Influence of Mobile Virtual Laboratory on Mobile Learning: Case Study of a Higher Institution in Nigeria

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Abstract—**Many studies have worked on virtual laboratory for desktop computers, yet the development of virtual laboratories for mobile devices is still at a developing stage because of its interface peculiarities and the assessment for its evaluation is yet to be established. This research has explored the use of Mobile Virtual Laboratory (MVL) for laboratory practicals in institutions of higher learning in Nigeria by designing, implementing and evaluating the developed MVL cross-platform application that works on different mobile operating systems, contrary to previous research works that deployed virtual laboratories for only specific mobile operating systems.A user evaluation of the mobile virtual laboratory developed was conducted wherebyasignificant relationship was found between conceptual learning, re-usability,mobile and virtual laboratories, whereas no significant relationship was observed with usability.**

Keywords-**Cross-platform;e-Learning; Learning Objects;m-Learning; Mobile Virtual Laboratory;Virtual Laboratory**

I. INTRODUCTION

A virtual laboratory is an interactive environment for creating and conducting simulated experiments using mobile devices. Virtual laboratories were created because it was necessary to use them in real-time, so that a huge number of persons can access it at anytime of the day, since a large number of people can share the same experience whether they are in the same town or geographically apart. Furthermore, the expenses of using a real laboratory can be, in many cases, a burden to institutions. The availability of mobile virtual laboratories is made through the Internet using multimedia (sound, images, graphics and animations), so it can be possible to simulate the experiences. Their objects are mainly drawn images or pictures of real things.

The increasing ability to access Internet through personalized, wireless, tiny, handheld and portable devices means that learning content can be accessed through these devices [1].

Learning objects have been variously defined. A learning object is "any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning" [2]. This study emphasizes the digital nature of a learning object and thus adopts Wiley's definition where a learning object is defined as "any digital resource that can be reused to support learning" [3]. The pedagogic importance for conceptual learning of learning objects characteristics such as reusability, portable, modular, adaptability, sustainability, durability, and interoperability cannot be overemphasized [4]. The authors however predicted that mobile technologies will very soon be the most used for learning because there is more demand for conceptual learning. They however suggested for further studies, improvement in user experience, evaluation of all learning gains when teaching content through mobile devices, creation or adoption of more e-content to a virtual mobile laboratory.

However, with the recent advances the mobile device technology mobile devices can also be used in order to open additional degrees of freedom within the virtual or remote teaching fields. Most students have mobile phones, and if virtual and remote courses are available for these mobile devices, they can work from anywhere and without temporal constraints.

This research carried out a comparative performance of various existing mobile virtual laboratory platforms [5-10] and compared it with the performance of the framework developed, thus addressed the difficulties related to seamless access to experiments of virtual laboratories across various mobile devices by developing a hybrid cross platform.

A. Mobile Learning

Ubiquitous technologies are making it possible for learners not to be bound in fixed classrooms for learning purposes. Such "anytime", "anywhere" computing platforms have

ignited a paradigm shift from e-learning models to m-learning models [11]. Hence increasing research attention is unfolding in the area of m-learning from industrialists, researchers, educationist and policy makers [1,12,13].

As a consequence, m-learning has been variously defined. While considering a mobile device as an enabler of learner mobility, M-learning was defined as learning which takes place at anytime in anyplace using a mobile device [12]. Similarly, m-learning was also defined as a form of e-learning which employs wireless, tiny, handheld and portable devices to extend and deliver learning to learners[11]. A view earlier expressedemphasized that m-learning is e-learning which uses mobile devices to deliver learning [14]. It is evident from the various definitions that m-learning is a form of e-learning which takes place at anytime in any place using ubiquitous technologies such as mobile phones.

B. Mobile platform Frameworks

Three major mobile platform development technologies reviewed are: Native applications, Web applications and Hybrid Applications[15-17].

- *Native applications*

Most, if not all, modern mobile operating systems provide developers with the necessary tools to develop applications that can later be installed by users to extend the smartphone capabilities. Each vendor provides developers with different tools, but the basics include a compiler and a debugger. These tools enable the developer to build native applications, with access to all the capabilities of the smartphone, such as camera, GPS, sensors, hardware acceleration. Taking advantage of these capabilities, the developer can build very interesting applications that integrate with the platform and provide an excellent user experience. Applications can be tested by running in the included simulator[15].

