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Mobile Learning of Numerical Simulations using Animations

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Abstract:The use of animations as teaching aids has long found its place in teaching and learning processes following its positive results. However, it is usually a computer-based animation that is being used which implies desk-bound learning and may not satisfy the 'anywhere, anytime' learning offered by mobile learning approach. Mobile learning employs mobile technologies and has proven to be an effective approach to facilitate learning as the learners go. This research work, adopts the use of animations in mobile platform to enhance teaching and learning of numerical simulations. A mobile learning system, NuSim was implemented on Android Platform to teach Euler Method, Euler-Cauchy Method, and Fourth-Order Runge-Kutta Method of numerical methods. NuSim was installed on some randomly selected students for testing purpose and found to be easy to use and also enhanced their learning.

Keywords: Animation, Mobile Learning, Numerical Simulation, Euler Method, Runge-Kutta Method.

I. INTRODUCTION

The continued need for effective learning remains a concern of every nation especially, the developing nations. Learning is what gives a nation its place in the highly competitive world of today and therefore, must be given high priority. It is the precursor for technological and economic advances [1, 2, 3]. However, many developing nations are still struggling with the challenges of how to ensure effective learning. Extensive researches have been conducted to find out the challenges associated with learning in such nations. Dictatorship, democratic instability, poverty, inequality, acceptability, cost, availability of manpower, and many more are the many challenges affecting developing nations of Africa like Nigeria [4][5].

One of the major challenges affecting Nigeria is availability of professional teachers/lecturers. The few available ones often times have too many students assigned to them for learning purposes (student-to-lecturer ratio), this certainly affects the learners' simulation rate and performance due to the fact that there is likely to be challenges when it comes to student's assessments, assignments, examination scripts, and most importantly attention given to students. The whole workload on the teachers/lecturers has made the teaching pedagogy and academic quality to become almost ineffective. This implies that the traditional method of learning where both the learner and the instructor meet face-to-face for learning to take place is still the most adopted method in such nations. Therefore, the question is, how can such Nationsuse different approaches to supplement this traditional method for effective learning? What are the challenges that may hinder the success of such approaches?

In the light of such questions, mobile learning readily suffices as one of the better approaches. Many developed and developing nations are adopting this approach and having tangible results to show [6, 7, 8, 9, 10]. Irrespective of the challenges, the adoption of such approach has often yield positive result; implying that more effort should be directed towards addressing the challenges and creating a better platform for mobile learning to thrive.

In Nigeria, where this research was taken, much research has gone into determining the prospects and challenges of adopting mobile learning in the education system [11, 8]. However, little research has been carried out to implement a mobile learning system [6]. In Kaduna University, where is the research was principally carried out, no mobile learning platform was existing as at the time of this research. Therefore, this research was done to determine the acceptability and effect of mobile learning in the Mathematical Sciences Department of the University.

This research, Mobile Learning of Numerical Simulations Using Animations, a mobile application was developed called NuSim to teach students Numerical Methods such as Euler, Euler-Cauchy, and Fourth-Order Runge-Kutta Numerical Methods.

II. BACKGROUND AND JUSTIFICATION

Animation is a technique of representing processes that continually change over time; it allows the visualizations of invisible concepts such as motion of molecules, pumping of blood by the heart, computer algorithm executions, etc. It may be considered as a technique of simulation of processes. Animations have long found a place in learning and have continually been improved in design and use since in the 1980s [12]. Such improvements have led to what is called Augmented Reality (AR) all of which aim at interactive use of technologies to improve learning experiences [13].

Animations are used among many other reasons to make explicit the dynamic changes of a process [14], show stages of a mathematical solution [15], advanced physics concepts [16, 17], and many more. The use of animations for learning purposes have also been assessed and found to improve learner's learning outcomes [18, 17]. Therefore, in this research, textual animation technique and graph are implemented as a mobile learning system to teach learners numerical simulations/methods on mobile platform.

Mobile Learning or m-learning is the process (both personal and public) of coming to know through exploration and conversation across multiple contexts amongst people and interactive technologies [19]. That is, m-learning allows for contextualization of learning that is impossible with desk-bound computing as it involves the exploitation of ubiquitous handheld devices, wireless networking and mobile telephony to facilitate, support, enhance and extend the reach of teaching and learning. At the initial, definitions of mobile learning focused predominantly on the attributes of technology, but now, have given way to more sophisticated conceptualization where mobility is the central focus [20]. This denotes not just physical mobility but the opportunity to overcome physical constraints by having access to people and digital learning and resources, regardless of place and time." [21]. Mobile learning has lots of benefits as documented by Attewell[22]. Thus, to benefit from what mobile learning has to offer, mobile learning system is implemented to teach learners numerical simulations/methods.

