Mobile Learning Objects Deployment and Utilization in Developing Countries

PAUL B. MUYINDA[4]
Department of Information Systems/Distance Education
Makerere University, Uganda

JUDE T. LUBEGA
Department of Information Systems
Faculty of Computing and IT, Makerere University, Uganda

KATHY LYNCH
ICT Research and Development
University of the Sunshine Coast, Queensland, Australia

Abstract

The increasing ability to access Internet via mobile devices means that learning objects can be deployed and utilized on those devices. Increasing research attention has been accorded to the design and development of reusable learning objects for tethered and mobile based learning management systems. Little research has been undertaken in regard to pedagogical models geared towards effective deployment and utilization of mLearning objects in different contexts and particularly of developing countries. This paper uses the Design Research approach to develop a UML based model for instantiating applications for deploying and utilizing learning objects on multi-generation order mobile phones in developing countries of Africa.

Keywords: mlearning, elearning, mlearning objects, learning objects, mlearning object model, mlearning objects utilization.

IJCIR Reference Format:

Paul B. Muyinda, Jude T. Lubega, and Kathy Lynch. Mobile Learning Objects Deployment and Utilization in Developing Countries. International Journal of Computing and ICT Research, Special Issue Vol. 4, No. 1, pp. 37 - 46. http://www.ijcir.org/Special-Issuevolume4-number1/article5.pdf.

1. INTRODUCTION

Gone are the days when mobile phones were only used for placing and receiving calls and text messages. The convergence of mobile phones with the Internet has added more value to them. This convergence has caused a paradigm shift by replacing the prefix ‘e’ with ‘m’ in the term ‘eLearning’ so as to give the equivalent term, ‘mLearning’ [Traxler 2007]. Likewise, an equivalent shift is brewing from the phrase ‘eLearning objects’ to the phrase ‘mLearning objects’. An eLearning object is a digital educational resource which is granulated into units that are reusable, adaptive, and can be re-purposed to different learning styles, knowledge levels and conditions [Wiley 2001]. eLearning objects are not suitable for mobile devices

[4] Author’s Address: Paul B. Muyinda, Department of Information Systems/Distance Education, Makerere University, Uganda, P.O Box 7062, Kampala, Uganda, mpbirevu@iace.mak.ac.ug, +256 (0) 77 2 406 919; Jude T. Lubega, Department of Information Systems, Faculty of Computing and IT, Makerere University, Uganda, jlubega@cit.mak.ac.ug, Tel: +256 (0) 77 4 600 884; Kathy Lynch, ICT Research and Development, University of the Sunshine Coast, Queensland, Australia

"Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than IJCIR must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee."
© International Journal of Computing and ICT Research 2010.
International Journal of Computing and ICT Research, ISSN 1818-1139 (Print), ISSN 1996-1065 (Online), Special Issue, Vol.4, No.1, pp. 37-46, October 2010.

because these devices possess resource constraint limitations, including low resolution, tiny screens and keyboards and low bandwidth [Grant et al. 2007]. Consequently, learning objects (LO) for mobile devices have to be authored. Such learning objects are known as mLearning objects (MLO) [Ayalla and Castillo 2008].

A mLearning object could take the form of carefully designed materials that take cognizance of mobile device limitations. However, according to Ayala and Castillo [2008], considering mobile limitations alone in the design of mLearning objects is being short sighted. Designing for learner personalization, collaboration and interaction completes the picture of a mLearning object [ibid].

A mLearning object could be used for online performance support to guide a learner working through a task, could be used for augmenting classroom instructions and other learning materials and could be used as instructions for operating a given device [Quinn 2002]. The size, presentation and scope of a mLearning object is dependant upon the capacity of the mobile device in question and how a given institution conceptualizes a learning object. A SMS sent out to students for academic and administrative support can be regarded as a mLearning object. In Ayala and Castillo's [2008] definition of a mLearning object, a software component is regarded as a mLearning object. In developing countries where learners own mainly low end mobile phones, SMS based learning objects are more feasible than resource heavy multimedia learning objects such as software modules [Brown 2005].

When a mLearning object is expressed as a software module, it can be run on a Java enabled mobile phone. Multiple choice quizzes, examination and lecture calendars, reminders for important events and frequent errors committed by students in a given course can be developed as Java midlets and delivered on java enabled phones [Toledano 2006]. The success of mLearning lies in the need to recognize the limitation of mobile devices so as to deploy learning objects onto them which address pedagogic assistance. Consequently, mLearning objects should be characterized by appropriate pedagogic values.

As the name suggests, mLearning objects abet mLearning. mLearning is a relatively young educational technology paradigm. As such, it has been variously defined. While considering a mobile device as an enabler of learner mobility, Traxler [2007] defined mLearning as learning which takes place at anytime in anyplace using a mobile device. Similarly, Luis de Marcos et al. [2006] defined mLearning as a form of eLearning which employs wireless, tiny, handheld and portable devices to extend and deliver learning to learners. A view earlier espoused by Brown [2005] emphasized that mLearning is eLearning which uses mobile devices to deliver learning. It is evident from the various definitions that mLearning is a form of eLearning which takes place at anytime in any place using ubiquitous technologies such as mobile phones. While emphasizing the mobility afforded by mobile devices, Traxler [2007] observed that mLearning is more than just the use of mobile devices for learning but the ability for one to electronically learn on-the-go.