- *Web applications*

The idea of using a single code base for targeting several platforms has been the main motivation for using web technologies such as HTML5, CSS3 and Javascript to develop applications. With access to the Internet and navigating through websites being a common functionality on smartphones, web applications for mobile devices have become popular. Recent smartphones include powerful Web browsers and Javascript engines, capable of rendering complex websites and with a very good support of the HTML5 and CSS3 standards [16].

- *Hybrid applications*

They are HTML5 apps wrapped in a native container and are cross-platform applications. Hybrid apps can be downloaded from the app stores and will also be partly installed on the system. Cross-Platform Applications (Apps) work similarly to standard native apps, as they are built using the platform's operating systems Application Programming Interface (API) and Software Development Kits (SDK). They have full access to the device hardware and sensors, and have a user experience that is native to the platform. Unlike native apps however, cross-platform native apps are generally not built using the default development tools of the platform but rather are built by using a 3rd party product or framework and the code is then compiled on different platforms to produce completely native apps that share code between them.

C. Cross-platform mobile application development tools

There are several cross-platform tools such as PhoneGap, Titanium and Codenane One. They allow implementing an application and its User Interface (UI) usingweb technologies like HTML, CSS. Codename One was selected because is the first and only tool to allow Java developers to write true native applications on all mobile platforms. It also provides a full-development tool chain for writing iOS applications in Java. Applications written in Codename One can be deployed to a variety of devices, including Android, iOS, BlackBerry, Windows Phone, and J2ME (although some features may not be available on lower powered devices).

A review of literature by [6-10] indicated that their focus is on developing device-dependent mobile apps for accessing the experiments of the mobile virtual laboratory. The limitations of this approach are that device dependent mobile apps cannot offer seamless access to various mobile operating systems as such limits the students that can access the various experiments.

From the literature reviewed there is need for further research on the following:

1. Development of a hybrid application that is cross-platform across various mobile operating systems.
2. Reusability of content across various institutions
3. Creating a platform for various HTML5 learning objects of simulated laboratory practicals.

This research work focused on addressing the research gaps by developing a hybrid cross-platform application and evaluated its implementation.

II. METHODOLOGY
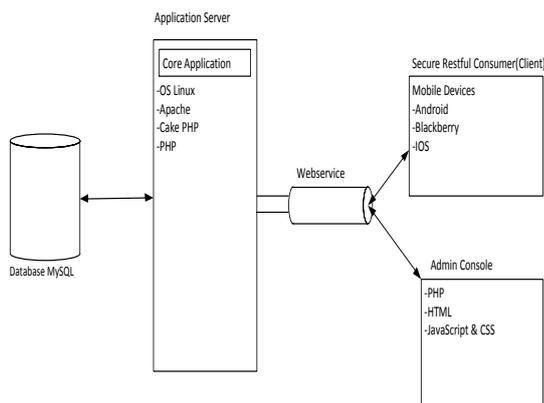
A. The Developed Mobile Virtual laboratory

Figure 1. Mobile Virtual Laboratory Architecture (Developed)

After a systematic review of literature, a needs assessment for mobile virtual laboratories was initially carried out to enable the researcher identify the mobile operating systems used by students and to identify related factors. Subsequently, a cross-platform Mobile Virtual Laboratory architectural framework was developed with the client side in Java using the Codename One tool and the server side in PHP. This had four layers which were application server, database server, client (Mobile device) and the admin console.

- *The Main Application server*

The application server takes care of application data and application files. It is responsible for serving requiredservices as needed by the Application Programming Interface (API) calls. It is also responsible for managing users credentials sessions and processing of user requests. It is running on an Ubuntu Linux Operating System (OS), Apache as web server and PHP as programming language.

- *Web Service*

A web service is a block of code that resides on the server and can be remotely invoked by the client. The client invokes the web service by calling a Hypertext Transfer Protocol (HTTP) link.

- *Database Level*

The database level comprises of MySQL 5.5.20 running on an Ubuntu OS communicating via Port 3306 and it is IP secured.

