that combines the qualitative and quantitative research approaches (Schoonenboom and Johnson, 2017), which focused on collecting, analyzing and integrating both the qualitative and quantitative research. Study data were collected through the questionnaire and interview. This approach provides a good insight towards gaining the reflections of the participants that could guide the design of smart learning environment for programming education in Nigerian HEI.

Questionnaires were developed and administered to gather data from randomly selected samples of students and teachers. During the distribution of questionnaires, we sought for the consent of participants to allow us to use the data for research purpose, which can be published even though their identities remain anonymous. Since participating in the study was voluntary, the participant can decide to withdraw from the study at any stage and time. A total of 210 students participated in the study, and 15 teachers also participated in the questionnaires administered. 180 (i.e., 85%) of the students were from Federal University Lokoja, while 30 (i.e., 15%) of the students were from Federal Polytechnic Idah. The constructs of the questionnaire elicited information on the principles that guide the design of the smart learning environment for programming education. The survey questions consist of Likert-scale options (Joshi et al., 2012).

The interview was used as the second data collection instrument. Six students were selected at random for an interview to find out about their perspective regarding the smart learning environment. Two focused groups were formed. Each of the interview groups consists of three students. The interview was conducted at different times.

The responses from the group interview were recorded using an Android smartphone with a smart recorder installed on it. The direct content analysis approached was applied to analyze the data gathered from the interview by transcribing the response for cross-referencing and identification of themes. Next, we read the transcripts and labelled relevant themes, concepts and events while deciding which codes are the most important, and creating categories by bringing several codes together. We codded in order to retrieve

vital information about a specific idea found in the data. Vital information about students' experiences and perceptions toward the introduction of the smart learning environment for programming education in Kogi State Nigeria context were retrieved through coding.

4 Results

We want the readers to note that the analysis of data was done according to the Likert-scale options coded as follows: Strongly Agree (SA = 1), Agree (A = 2), Neutral (N = 3), Disagree (D = 4), and Strongly Disagree (SD = 5). It, therefore, means that in our descriptive statistics, the lower the value of the Mean (M), the greater the numbers of responses in favour of the questionnaire construct; similarly, the higher the Mean (M) value, the less the number of responses in favour of the questionnaire construct.

4.1 Awareness of the smart learning environment

The study shows that 76.2% (n = 210) of the students possess smartphone while 100% (n = 15) of the teachers possess smartphone

Regarding the awareness of the smart learning environment, the result in Table 1 shows that a greater number of students (M = 1.86) are aware. Similarly, the mean score for teachers (M = 1.3) also shows that a greater number are aware of the smart learning environment. Interestingly, it was found that teachers are more aware of smart learning than the students.

Table 1 Awareness of smart learning environment

	1. I am aware of smart learning environment		*2. I know about smart learning environment before coming into the University*		*3. I access learning/teaching related materials with the mobile phone*	
	M	SD	M	SD	M	SD
Students (n = 210)	1.86	0.94	2.29	0.94	1.52	0.94
Teachers (n = 15)	1.30	0.49	3.00	0.85	2.00	1.46

Regarding the awareness of smart learning before coming into the higher institution of learning, the result surprisingly shows that 57.1% of the students (M = 2.29) are aware of the smart learning environment before coming into the university as against 33.3% of the teachers (M = 3.0). Similarly, more students access learning materials with their mobile device compared to the teachers (students M = 1.52< teachers' M = 2.00).

4.2 Use of the smart learning environment

Regarding the use of smart learning environment for programming courses, more than half of the students (M = 3.10) indicated not to have used the smart learning environment programming courses.