The ability to learn on-the-go has been occasioned by the increasing ability of mobile devices to access mLearning objects from Internet and content repositories. There has been significant research in the design and development of learning objects for wireless handheld devices [Ayala and Castillo 2008; Nakabayashi et al. 2007; Yang 2007; Goh and Kinshuk 2006; Toledano 2006; McGreal et al. 2005; Quinn 2002] but less research on how to effectively deploy and utilize them in different contexts [Kurubacak 2007; Pettit and Kukulska-Hulme 2007] including those of developing countries of Africa. In this paper, we report on a generic UML based model that we developed for instantiating mLearning object applications for multi-generation order mobile phones of learners in developing countries of Africa. The model is called a mLearning Objects Deployment and Utilization Model (*MoLODUM*). The model was developed as part of the corresponding author's PhD output (http://distance.mak.ac.ug/mpbirevu/phd_dissertation). This paper is organized as follows. In *Section 2*, we show the need for the *MoLODUM* in developing country context. In *Section 3*, we use operational scenarios from a distance learning student support system to derive the *MoLODUM* classes. In *Section 4,* we show one aspect of *MoLODUM* validation and provide concluding remarks and future research work in *Section 5*.

2. CONTEXTUALIZING DEVELOPING COUNTRIES

The focus in this paper is placed on developing countries of Africa. We argue that learning contexts in developed countries are different from those of developing countries of Africa and hence require rethinking of eLearning delivery model. The physical infrastructure, ICT access and usage, mobile phone acceptance

and ownership, and demographics and geography of developing countries present unique factors. The physical infrastructure in developing countries is characterized by:

- Fewer brick and mortar universities and secondary schools
  - Always leading to high illiteracy levels
- Poor roads and postal services
- Poor landline phone network connectivity
- Poor connectivity to national electricity grid system
- Little or no desktop computer Internet bandwidth outside major cities and towns
  - Internet connectivity is usually found in Internet cafes and university campuses
- Limited number of desktop computers
  - With a high computer illiteracy rate, especially in rural and non-city areas.

Whereas the above factors are detrimental to 'conventional' eLearning, all is not lost for developing countries in this sphere. The grey areas in 'conventional' eLearning can be re-engineered through mobile telephony features. The mobile telephony features in developing countries that can re-engineer the 'conventional' eLearning model include:

- Mobile network connectivity that is permeating even in remote villages
- High levels of mobile phone ownership, acceptance and usage. By 2007, Africa had 89.7% of its total telephone subscribers as being from mobile phone users [ITU, 2007]. In Uganda alone, the ratio of mobile phone subscribers to fixed telephones stood at about 9.7 to 1 [ibid]. At Makerere University in Uganda, by 2008, over 98% of the distance learners owned mobile phones [Muyinda et al. 2010]
- Abundant supply of sunshine hence a high potential for solar power for charging mobile phone batteries even in rural areas [Muyinda et al. 2010] and
- Regulatory and licensing systems for mobile network connectivity that are deregulated and hence encouraging investments in the telecommunications sector.

In addition to the mobile telephony features, African countries are increasingly adopting the distance learning model. The distance learning model in developing countries is more traditional than that in developed countries [Muyinda et al. 2009]. Traditional distance models mainly depend on hardcopy study guides and modules and residential sessions [ibid]. Of late however, traditional distance learning units are making efforts to integrate ICTs into their student support systems [Muyinda et al. 2010; Muyinda et al. 2009; Aguti and Fraser 2006]. For better results, model based ICT integration is preferred. The *MoLODUM* reported on in this paper comes in handy. The *MoLODUM* provides a development framework to enable learners in developing countries obtain access to and use learning objects, delivered over the Internet, regardless of their proximity to higher education institutions through the use of mobile phones.

3. THE MOLODUM

Whereas resources are abundantly available for PC learning objects, learning objects for mobile devices have to be granulated so that they are viewable and sequenceable on tiny screens via limited bandwidth pipes. Learning objects that can be accessed by and delivered on mobile devices are called mLearning objects [Ayala and Castillo 2008; Nakabayashi et al. 2007; Yang 2007; Trifonova and Ronchetti 2006; Toledano 2006; Quinn 2002]. A mLearning object is "an interactive software component, personalized and reusable in different contexts, designed to support an educational objective through a mobile device in situated learning or collaborative learning activities" [Ayala and Castillo 2008, p.153]. This implies that a mLearning object is not only restricted to content on the mobile device but also the interface to the content or activities related to the use of the content or all of these.