- *Connection oriented services*

In this case the client, usually a browser or a flash program, calls aweb service and get the reply as data. The serverkeeps listening on a specified port (HTTP 80) forany incoming requests. A Representational State Transfer (RESTful) or Simple Object Access Protocol (SOAP) webservice performs the experiment using signalgeneration and acquisition operations and aresponse in XML format is sent back and the clientconverts the data and displays it to the user.

- *Secured Restful Consumer (Client)*

The client side of the application is supposed toperform the following functions and characteristics:
i.) Logging into the systems:
This interface takes user credentials from the user. The server side consists of PHP files with MySQL as database.
ii.)Run the experiment: The interface must receiveproper input parameters from the user regardingthe experiment. Validation is necessary forcorrectness of input data to be transmitted to theserver.
iii.) View results: The results returned are always inXML format or in a picture format. The interfacemust plot graphs, charts or simply show the data.
iv.) It is a small program that can run fast and fits within the small display area.
v.) The mobile virtual laboratory client applicationneeds to parse Extensible Markup Language (XML) files.
The client interface was built using a Cross-platform Java program codename one.

One hundred and twenty targeted learners were purposively selected and 102 consented participants completed the questionnaire. The evaluation was carried out using Science students from Ambrose Alli University, Ekpoma – Edo State. This institution was selected because it is located in a rural area and this requirement was important in the evaluation of the Internet penetration in rural areas of Nigeria for m-Learning. The students undertook mobile virtual laboratory practical's using the various simulated practical lab sessions from PhET in Chemistry, Physics and Computer science (Logic gates).

The information assessed included socio-demographic data of respondents, the researcher evaluated the impact of the mobile virtual laboratory on usability, conceptual learning and reusability. At the beginning of the experiment, participants had a one-hour orientation session about how to download and use the mobile virtual laboratory components. In the orientation session, each student was informed of the study and briefed on the research instrument.

After returning the questionnaires, the data was processed in preparation for analysis. Data werechecked to ensure that there were no inconsistencies and inaccuracies. However, care

was taken during survey design, to ensure that clear instructions are given. Each questionnaire was given a unique identifier to avoid duplicate entries during analysis.
The Statistical Package for Social Sciences version 21 [18] was used to conduct the statistical analysis. The researcher used the Friedman's test to determine test of significance.

To access the virtual laboratory students with Android or Blackberry phones which were the predominant devices used by the students as deduced from the needs assessment, were to use either of three options; website address, Quick Response (QR) code and for those who use android phones they could download the app from the app store.

Different kinds of resource tools were provided to assist students in achieving the learning objectives by participating in the laboratory practicals. At the end of the program, the students were asked to answer the given quizzes.

B. User interface design

The Graphic design is an important part of the app because it bonds users with the app emotionally. Main app icon is an important part of graphic design. While designing the main screen, the focus was on keeping simplicity and ease of use. See screenshots of the user interface. Figure 2 to Figure 5.
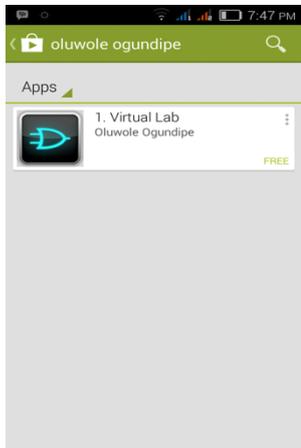

Fig 4. Students authentication interface

Fig 5. Screenshot showing the virtual lab

Fig 2. Virtual Lab in the Google app store

Fig 3. App in Google Store for installation

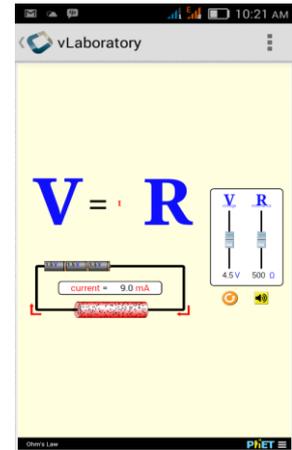Figure 4.is a screenshot of the students authentication interface that receives the unique identifier (Reg.No.) and the password for login. Figure 5.is the screen shot of the laboratory practical's. This particular experiment is a physics practical laboratory experiment (Ohm's law). The simulated laboratory practicals were got from PhET repository.