Table 2 Use of a smart learning environment

	Constructs (C)	*M*	*SD*
Students (n = 210)	C1. I have been taught a programming course with a mobile smart learning solution	3.10	1.11
	C2. I will prefer to learn to program with a smart learning solution rather than the white/blackboard style	1.62	0.85

Teachers (n= 15)	C1. I have been teaching programming courses with a mobile smart learning solution	3.67	1.11
	C2. I will prefer to teach programming with a smart learning solution rather than the white/blackboard style	1.67	0.49

Regarding the teachers' experience on the use of smart learning environment, most of them responded not to have used the smart learning environment for introductory programming. Regarding the preference of learning programming education with the smart learning environment, Table 2 interestingly shows that both the students and teachers are willing to embrace the use of the smart learning environment for programming courses than the conventional use of the whiteboard

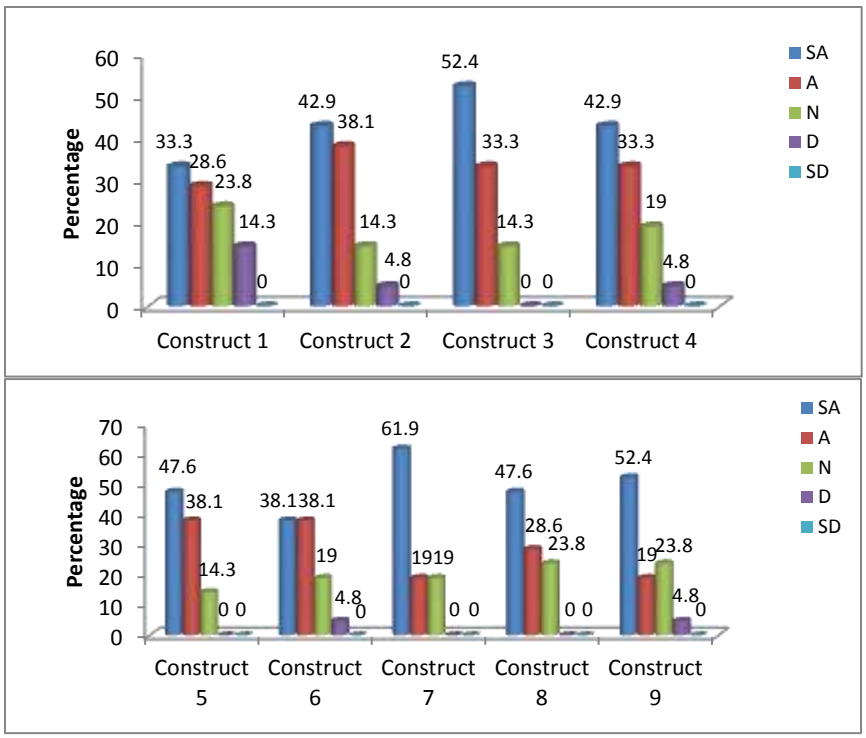
4.3 Students and teachers' contributions towards the design of a smart learning environment

In order to provide an answer to the research question on the practical guide towards the implementation of the smart learning environment, we analyze the quantitative data as presented in Tables 3 and 4 for students and teachers respectively. In Table 3, we realized that among other smart learning components, students are most concerned with personalization, adaptivity to learning style, feedback mechanism, and learning supports. This perception of the students was clearly expressed in their responses (see Figure 3).

Table 3 Students' perspective regarding the design of the smart learning environment

Constructs (C)	*M*	*SD*
C1. In a mobile learning situation, the environment and location at any point in time affects my understanding and performance	2.19	1.05
C2. I would like the mobile smart learning system to keep a record of my profile and learning progress	1.81	0.85
C3. I would like the mobile smart learning system to be adaptive to device screen resolution and to personalize learning	1.62	0.72
C4. I prefer mobile smart learning system implemented on a device that has features such as sensors, camera, RFID & speakers	1.86	0.89
C5. I would love the smart learning system to be developed with robust back-end & front-end and flexible to work both online and offline	1.67	0.71
C6. I prefer the smart learning system that has analytics that evaluate my performance and take certain decisions to improve my learning	1.90	0.87
C7. I prefer the smart learning system that gives a tutorial, learning guides to support learners and feedback mechanisms	1.57	0.79
C8. I would love a smart learning system that allows automatic scheduling of tasks	1.76	0.81
C9. I would prefer the smart learning environment with components that motivate continues learning, for example, puzzles	1.81	0.96

Figure 3 Students' perspective regarding the design of the smart learning environment



On the other hand, the teachers have shown concern for a learning environment that can aid in evaluating student's performance; motivate teaching; work both online and off-line and has proper feedback mechanisms. These were all expressed in the analysis as shown in Table 4 and Figure 4.