Research into the design and development of mLearning objects is ongoing [Ayala and Castillo 2008; Nakabayashi et al. 2007; Yang 2007; Trifonova and Ronchetti 2006; Goh and Kinshuk 2006; Toledano 2006; Zhang 2003; Quinn 2002]. Equal research effort has been called for in the area of mLearning objects deployment and utilization [Pettit and Kukulska-Hulme 2007; Kurubacak 2007]. Since uptake of mobile phones in developing countries has surpassed industry analysts' predictions, development of the *MoLODUM* was vital. The *MoLODUM* provides answers to the research question, 'How can learning objects be brokered and utilized on varied generation order mobile phones'? The *MoLODUM* presents several benefits.

Wide access to mobile phone technology, coupled with the need to educate a population that is geographically dispersed and with limited number of higher education institutions, accentuates the need for a pedagogically effective *MoLODUM*. Once learners are able to automatically broker and utilize content from learning object repositories using their mobile phones, they can learn regardless of their location and the time. This adds value to existing eLearning and classroom models and increases flexibility and personalization in learning, and more importantly, provides a wider access to education.

Education is a major key in bringing developing nations forward and out of poverty. However, within these countries, there is a significant disparity between the availability of higher education in rural and city based regions. The ability to access education using the accepted, accessible and affordable mobile phones has the opportunity to bring higher education into the hands of all deserving citizens.

A new breed of learners, now referred to as the "net generation" [Fisher and Baird 2007, p.2] or digital natives [Prensky 2001, p.2], with high affinity for mobile technologies for accomplishing communication, business, banking and educational related tasks is emerging. In the not so far future, it will be difficult to draw a line between mobile and 'conventional' eLearning or distance and 'conventional' classroom learning for these learners. The *MoLODUM* is one such effort to tap into the digital learning styles [Fisher and Baird 2007] of the net generation or digital native learners.

The *MoLODUM* is a novel research contribution to the maturity of the field of mLearning in particular and information systems in general. As a young field, scholars such as Traxler [2007], Kurubacak [2007], Pettit and Kukulska-Hulme [2007], Motiwalla [2007], Sharples et al. [2005], Keegan [2005] and others, have called for the development of theories, models, frameworks and tools that can enable the mLearning field to mature. The development of the *MoLODUM* responds to this call. In *Section 3.1,* we profile the *MoLODUM* development process.

3.1 *MoLODUM* development process

The *MoLODUM* was developed following an object oriented methodology underpinned by the Design Research approach [AIS 2007; Reeves et al. 2005]. In developing the *MoLODUM,* we aimed at grounding the development of mLearning applications for supporting distance learners. Why distance learners? Authors such as Traxler [2007], Goh and Kinshuk [2006], Trifonova and Ronchetti [2006], Brown [2005] and others have established that mLearning is most suited for supporting learners on-the-go. In the section that follows, we give operational scenarios for actors in a distance learning model and elicit challenges from them which have mLearning based solutions. These solutions form the constructs from which we abstract the *MoLODUM* classes. The key actors in a distance learning model are lecturers, learners, administrators and information and communications technology [Muyinda et al. 2009].

3.1.1 Distance learning, teaching and administration scenarios

ICT based learner support is still deficient in the majority of distance learning units in developing countries [Aguti and Fraser 2006]. Consequently, most of the learner support systems are manual, a thing which presents enormous challenges to the actors. Most of the challenges could be solved through mLearning. The scenarios given here below were drawn from the Department of Distance Education at Makerere University in Uganda. They embrace academic and administrative learner support processes.

Distance learners come for residential sessions at the University main campus for six weeks in a semester of seventeen weeks. In the remaining eleven weeks, learners carry out independent studies at their homes, in study centers, in public libraries, in their offices or while traveling. Attending residential sessions is not compulsory for learners. Lecturers, administrators and learners provide academic and administrative support to learners during and after residential sessions.

The lecturers' academic support include: provision of course outlines, study guides and modules, overview of content in the course modules, additional reading materials, reading lists and take-home assignments. The lecturers also provide rhetoric questions and clues to such questions so as to stimulate group discussions. After each residential session, lecturers support learners by answering their queries, giving them summaries of what transpired in the residential sessions, providing explanations to perceived difficult portions in the course modules and sending learners useful soft and/or hardcopy content whenever deemed necessary. With funding support from the Department, lecturers visit study centers and provide more tuition and academic support to learners.

The administrators provide information related to fees payments, reminders to learning events, university almanac, deadlines for assignments and registration, information about lecture and examination venues, alerts about timetable changes, due dates for library books, overdue library books and new reading materials in the library. Other administrative information passed on includes requirements for attending a

given class, motivational messages, counseling services and location of various services in the university.

The learners support each other by sharing useful academic and administrative information. In addition to information being pushed to them, learners also pull information from the other actors.

The most common media for information exchange are: admission letters, circulars, fliers, brochures, radio, telephone calls, text messages, newspapers and residential session meetings. Circulars are pinned up on notice boards at the main campus and study centers. Learners sometimes physically visit their administrators, lecturers and classmates or place calls or text messages seeking academic and administrative assistance. The different actors could use Internet and e-mail for learner support but less than 25% of the learners have access to the Internet. All actors have access to mobile phone services but these services are financially and cognitively costly. The mobile phones owned by the learners are of low through to high end generation order and are prone to the usual limitations of mobile phones – low bandwidth, low resolution, limited memory and tiny keypad and screen. Low end mobile phones cannot be used to access Internet but can be used to place and receive audio calls and text messages. In addition to these services, high end mobile phones can access Internet via a GPRS connection.