III. RESULTS

After the result of the needs assessment, which revealed that majority of the students, used the Blackberry and the Android phones one hundred and twenty targeted learners were purposively selected and 107 consented participants completed the questionnaire. Since it was necessary to profile the users who would benefit from the mobile virtual laboratory by students who use blackberry and Android devices, this was achieved by using purposive sampling.

Figure 2.is a screenshot of the virtual laboratory app in the Google play Android app store for download. Figure 3.is the screenshot of the installation interface indicating the number of downloads, the rating of the app and the category the app belongs to for the user to take an informed decision before downloading.

Table 1. Indicates the basic demographic characteristics of the respondents that participated in the mobile virtual laboratory experiment.

Table 1.

VARIABLES	FREQUENCY (N = 107)	PERCENT (%)
YEAR		
100 LEVEL	62	57.9
200 LEVEL	20	18.7
400 LEVEL	15	14.0
500 LEVEL	8	7.5
600 LEVEL	1	.9
MSC/GRADUATE	1	.9
SEX		
MALE	51	47.7
FEMALE	56	52.3
PROGRAMMES		
Faculty of Natural Science (FNS)	101	94.4
Management Science (MGT. SC.)	2	1.9
Medical. Science	4	3.7

SOURCE: Field survey (2014)

This shows that majority of the participants were year 1 (100 level) students. 52.3% of the respondents were female while 47.7% were male. Majority of the participants were from the Faculty of Natural Science.

IV. DISCUSSION

The user evaluation was carried out to assess, usability, conceptual learning and reusability. The results in these sections provided better understanding into the learner outcomes from the use of mobile virtual laboratories for m-learning.

Learners background information relates to their gender, category of programme of study and year of study. In the survey slightly less than half of them were male and slightly over half of the one hundred and seven participants were female. Over three quarters of the learners surveyed were from the Faculty of Natural Sciences while less than a quarter of them were from the Management Sciences and Medical Sciences. Participants were drawn from various years of study while over half of them were 100 level students, about one quarter of them were 200level students, 400 level and 500 level were about one quarter while the rest of the students , were 600 level andMaster of Science (M.Sc.) postgraduate students.

It was revealed that there was no statistically significant relationship between Mobile Virtual Laboratory and the usability of mobile hand held devices this was likely due to the fact that for most of the participants, this was the first time they were using a Mobile Virtual Laboratory. Contrary to [8] with a large sample size, the study showed that there is no significant relationship between Usability and mobile virtual laboratory. The contrast in the findings could be a result of the sample size of the study.

The study shows that there is a significant relationship between mobile virtual laboratory and conceptual learning of students. This supports a similar result that postulated that its use for learning, improved learning outcomes [5]. The study also showed that there is a significant relationship between mobile virtual laboratory and re-usability. This was because the MVL was designed to run any HTML5 learning object uploaded from the repository or any source making use of the native component particular to each device. The advantages are that this increases flexibility of the learning content thereby increasing cost effectiveness by allowing reuse of the learning content.

V. CONCLUSION

Mobile learning is the future of education in Nigeria and many developing countries particularly because of the improvement in Internet penetration and the availability of mobile devices. This study identified the factors that can guide stakeholders considering the implementation of MVL. Given that MVL uptake will be easy and enhanced if planning is done with the consideration of learner factors like informed choices, convenience, mobile device, preferred network, cost existing infrastructure amongst others are considered.

Analysis of this study indicates that while there is important evidence in Nigeria that there is an increase in the usage of mobile devices, more research work needs to be carried out on how it can be used positively to impact educational outcomes. One of the methods is what has been discussed in this study, which is the adoption of Mobile Virtual laboratory for teaching science practical experiments.

This paves way for other researchers to build or develop tools for other academic levels from secondary education level to the tertiary level. Mobile Virtual Laboratory implementation strategies require policy makers to ensure that various stakeholders take advantage and explore the opportunities in reaching out to rural communities. We also advocate creation of awareness on MVL.

Future works

Future work would be in the area of measurement of the possible impact that can be achieved with the proposed approach in terms of administering the survey instrument in two other institutions of higher learning and then carry out a comparative analysis of the result.

REFERENCES

[1] Ayala, G., and Castillo, S. (2008, March 23-26). *Towards Computational Models for Mobile Learning Objects.* Paper presented at the Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education (WMTE'05), Tokushima, Japan.