Table 4 Teachers' perspective regarding the design of the smart learning environment

Constructs(C)	*M*	*SD*
C1. In a mobile learning situation, the environment and location at any point in time affects the learner's understanding and performance	1.87	0.92
C2. I would like the mobile smart learning system to keep a record of my profile and teaching processes	1.73	0.70
C3. I would like the mobile smart learning system to be adaptive to device screen resolution and to personalize learning/teaching	1.93	0.89
C4. I prefer mobile smart learning system implemented on a device that has features such as sensors, camera, RFID & speakers	1.67	0.72
C5. I would love the smart learning system to be developed with robust back-end & front-end technologies and flexible to work both online and offline	1.80	0.68
C6. I prefer the smart learning system that has analytics that evaluate my student's performance and take certain decisions on how to improve	1.67	0.62
C7. I prefer the smart learning system that gives a tutorial, learning guides to support learners and feedback mechanisms	1.47	0.52
C8. I would love a smart learning system that allows automatic scheduling of tasks	1.73	0.80
C9. I would prefer the smart learning environment with components that motivate continues learning, for example, puzzles	1.93	0.70

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Figure 4 Teachers' perspective regarding the design of the smart learning environment

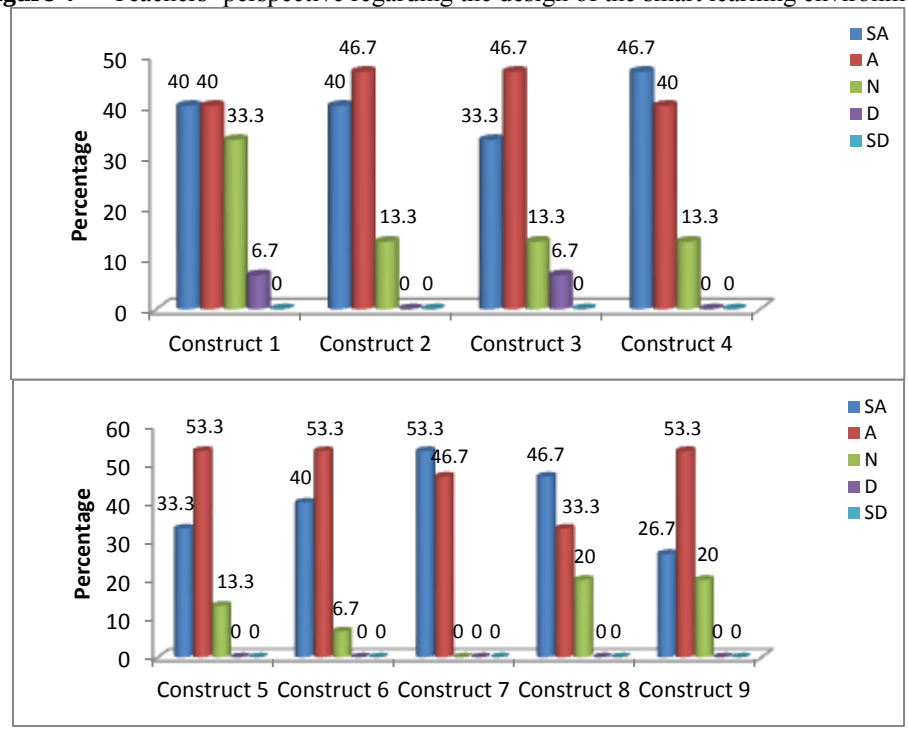

Table 5 presents specific components and features of the smart learning environment and compared the responses from the students and teachers regarding the features. The table provides insight into identifying the tentative features that could guide the designing and implementation of a smart learning environment in Nigerian HEI context.