3.1.2 Challenges from the scenarios

The scenarios in *Section 3.1.1* present several challenges. To start with, a circular can be removed from the notice board as soon as it is pinned up. In some instances, some learners miss seeing the circular altogether because it is mixed with many other notices on the notice board or because it was removed. Some learners will only read the circular when they come for a residential session or visit a satellite center. Some learners will read the circular when the message being communicated is obsolete. A circular may not be pinned up on all the notice boards at the main campus and satellite centers. A circular does not provide just-in-time synchronous collaboration and thus can not personalize information for last minute changes to learning events. For instance, a lecture venue change cannot be suitably communicated using a circular. It can also not be communicated by an e-mail due to its asynchronous nature in environments with scarce desktop computers and Internet.

The suitable media of communication would be the mobile phone but it is associated with high financial and cognitive costs, resource limitations and lack of policies for its use in learning. The high financial costs have forced some actors to subscribe to more than one telecommunication service provider in a bid to enjoy cheaper tariffs for within network services. This has led to instability in telephone contacts of some actors. Constant changes in telephone contacts also arise due to the rampant theft of mobile phones. Thus just-in-time collaboration is constrained as a result of not having some actors' telephone contacts. High financial costs also arise from the high cost of acquiring a high end mobile phone and maintaining a GPRS Internet connection and other communication needs. The high cognitive costs arise as a result of actors receiving and having to attend to a great number of calls and text messages at the same time. Besides, the actors' mobile phones have only limited memory to hold a limited number of text messages. Thus ensuring learning equity among learners with varied generation order mobile phones presents an enormous pedagogical challenge. Further, network connectivity is not uniform in all locations of developing countries of Africa.

Some learners do not attend residential sessions and the challenge with this is how to ensure that all information packaged for a residential session is passed on to them. Relatedly, there is a challenge of inability by the learners to have synchronous assistance for hard to understand portions in given study modules because they are not in the vicinity of their lecturers or classmates. In some cases, learners may not even know their classmates. The learners incur travel costs to physically get to their lecturers or classmates.

Most of the challenges illuminated here can be solved through mLearning.

3.1.3 mLearning solutions domain

In our design, the mLearning solutions adduced to solve the challenges in *Section 3.1.2* formed the *MoLODUM* constructs. Constructs are the conceptual vocabulary of a solution domain [AIS 2007]. In this section we briefly provide these constructs and draw object oriented classes from them. Then in *Section 3.1.4* we collaborate and inter-relate the classes using UML to form the *MOLODUM*.

The challenge of learner support via mobile phones calls for value addition to these devices by way of pedagogically deploying and utilizing learning objects onto them. This calls for the *MobileLearningObject* class responsible to profile the mLearning objects. Such mLearning objects could be SMS messages, WAP objects, audio podcasts, Internet to mobile text messages and rich text files. The *MobileLearningObject* class should therefore consist of attributes for organizing learning objects,

granulating learning objects and determining appropriate media types for deploying on the rendering device. Learning objects can be organized as course modules having attributes related to content parts, chapters and sections [Goh and Kinshuk 2006]. They can also be granulated according to the level of difficult to cater for beginning, intermediate and advanced learners [ibid]. The *MobileLearningObject* class should be responsible for rendering content in different media types including text, audio, video, graphics or a combination of these. Further, the class should have an attribute to determine whether a required learning object is resident online or offline the system. Above all, there should be pedagogical considerations in the entire composition of a mLearning object. The pedagogy attribute represents the teaching models and expertise needed in delivering the content in the learning object [Goh and Kinshuk 2006]. Thus this class should have operations for getting the required pedagogy, the properties of the device on which the learning object is to be deployed, the interface of the rendering device and the mobile network connectivity conditions.

Learning objects are deployed and utilized by different actors. Consequently, there is need for a *MobileLearningObjectUser* class to profile all the usability issues of a mLearning object. The main actor in our model is the learner. The *MobileLearningObjectUser* class should therefore be responsible for determining the learner's learning history, style, context and motivation to learn [Goh and Kinshuk 2006]. Other mLearning object users are administrators and lecturers. There should be an attribute in this class to profile the roles of the mLearning object users in the system. This helps in deploying the right learning object to the right user. Usability issues for a learning object depend on the capability of the user's mobile device and the mobile pedagogy at play. This requires the *MobileLearningObjectUser* class to have operations for determining the device property, rendering device interface and the pedagogy being applied.