The mobile phone's technology has brought with it a total change in the learning methods and the outcome thereof. This follows from the functionalities that are continually being incorporated into them and being exploited. This improvement has led to the development of many miniaturized devices such as the mobile phones and others. Even though a simple definition of a mobile phone is "a telephone which is connected to the telephone system by radio instead of by a wire, and can therefore be used anywhere where its signals can be received" (Cambridge Dictionary), this definition does not qualify today's mobile phones since they are now able to run other applications that do not require the telephone systems. The evolving features of mobile phones have made them to become more portable and appealing because of their small size; rich multimedia presentations, and the capability to run third party programs. They also have memory large enough for small data and applications, long battery life and many more. That is, the today's mobile phone are getting as powerful as the personal computers, with processors, platforms and operating systems that allow developers to develop compelling applications that are in increasing demand and have led to the mobile phone's increasing popularity and adoption in learning environments; some also run applications that are standalone (that is, do not require internet connection or network). With the capabilities provided with mobile phones, one needs to ask himself how he can take advantage of such a technology.

Such questions as above have been the driving force behind the interest of Academicians to assess mobile technology and its impact in learning; and have come to understand that instead of being a threat to the academic development, mobile technology is rather an advantage, since it allows communications and which is what learning centers upon. Therefore, supported the use of mobile phones and other mobile devices (such personal digital assistant) for learning purposes.

Mobile learning goes beyond technological enthrallment; it is the new face of electronic learning environment [23], where 'the value of deploying mobile technologies in the service of learning and teaching seems to be both self-evident and unavoidable' [24]. This holds because "With learners going mobile, supporting their learning through mobile phones to be timely and appropriate, especially for learners in an open and distance learning environment" [25].

Numerical methods which are actually numerical analysis that describe the different algorithms for solving numerical solutions for differential and integral equations; among which are Euler, Euler-Cauchy, and Runge-Kutta Methods which are considered in this research work.

Numerical analysis does not seek exact answers (complete solutions), because they are often impossible to obtain in practice; instead, it is concerned with obtaining approximate solutions while maintaining reasonable bounds on errors. The result is obtained by repeating a set of instructions, that is, the algorithm that describes the method for such solutions. The foundations of all numerical methods depend on Taylor's series defined by a function Where$\boldsymbol{x = x_0}$and $\boldsymbol{y = y_0}$then using $\boldsymbol{h}$ as the step size, we have the Taylor's expansion as

$$\boldsymbol{y(x_0 + h) = y(x_0) + y'(x_0) + \frac{h^2}{2!}y''(x_0) + \frac{h^3}{3!}y'''(x_0) + \cdots}$$

Simulation analysis offers a variety of benefits; it can be useful in developing theories and empirical work. It can provide insight into the operations of complex systems and explore their behavior. It can examine the consequence of theoretical arguments, assumptions and generate alternative explanations and hypothesis, test the validity of explanations [26]. Therefore, the knowledge is required by every mathematics and engineering student. Such knowledge is thought in Mathematical Methods (MTH 201) and Computational Sciences (CSC 309) in Kaduna State University.

III. REVIEW OF RELEVANT LITERATURES

Animation techniques have long been adopted in the learning. Here, a review of relevant literatures is provided.

Chun et al. conducted an experiment to find out the enthusiasm of learners in Mathematics when taught using multimedia animation for teaching in primary school and found that the students showed more enthusiasm. They had two sets of learners, one taught using traditional teaching method and the other taught using multimedia animations [27].

At the School of Biomedical Sciences, The Chinese University of Hong Kong, animations was employed to supplement learning of Physiology content, and the effectiveness assessed for a period of four years. They found that animations had a positive result on the learning outcome as it "… explain content more explicitly to students …" They also stated "that there is greater demand for similar learning tools from students" [28].

Joel and Has him conducted a research at the University of Dares Salaam, Tanzania to find out the effectiveness of the use of animations in the teaching of computer science. They found that the process of developing animations improves the quality of course design and thus the performance of learners [29].