Table 5 Comparing students and teachers responses regarding the features of the smart learning environment

Constructs (C)	*Students Mean (SM)*	*Teachers Mean (TM)*	*Mean Difference (MD)*
C1	2.19	1.87	0.32
C2	1.81	1.73	0.08
C3	1.62	1.93	0.31
C4	1.86	1.67	0.19
C5	1.67	1.80	0.13
C6	1.90	1.67	0.23
C7	1.57	1.47	0.10
C8	1.76	1.73	0.03
C9	1.81	1.93	0.12

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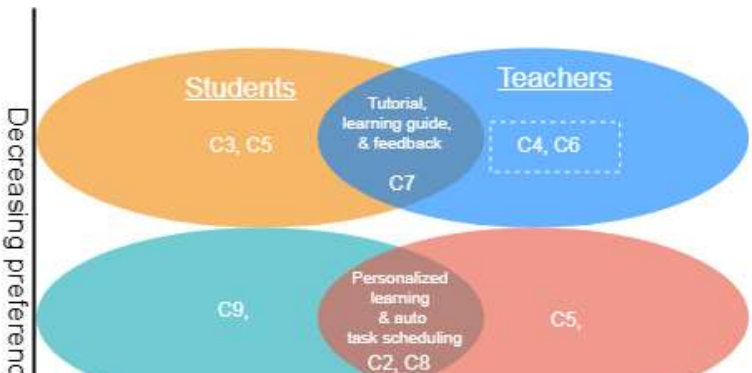

Figure 5 was based on the analysis in Table 5, which presents the students mean (SM), teachers mean (TM), and the constructs (C). It can be seen from Figure 5 that presenting tutorial, learning guide, and feedback mechanism in C7 are the most prioritized features of the smart learning environment by the students and teachers. The analysis also shows that personalised learning (i.e., users profiling) and automatic task scheduling (C2, C8) are the nest in the priority order. Finally, location awareness in C1is the least prioritized feature of the smart learning environment as depicted in Figure 5. The analysis did not show that other features of the smart learning environment (C3, C4, C5, C6, and C9) have common interest in terms of responses from the teachers and students regarding the features of the smart learning environment. However, is it obvious that C4 and C6 has the likelihood of being considered as features of SLEs by the students and teachers.

4.4 Qualitative analysis: expectations towards the design features of the smart learning environment

Based on the interviews with the students, expectations that can guide the designer of a smart learning environment emanated. Although the quantitative analysis revealed that they have no experience with the smart learning environment, however, they have expressed certain expectations regarding the features of the smart learning environment, which is presented in this section. For example, one of the participants expressed that

> "smart learning environment should be able to classify learners and learning content into beginner, average, and master."

Another participant said:

> "I prefer to learn with the smart learning environment that allows access to learning materials in different file formats."

The participants expressed that the current mode of learning programming education does not enhance their understanding. Computer programming has been taught under poor

conditions where teachers, teaching materials, and facilities for practical sessions are grossly limited. One of the 400 level students remarked that

> "the way we studied programming courses right from 200 levels has been through the use of the whiteboard and marker; the lecturers come into the class and explain on the whiteboard, and we thereafter research on our own."

Another respondent said:

> "sometimes the lecturer comes into the class with a soft copy of learning materials and explain. For example, Visual Basic was taught using the same method."

When there were asked during the interview how they usually practice, for instance, programming courses after class, one student remarked thus:

> "those that have laptops install the programming tool on their laptops and learn with the guide from a maybe online tutorial."

Moreover, certain factors have been identified to have an impact on the learner's learning experience. For example, the students have recognized the impact of the environment during learning, especially programming. According to one of the respondents,

> "I like to learn in an environment that is not noisy, like in the library or secluded area where I can stay focused and not distracted."

Similarly, the emotional state of the learner has been recognized as a factor that affects learning. Other factors discovered to impact learning are the material and means of learning. The participants expressed that if learning can be accessed via the readily available smartphones and other affordable handheld portable devices, learning of computer programming can become more accessible and motivating. A participant said,

> "since the smartphone is always on our hands, at any time one can login to engage in learning."