Since learning objects users employ mobile devices to collaborate and interact with each other, we need a *MobileDevice* class to profile the mobile devices. This class should profile the mobile device being used by the learner before learning objects are deployed on it. By profiling the device in use, its generation order, presentation and operational capabilities can be determined. Likewise, the *MobileDevice* class should be able to determine the mobile device's limitations. Once the limitations are determined, the *MobileDevice* class should be able to permit a mLearning object user to put in place mechanisms to mitigate the mobile device limitations. The *MobileDevice* class should consist of operations for determining an institutions device policy and mitigating mobile device limitations.

There should be a *LearningObjectBroker* class to coordinate the activities of all other classes. This class should provide software and algorithms to enable other classes in the model to perform their responsibilities. It should coordinate the presentation, interactions and navigation of the learning object. It should have attributes for identifying the different sources of learning objects, their access types, IPR issues on them and the cost of acquiring those learning objects. It should also be responsible for determining all the resources needed to utilize a brokered learning object and the transformations needed, if any, on a learning object retrieved before being deployed on a mobile phone. The *LearningObjectBroker* class must have operations for determining the required pedagogy, composing a learning object, searching and retrieving a learning object from learning object repositories, transforming a learning object from PC to mobile devices format and providing an audit trail for learning object usage and deployment.

The *LearningObjectBroker* class should use the *ConnectivityProfiler* class to profile network conditions. In developing countries, Internet and mobile network connectivity is intermittent. There are times when a learner's mobile phone is offline because they are in an area with no connectivity or due to lack of electricity for charging the mobile phone battery. Internet may not be accessible due to limited or lack of airtime credit. All these situations present conditions of offline connectivity. The *ConnectivityProfiler* class must be able to profile the offline and online states of the learner's mobile device with the aim of mitigating offline states. The *ConnectivityProfiler* class has a responsibility of profiling the network condition of the learner's mobile device, the networking technologies and network service providers available to the learner. It should thus have operations to determine the mobile network condition and mobile device property. The class should have operations for pre-fetching and hoarding learning objects for use during offline times.

The *LearningObjectBroker* class searches, retrieves and stores learning objects in a learning objects database represented in our model by the *LearningObjectRepository* class. The *LearningObjectBroker* class also warehouses actors' credentials. Whereas the mLearning system can have its in-house learning objects repository, it is a good idea to allow the system to access external repositories as well. The *LearningObjectRepository* class should have an attribute for determining the devices to which

a given learning object is renderable. It must therefore have operations for receiving and processing learning object requests and giving appropriate responses. It should be able to warehouse learning objects for PCs and mobile devices.

In order to use PCs and mobile devices to access, deploy and utilize learning objects, it is necessary to implement *PCInterface* and *MobileInterface* classes to profile PC and mobile devices interface respectively. Learning objects for mobile phones are different from those for desktop computers because of the different interface characteristics. The mobile phone interface is tiny and of a low resolution. Hence content has to be transformed to fit this interface. The *MobileInterface* class should be responsible for providing a mobile phone interface in which content transformed for mobile phones can be deployed and utilized. *MobileInterface* class profiles interface characteristics of a mobile device in question so that learning objects are appropriately rendered into it. This class should have operations for requesting, composing, deploying and receiving mLearning objects. On the other hand, learning objects users employing desktop computers need a *PCInterface* class to model the desktop computer interface for learning objects. The *PCInterface* should have operations for requesting, composing, deploying and receiving learning objects.

All operations in the different model classes should be underpinned by an institution's mLearning pedagogy (*MobileLearningPedagogy* class) which in turn should be guided by that institution's mLearning policy (*MobileLearningPolicy* class).