King-Dow and Shih-Chuan conducted an effective assessment of applied animations in exploring dynamic physics instructions for college students' learning and attitude and found that the students' performances were better irrespective of gender, major or disposition [17].

Blanca at 2015 AAAS annual meeting at San Jose, CA presented "Using Animations to Learn Science: A Literature Review" where a study on why learners often have difficulty understanding abstract concept in high school and college science; and how computer animations could be used to enhance their understanding. It was revealed that the use of animations is an effective means to supplement the traditional methods of instructions. However, it was recommended that animations should be designed based on evidenced-based multimedia design principles [30].

All of the above studies employed personal computer based animations. This imply that learning is still desk-bound and cannot be an 'anywhere, anytime' learning. Therefore, in this paper, we took advantages of the now mobile platform which include computing power and better screen resolutions to implement a mobile learning system for numerical methods. Also, It is observed that most m-learning systems are implemented with technologies that are web-based, providing users with the platform for interaction and collaboration with others during learning; thus, learning may be constraint by cost and locations where network service is not available, which does not satisfy the valuable lessons learned from the implementations of m-learning systems which are also recommendations of the requirements of mobile learning systems as observed by [22], that learning materials posted online where mobile device users can also read from is a good idea but can be constraint by costs and inconvenience of signal disruption whilst traveling or poor signal in some remote rural areas are inevitable; and he also stated that "Attempting to deliver a monolithic mobile learning system leads to inflexibility, limits ability to take full advantage of the heterogeneous mixture of hardware and services available and detracts from facilitating blended approaches to learning delivery." Therefore, the application is implemented to support both interactive and self-motivated learning of numerical methods.

IV. DESIGN AND IMPLEMENTATION

The stated algorithms were successfully implemented and the application, NuSim was tested using Emulator and Android Mobile Phones; with the application, one can provide a differential equation, initial values, step size and the number of iterations provided the differential equation is made of ***x*** and ***y*.** The program has the capability to accept, run, perform, execute and give the final answers to numerical iteration method in tabular form or tutors the user on how to go about to get the results. NuSim has the high-level view shown in Fig.1

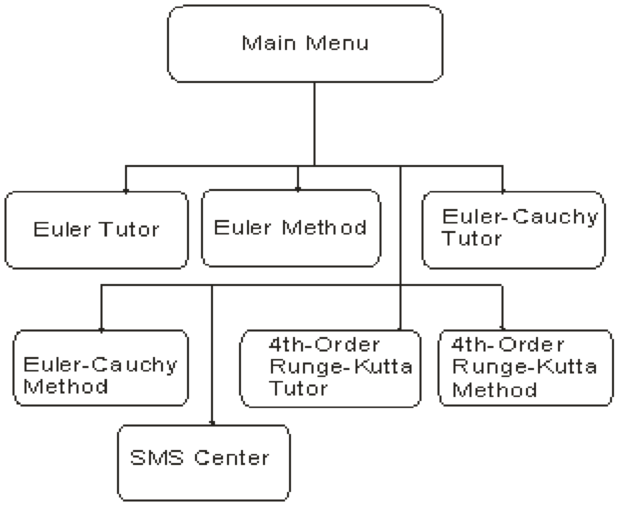

Fig.1: General System Design.

The learning system developed can be used by learners for both learning and running of numerical simulations, and for interaction purpose; and by tutors to assess a learner using a customized text-based functionality of the system. A tour of NuSim is provided next.

4.1 Methods Selection

After the splash screen, the methods interface is displayed. Here, the user can select from the options presented such as Euler Method, Euler Tutor, Euler-Cauchy Method, Euler-Cauchy Tutor, Fourth-Order Runge-kutta Method, Fourth-Order Runge-kutta Tutor. The user may also press on the Menu button of the keypad for these options and SMS Center included can be accessed from the menu.

Fig.2: Menu Options

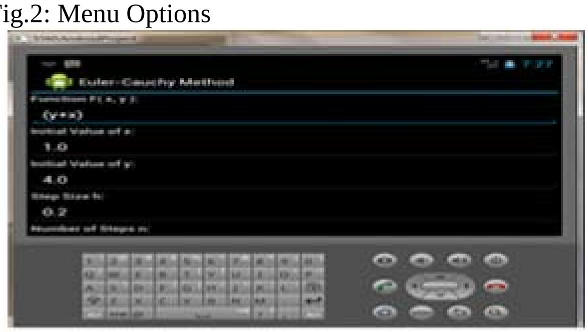

Fig.3: Supplying Input.