[2] Bottentuit Junior, João ;Coutinho, C.; Alexandre, D. (2006) Mlearning e Webquests: as novastecnologiascomorecursopedagógico. Proceedings of 8th International Symposium on Computers in Education (SIIE2006).Servicio de Imprenta de la Universidad de León, v. 2. p. 346-353.

[3] IEEE (2010). WG12: Learning Object Metadata. Retrieved August 9, 2013, from *http://ltsc.ieee.org/wg12/*

[4] Bottentuit Junior, João ;Coutinho, C.; Alexandre, D. (2006) Mlearning e Webquests: as novastecnologiascomorecursopedagógico. Proceedings of 8th International Symposium on Computers in Education (SIIE2006).Servicio de Imprenta de la Universidad de León, v. 2. p. 346-353.

[5] Chen, X.; Kehinde, L.;Zhang, Y.; Darayan, S.; Olowokere, D.; Osakue, D. (2011) Using Virtual and Remote Laboratory to enhance Engineering Technology Education. American Society for Engineering Education.

[6] Guerra, M.; Francisco, C.; Rui, M. (2011) PortableLab: Implementation of a Mobile Remote Laboratory for the Android Platform. IEEE Global Engineering Education Conference (EDUCON) – "Learning Environments and Ecosystems in Engineering Education".MOBIlearn project website, MOBIlearn – the wings of learning, *http://www.mobilearn.org/*

[7] Ordurna P.; Garcia-Zubia J.; Irurzun J.; Lopez-de-Ipina, D. Rodriguez-Gil, L (2011) Enabling mobile access to Remote Laboratories. IEEE EUCON Education Engineering 2011-Learning Environment and Ecosystems in Engineering Education.

[8] Rochadel,W.; Silva, J.; Simao, J.; Alves, G.; Marcelino, R.; Gruber, V. (2013) Extending Access to Remote Labs from Mobile Devices in Educational Contexts. IJOE-Volume 9, Special Issue 3: "REV2013"

[9] Bhosale, Y. and Livingston, L. (2014) V-Lab: A Mobile virtual Lab for Network Security Studies. International Journal of Computer Applications (0975-8887).

[10] Shah, K., Ghosh, A., Hossain, M., Lee, Y. (2014) Enhancing Engineering Educational Using virtual Lab Technology. Retrieved December 04th, 2014 from http://www.asee.org/documents/zones/zone1/2014/Student/PDFs/

[11] Luis de Marcos, H. R. J., Gutiérrez A.J., Pagés C., andMartínez, J.J. (2006). Implementing Learning Objects Repositories for Mobile Devices. Retrieved October 24, 2013, from *http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-208/paper04.pdf*

[12] Guerra, M.; Francisco, C.; Rui, M. (2011) PortableLab: Implementation of a Mobile Remote Laboratory for the Android Platform. IEEE Global Engineering Education Conference (EDUCON) – "Learning Environments and Ecosystems in Engineering Education".MOBIlearn project website, MOBIlearn – the wings of learning, *http://www.mobilearn.org/.*

[13] Uden, L. (2007). Activity theory for designing mobile learning.*International Journal of Mobile Learning andOrganization, 1*(1), 81-102.

[14] Brown, H. T. (2005). Towards a Model for m-Learning in Africa. *International Journal on E-learning, 4*(3), 299-315.

[15] Hasan, Y., Zaidi, M., Haider, N.,Hasan, W. and Amin, L. (2014) Smart Phones Application development using HTML5 and related technologies: A tradeoff between cost and quality. International Journal of Computer Science. Issues, Vol.9. Issues 3,No 3.

[16] Juntunen, A., Jalonen, E., Luukkainen, S. (2013). HTML5 in Mobile Devices-Drivers and Restraints. (HICSS) 2013. 46th Hawaii International Conference on System Science.

[17] Garaizar, P.,Vadillo, M. and Lopez-de-Ipina, D. (2012) benefits and Pitfalls of using HTML5 APIs for Online Experiments and Simulations. IJOE- Volume 8, Special Issue 3.

[18] SPSS for Windows 21.0 (Computer software). (2012). Chicago, IL: SPSS Inc.