Other themes and expectations regarding the components of the smart learning environment—context, location, preferences, and devices—are have been discussed by the students. For example, they expressed their interest in learning from any location rather than the traditional classroom or lab setting. In addition, the hash condition of the weather, the sitting arrangement and the number of students per class were some of the issues raised. Hence, they prefer a system that makes learning flexible and stress-free. One of the respondents remarked that

> “I do not always like the sitting arrangement in my class; the students are too many and sometimes seat under a hash whether condition.”

The participants also discussed the issue of devices that are capable of enhancing smart learning. Though the majority of the students possess the smartphone, cost of internet subscription is of great concern to them. Many acknowledged that they would not be able to afford internet connectivity continuously and hence advocated for smart learning solution that can be accessed offline. Similarly, one of the participants wants a kind of feedback mechanism that motivates learning by remarking that;

> "I prefer a smart learning environment that has a grading or credit rewarding mechanism to encourage learning."

To some participants, they are concerned about the interactivity and adaptive interface of the system. All of these expectations and advocacies expressed by the stakeholder forms part of the principles to guide the design of the smart learning environment (see Table 4).

4.5 Potential design features for the smart learning environment based on the study

In this section, we present the tentative design features for the smart learning environment for programming education. The design features emanate from the outcome of this study. The convergence of interest in the features of the smart learning environment among the students and the teachers of HEI in the Nigerian context and the common interest identified are connected to the components of the smart learning environment (Figure 1) and presented in Table 6.

Table 6 Potential design features for the smart learning environment

SLE Components	***Design Features***	***Design Guidelines***
Context	• Learning environment (location) • Learner's preferences and scenarios	Take into cognizance the learner's location at any instance (Students could learn computer programming while in a bus, in the lab, in the class, at cafeteria etcetera). For example, a student's response to an interview question in our earlier analysis was "I like to learn in an environment that is not noisy, like in the library or …" Users can specify the learning module and style by quickly responding to a few survey questions. Other learning scenarios also matters.
Users	• Personalized learning • Adaptive interface • Responsive design to screen resolution	As depicted in Table 5, which indicates the most prioritized and common features of smart learning system among students and teachers, the learning experience should be personalized and feedback given to the learner at different stages of learning. The system should have the log for users and track their performance. The system has to have the ability to adapt to the user's context, which can be determined, specified or implied. Screen resolution should be responsive (adjustable to devices' screen resolution) without losing tabs, menus or features.
Devices	• Mobile devices with smart features and sensors	In consonant with the analysis of the study that shows that majority of the students and 100% of the teachers possess smartphone, it is pertinent to design a smart learning environment that is compatible with such devices (Smartphones, Tablets, PDA, and Wearable devices). These devices have features that allow acquisition of context/contents of the users through camera, GPS, RFID, or speaker.
Technology	• Network Communication • Server • Databases • Web services	Internet, wireless connections and cloud technology are needed to ensure a seamless flow of communication between the system and the users. However, some students have expressed their wish to have an offline system due to limited resources to subscribe to the internet. For example, students

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	• Front and back-end technology	(M=1.67) and teachers (M=1.80) indicates that they would want the smart learning environment to be accessible both offline and online mode.
Pedagogy	• Learning content • Task scheduling • Performance evaluation • Feedback mechanism • Supporting tips & guide • Motivation to learn more	As remarked by one of the students in our earlier interview analysis, which states that "…I prefer a smart learning environment that has a grading or credit rewarding mechanism to encourage learning"; it will be interesting to learners if features that motivate learning such as quiz-like features are integrated into the design. Similarly, learning analytics are required to measure the performance of the learner, especially in a programming task. For any correct or incorrect attempt, users should get feedback. In the case of incorrect attempt, detailed analysis should be provided for quick rectification. Learning guide, tips, and other support tools will be helpful to computer programmers, both novices and amateur learners. The system should also allow for inputting, editing and updating contents

5 Discussions

The objective of this study is to investigate the level of awareness and use of the smart learning environment in Nigerian higher education institution and provide the potential features and guidelines for designing a smart learning environment for programming education in Nigeria context based on the reflections from the students and teachers. These reflections are connected to the components of the smart learning environment. The result of the study showed that majority of the students (76.2%) possess smartphones (see Table1), which is consistent with the result of the previous researchers (Periera and Rodrigues, 2013; Self citation). On the other hand, all the teachers (100%) that participated in the study possess smartphones.