4.2 Running Simulations

To run simulations, the user can have the system generate the results or have the system tutor him how the results are being generated. This cannot be done until the user supply the initial value problem of the first-order ordinary differential equation which include, the *Function*,

initialvalue of *y*, *initialvalue* of *x*, the *step size* and the *number* of *steps* the iterations to be performed.
For example using the test case:

$$y^{'} = y - xfory(4) = 1, h = 0.2\ andn = 5$$

To input this problem, the user needs to add brackets where necessary, (y-x). It should be noted that for this system, it is recommended that there shouldn't be spaces in the input, and that as a rule, logarithms and trigonometric functions are enclosed within brackets such as (Log(x)), (sin(x+y)) etc; and that logarithm are taken in base ten while trigonometric functions are taken in degrees. Therefore, the appropriate expression to be input for the above test case is (x+y), see Fig.3.
After supplying the input, the user needs to scroll down to unveil the "Compute" button which is clicked for iterations to begin. As earlier stated the system may just generate the result and present it to the user or tutor the user to on how the result is generated depending on whether "Method" or "Tutor" option was earlier selected. Fig.4A shows the generated result while Fig.4B shows the Tutor's approach to teaching user how to perform simulations. For the Tutor, the user may scroll up and down to view the tutorial text.

Fig.4A: Generated Result.

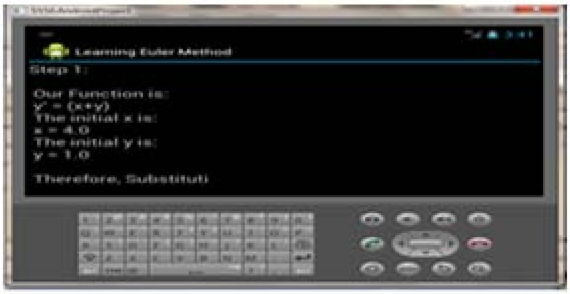

Fig.4B: Tutor Animations.

4.3 Viewing Graph
As shown in Fig.4A, the user may view the graph of the generated solution by clicking on the button "Graph" and can also close the result of iterations by clicking on "Close Result". To view the graph of above initial value problem, lets increase n = 20 for visibility. See Fig.5 below

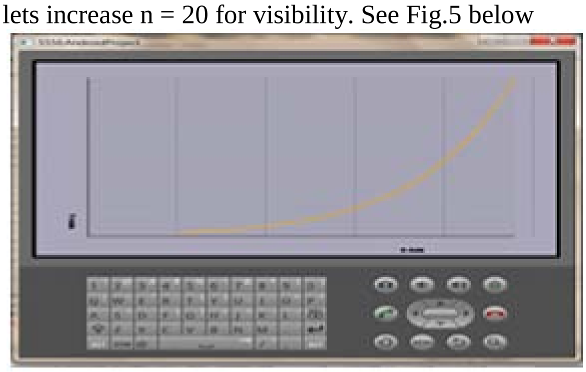

Fig.5: Viewing Graph.

4.4 SMS Center
With the application, an SMS Center is provided for interaction between users. It is to be used for sending and receiving. See Fig.6A & B below.

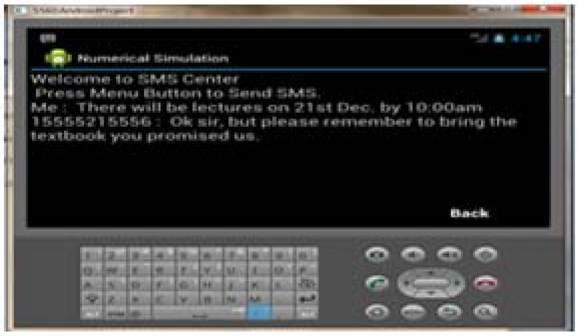

Fig.6A: Lecturer Sending SMS.

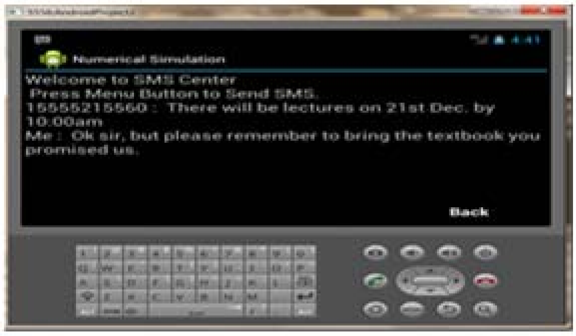

Fig.6B: Student Sending SMS.