3.1.4 The Model

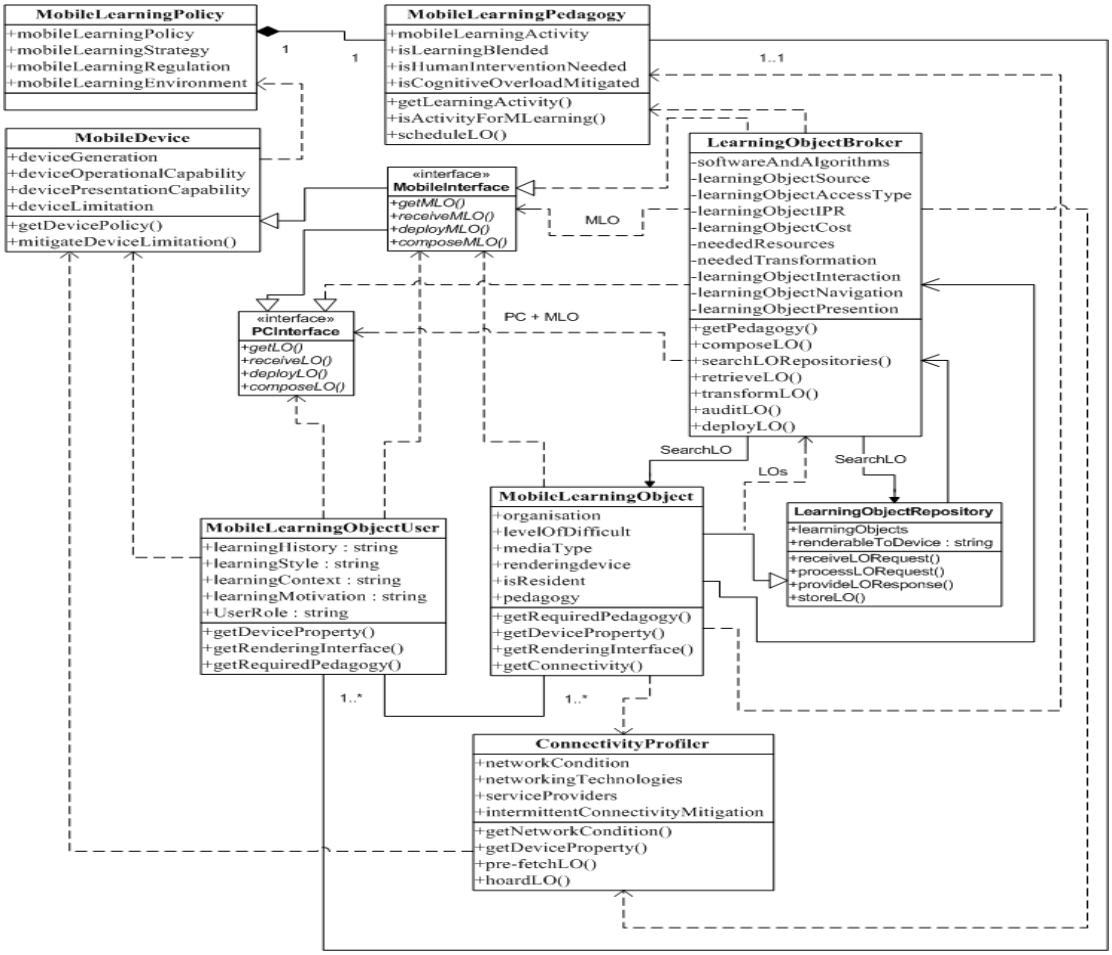

FIGURE 3.1. The *MoLODUM*

Arising from the responsibilities of the ten classes abstracted in *Section 3.1.3,* we modeled each class and established the collaborations and relationships among the classes as per the scenarios in *Section 3.1.1.* The class diagram arising from the class relationships and collaborations formed the mLearning object deployment and utilization model (*MoLODUM)* shown in *Figure 3.1.*

4. MOLODUM VALIDATION

We developed a prototype mLearning system and used it to validate 82% (27 out of 33) of the *MoLODUM* class operations. The system was based on thin client - server architecture. The architecture comprised a Web server, Web and WAP portals, DBMS, an SMS gateway with a mobile phone modem, low and high end mobile phones, desktop computers and GPRS, GSM and Bluetooth network connectivity. The functional requirements for the system were designed using use cases. The Web server was implemented using IIS. Web and WAP portals were implemented using ASP.NET and C#. The DBMS (learning objects repository) was implemented using MySQL. The SMS gateway was implemented using C#.

We validated the *MoLODUM* by comparing the prototype mLearning system functionalities with the operational scenarios in *Section 3.1.1*. For purposes of illustration, we validate the aspect of ensuring equity in learning among students using multi-generation order mobile phones. Such a cocktail of mobile phones generations presents serious limitations. The illustrations are shown in *Figures 4.1, 4.2* and *4.3*.