Similarly, several students and teachers are aware of the smart learning environment. Comparing the extent of awareness among students and teachers, the teachers are more aware of the smart learning environment than the students. On the aspect of the use of the smart learning environment for learning or teaching introductory programming, both the students and teachers have not used it for either learning or teaching. This perhaps may be because smart learning environments are not available for teaching and learning in the Nigeria context. This finding is consistent with the concern raised by Kamba (2009). The first author's doctoral research objective is to bridge this gap by providing a smart learning tool for programming education in Kogi State HEI.

In addition, the current study also found that students prefer learning environment that adapt to learner's need, motivates learning, personalizes individual learning and could be accessed online or offline. A possible explanation for these preferences may be that the traditional methods of learning that exist in this context lack motivation. The desire for motivation to learn according to the students can start by making available adequate computers and internet facilities in the laboratory as the impetus for learning computer programming. Many a time, teachers present programming knowledge to the students on the whiteboard without practical session, which supposed to give the students an

opportunity to apply the knowledge. Therefore, students have to make further effort to practice the programming topics.

Another important finding was that teachers are desirous of having a smart system that can aid the teaching of programming, allow efficiency and able to evaluate the student performance. The findings of this current study are consistent with previous authors (Self citation; Chao et al., 2013), who also found that students and teachers desire methods that have a direct impact on the pedagogy of programming education, and system that makes the learning of programming interesting.

Similarly, our study has shown that the students and teachers have a common interest in the features of the smart learning system. Some of these common interests include a system that is robust and flexible; accessible online and offline; support quick feedback; teaching guide and tips; user profiling, personalizing, and motivation for continuous learning. To be précised, the study has shown that learning guide and feedback mechanism are the most prioritized features of the smart learning environment. Next features in the order of priority are the learners profiling, personalization and automatic task scheduling. However, location awareness was the least prioritized feature of the smart learning environment.

Moreover, the identified potential features for the smart learning environment, which emanates from this study, are essential and will provide a guide when modelling a smart learning environment for programming education. Furthermore, it is important to note that the students and teachers are both interested in embracing the use of the smart learning environment for programming education by identifying relevant features from their perspective, necessary to be considered when designing the smart learning environment.

6 Conclusions and Future Work

This paper described the advancement in learning technology, the transition of learning environments and the significance of the smart learning environment on the education system. The study provided insight into the design guidelines for the smart learning environment for programming education in Nigeria. In addition, the study indicated that students and teachers possess smartphones in Nigeria. They are both aware of the smart learning environment, but have no experience for teaching and learning with it. Interestingly, the result equally shows that they are willing to leverage the potential of using their smartphones to learn programming education. These findings are enabling factor that justifies the intention of the authors to implement the smart learning environment for programming environment in Nigeria context. Our result also reflects the students and teachers' perception regarding the components of the smart learning environment for learning and teaching introductory programming in Nigerian HEI.

A noteworthy contribution of this work is the connection between the identified potential features of the smart learning environment and its components. This connection between the components and features of SLE, which emanate from the students and teachers' reflections, to the extent of the author's knowledge, has not been discussed by previous researchers. It is important to consider this contribution relevant to future research(er) in this field.

This study investigated only the students and teachers as the stakeholders of programming education in Nigerian HEI. This is a limitation, as including other stakeholders such as the government and agencies of education could give a wider

perspective regarding the use of SLE for programming education. In conclusion, the authors recommend the following: that a smart learning environment should be used for programming education in Nigerian HEI to achieve effective learning experience; that designers of SLEs should consider the identified potential features when designing a smart learning solution. As part of the first author's doctoral studies, future work will involve defining the requirements for SLE in programming education in line with the identified potential features and thereafter design the prototype.

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