4.5 Assessing the Student
It was stated in the aims and objectives of this project that the application will allow teacher/lecturers assess the student by employing the model of 'open test' technique, or students within themselves testing one another. The so called 'open test' model is based on time given a student to answer a given number of questions. The complexity of a question will determine the length of time given the student with consideration of the fact that the student is allowed to open other materials and read from them. Therefore, the time given is often shorter than expected by the student who will of course want to read from materials to answer a question.
The application therefore demands that 'handshake' messages be sent between the lecturer and the student before the test question(s) is/are sent over to the student. This is to ensure that the student is willing to take the test at that point in time or not and to enable the application be intelligent enough to monitor the student. Though this project considers and incorporates this degree of intelligence to allow for assessment of student, it is not a necessary condition that the application must be used for such purposes. Therefore, other models can be adopted as it is convenient for the users.
To achieve this, the application implements a module called 'SMS Center' whose intelligence is activated when the 'handshake' messages are sent at least from the student to the lecturer. Once this is done, the student cannot exit the SMS Center interface by restarting the phone, pressing the 'Back' key or the 'Home' key; he can only exit the application by pressing the 'Back' button on the interface which prompt the users about their actions and also allow them to take decisive actions. See Fig.7 below. If the student click 'Yes' on the dialog box which means he/she has sent

his/her result, then application will sent a message to the lecturer that reads “Student has exited the SMS Center” and then exits the interface. Mention need be made here that the normal SMS application that comes with the phone can be used for dispatching information while the implemented one is used for the assessment.

Fig.7: Exiting the SMS Center.

V. EVALUATION, RESULTS AND DISCUSSIONS

To evaluate NuSim, a randomly selected students with Android Mobile Phones were selected from 200L whom were about to take the Mathematical Methods I; the number of them were 48 students of both gender. The selected students, at the end of the semester examination before they would take the course, were introduced to NuSim and guided through a tour of some of the functionalities thereof after which were left to themselves with their phones and NuSim all through the break that lasted three months. At the end of this period, at resumption the students were given a test before taking the course properly in the class and the students’ performances were amazing.

The number of male students was 28 and 20 female students; out of whom 31 students scored above 70% of the test score; 10 students scored between 60 and 70% and 7 students scored between 50 and 59% of the test score. This results shows that mobile learning as it has been described by other researchers has the potential to turn the face of learning in Nigeria.

Interacting with students on their experience with NuSim, the students on the general complaint about the SMS Center functionality that it limited their interaction. They agreed that it would had been better if it allowed for a chatting platform in it. This was contrary to the initial influence (cost and access to internet) that led to the use of SMS in the application. However, they agreed that NuSim influenced their studies pattern, especially their will.

VI. CONCLUSION AND FUTURE RESEARCH DIRECTION

In this paper we developed an application to facilitate the teaching pedagogy using textual animation. Having achieved the set objectives, it is believed that this will open a developing nation like Nigeria to better learning options by taking the advantages technologies such as mobile devices have to offer for a better learning. It is clear that mobile technologies such as mobile phones have come with capabilities that can be exploited to facilitate learning and the teaching pedagogy.

With the level of success achieved in the implementation of this learning system, the following are hereby recommended.

Mobile technology should not be looked at as a threat to teaching pedagogy but as a way of enhancing it. Therefore, its integration into learning aids should be adopted and be encouraged as it will not only help the teacher/lecturer but also improves the academic standing or outcome of learners.

The implementation of mobile learning systems in a nation like Nigeria is a necessity due to the growing number of students being admitted into the various institutions every year. This will help the lecturer in managing the class and improving contact and attention given to students by the lecturer/teacher. This is known to be the backbone of learning.

For the enhancement of the application, it is recommended that a chart server be Implemented so as to reduce the cost of learning since SMS cost more and was not did not really provided the level of collaboration expected.

The application handles some methods of numerical differentiation; therefore, other methods can be included for better understanding of all the algorithms. Also, numerical integrations should be included. It should state here that other aspects of learning can be effectively handled by mobile technology. Therefore, these aspects should be considered for the extension of the mobile learning system.

To implement a very good mobile learning platform, research of the current trends becomes a necessity. Therefore, further research should be conducted and be adopted for better learning approaches.

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