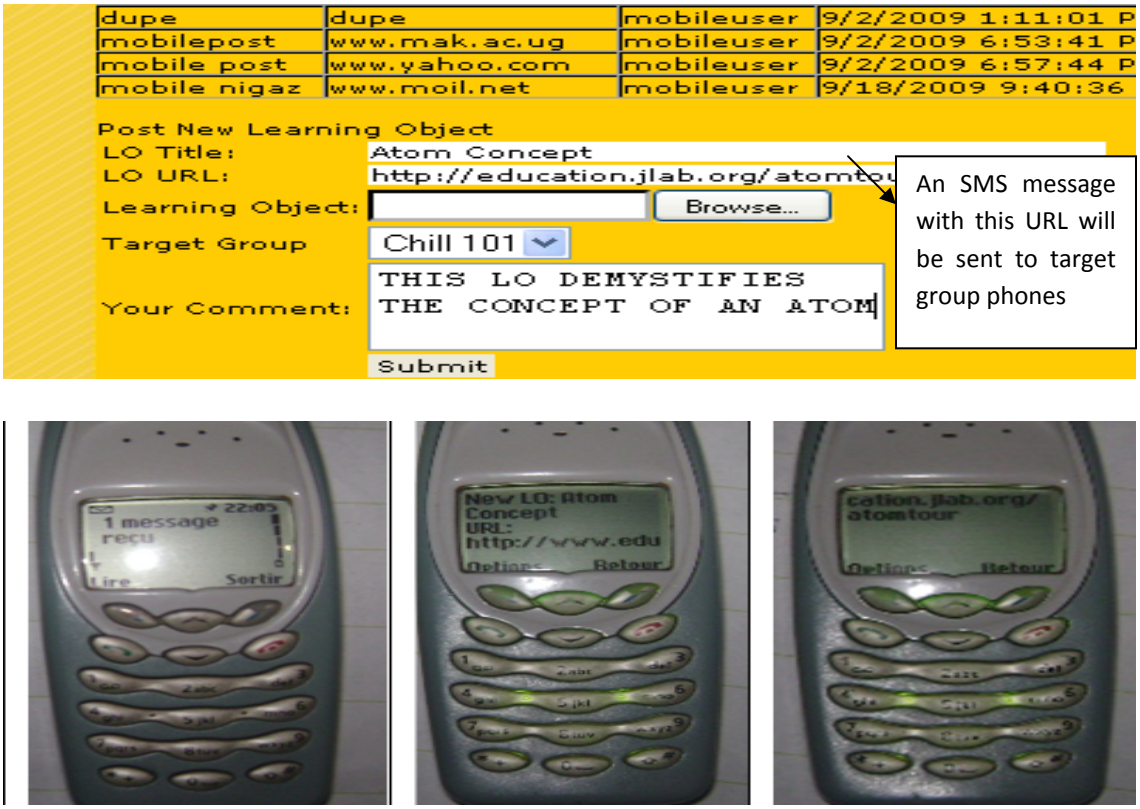

FIGURE 4.2. Low end mobile phone user receives a SMS with a LO URL link

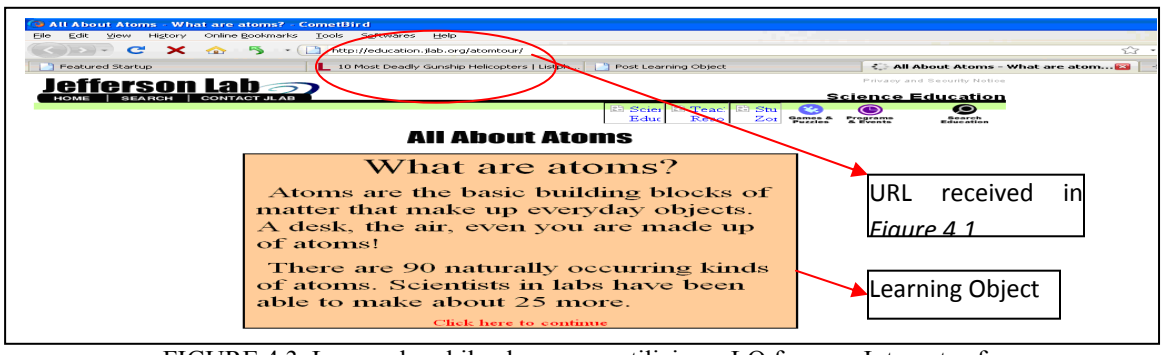

FIGURE 4.3. Low end mobile phone user utilizing a LO from an Internet cafe

Our system employs the notion of an SMS to mitigate mobile phones limitations. A lecturer wishing to deploy a learning object onto learners' mobile phones uses the Web portal in *Figure 4.1* to prepare a learning object. Learners' mobile phone capabilities are profiled at the time of capturing their credentials in the database. The system pushes the learning object plus an SMS containing a URL link to the learning object to low and high end generation order mobile phones. Low end mobile phones only receive the SMS message (*Figure 4.2*). Using the URL in the SMS, a learner goes to an Internet café and accesses the learning object (*Figure 4.3*). This blending mitigates the mobile phone limitations and ensures equity in learning.

4. MOST FEASIBLE LEARNING OBJECTS

Considering the constraints imposed across the continuum of mobile phones available to learners, it is feasible to deploy text and audio based learning objects on these phones. In the distance learning scenario, the text based learning objects could be related to reminders for residential sessions, changes in lectures and examinations venues, deadlines for assignments and registration, tips for studying at a distance, information about study materials, due dates for library books, university almanac, field research guidance, and other academic counseling information. Audio snippets of learning materials could also be deployed for learners to listen to during their free time.

5. CONCLUSION AND FUTURE WORK

It is possible to deploy and utilize learning objects on multi-varied generation mobile phones. The *MoLODUM* presents a framework for instantiating mLearning objects applications for learners in developing countries. By putting in place mLearning object applications instantiated from the *MoLODUM*, the digital divide brought about by limited access to desktop computers and Internet in rural and non-city locations of developing countries can be narrowed. Further, cheaper ways of just-in-time and just-in-place collaboration, interaction and support to distance learners can be achieved. Also, mLearning applications instantiated from the model can provide a stepping stone for breaking into the digital learning styles of the digital native or net generation learners. The inherent limitations to the fulfillment of our model are likely to emanate from the high cost of mLearning and lack of mLearning policies, pedagogies and curricula. Commitments to mLearning from all its stakeholders can mitigate the high costs. We suggest future research work in mLearning pedagogies and curricula, mLearning policies and strategies and service oriented architectures for mLearning and mLearning management systems (mLMSs) based on *MoLODUM.* Also, more research work need to be done in determining the unit cost of implementing mLearning.

6. ACKNOWLEDGEMENT

This paper is based on the corresponding author's PhD work. We would therefore like to thank Makerere University, SIDA/SAREC and NUFFIC for funding this PhD Research.

7. REFERENCES

AGUTI, N. J. AND FRASER, J. W. 2006. Integration of Information Communication Technologies (IICTs) in the Distance Education Bachelor of Education Programme, Makerere University, Uganda. *Turkish Online Journal of Distance Education -TOJDE*, 7 (3), Article: 7.

AIS 2007. Design Research in Information Systems. Retrieved November 7, 2007, from http://www.isworld.org/Researchdesign/drisISworld.htm

AYALA, G. AND CASTILLO, S. 2008. 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.

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

FISHER, M. AND BAIRD, E. D. 2007. Making mLearning Work: Utilizing Mobile Technology for Active Exploration, Collaboration, Assessment, and Reflection in Higher Education. *Journal of Educational Technology Systems* 35(1), 3-30.

Goh, T. and Kinshuk, D. 2006. Getting Ready for Mobile Learning - Adaptation Perspectives. *Journal of Educational Multimedia and Hypermedia* 15 (2), 175-198.

GRANT, J., LYNCH, K. AND FISHER, J. 2007. Looks Can Cost; Especially On A Small Screen. *Paper presented at the 7th IFIP International Conference on e-Business, e-Services, and e-Society (I3E2007)*, Wuhan, China.

ITU 2007. Mobile cellular subscribers. Retrieved June 12, 2009, from http://www.itu.int/ITU-D/icteye/Reporting/ShowReportFrame.aspx?ReportName=/WTI/CellularSubscribersPublic&RP_intYear=2007&RP_intLanguageID=1

KEEGAN, D. 2005. The incorporation of mobile learning into mainstream education and training. *Paper presented at the 4th World conference on m-learning (MLearn 2005)*, Cape Town, SA.

KURUBACAK, G. 2007. *Identify Research Priorities and Needs for Mobile Learning Technologies in Open and Distance Education: A Delphi Study*. College of Open Education, Anadolu University, Anadolu

LUIS DE MARCOS, H. R. J., GUTIÉRREZ A.J., PAGÉS C., & MARTÍNEZ, J.J. 2006. Implementing Learning Objects Repositories for Mobile Devices. Retrieved October 24, 2009, from http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-208/paper04.pdf

MCGREAL, R., CHEUNG, B., TIN, T. AND SCHAFER, S. 2005. Implementing Mobile Environments using Learning Objects: The Athabasca University Digital Reading Room. *Paper presented at the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05),* Tokushima, Japan

MOTIWALLA, F. L. 2007. Mobile learning: A framework and evaluation. *In Computers & Education* 49 (3), 581-596.

MUYINDA, B. P., LUBEGA, J. AND LYNCH, K. 2009. A Model for Scaffolding Traditional Distance Learners for Constructivistic Online learning. *Makerere University Journal for Higher Education (MAJOHE)* 2, 155-176.

MUYINDA, B. P., LUBEGA, J. AND LYNCH, K. 2010. Unleashing mobile phones for research supervision support at Makerere University, Uganda: the lessons learned. *International Journal of Innovation and Learning (IJIL)* 7(1), 14-34.

NAKABAYASHI, K., HOSHIDE, T., HOSOKAWA, M., KAWAKAMI T. AND SATO, K. 2007. Design and Implementation of a Mobile Learning Environment as an Extension of SCORM 2004 Specifications. *Paper presented at the Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007),* Niigata, Japan.

PETTIT, J. AND KUKULSKA-HULME, A. 2007. Going with the grain: Mobile devices in practice. *Australasian Journal of Educational Technology* 23(1), 17-33.

PRENSKY, M. 2001. Digital Natives, Digital Immigrants. *On the Horizon* 9(5), 1-6.

QUINN, N. C. 2002. *Flexible Learning: Mobile Learning Objects*. Knowledge Anywhere, Bellevue.

REEVES, C. T., HERRINGTON, J., & OLIVER, R. 2005. Design Research: A Socially Responsible Approach to Instructional Technology Research in Higher Education. *Journal of Computing in Higher Education* 16 (2), 97-116.

SHARPLES, M., TAYLOR, J., AND VAVOULA, G. 2005. Towards a Theory of Mobile Learning. *Paper presented at the 4th World conference on m-learning (MLearn 2005)*, Cape Town, SA.

TOLEDANO, M. C. M. 2006. Learning objects for mobile devices: A case study in the Actuarial Sciences degree. *Current Developments in Technology-Assisted Education* 2006, 2095-2099.

TRAXLER, J. 2007. Defining, Discussing, and Evaluating Mobile Learning: The moving finger writes and having writ…. *International Review of Research in Open and Distance Learning* 8(2), 1-12.

WILEY, D. A. 2001. *The Instructional use of Learning Objects*. Association for Educational Communication and Technology, Bloomington.

YANG, M. 2007. An Adaptive Framework for Aggregating Mobile Learning Materials. *Paper presented at the Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007)*, Los Alamitos, California.