DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES

By

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DECLARATION

I declare that to the best of my knowledge this dissertation is original, has never been submitted to any university for a similar award and no part in it has plagiarized work. I take full responsibility for any errors and omissions that may be found therein

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APPROVAL

We the undersigned certify that Mr. Paul Birevu Muyinda carried out his PhD research under our supervision. We hereby pronounce that his dissertation is ready for final submission. We have consented to the submission of this dissertation after satisfactorily reading through the copy. Therefore this dissertation is submitted to the University with our due approval.

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DEDICATION

This work is dedicated to:

My wife Florence Daphine Muyinda and children, Prossy, Faustin, Priscilla, Peyton, Paulson and Joan, for your support, understanding and love and care you missed during my absence

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ABBREVIATIONS/ACRONYMS

ADL	Advanced Distributed Learning
AIS	Association of Information Systems
ANSTI	African Network for Scientific and Technical Institutions
ASTD	American Society for Training and Development
AVOIR	African Virtual Open Initiatives and Resources
AVU	African Virtual University
CoPs	Communities of Practice
DVC	Deputy Vice Chancellor
EDGE	Enhanced Data Rates for GSM Evolution
ELE	Electronic Learning Environment
E-Learning	Electronic Learning
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communication
HTML	Hyper Text Markup Language
IEEE	Institute of Electrical and Electronics Engineers
IM	Instant Messaging
IMS	Instructional Management Systems
IPR	Intellectual Property Rights
ITU	International Telecommunications Union
IVR	Interactive Voice Recognition
J2ME	Java 2 Micro Edition
KEWL	Knowledge Environment for Web-based Learning
LAN	Local Area Network
LCMS	Learning Content Management System
LMS	Learning Management System
LO	Learning Object
MCSCL	Mobile Computer Supported Collaborative Learning
MLCSP	Mobile Learning Cost Sustainability Plan
M-Learning	Mobile Learning

MLO	Mobile Learning Object
MMS	Multimedia Media Services
MoLODUF	Mobile Learning Object Deployment and Utilization Framework
ODeL	Open, Distance and e-Learning
PC	Personal Computer
PDA	Personal Digital Assistant
PDF	Portable Document Format
SCORM	Sharable Content Object Reference Model
SMS	Short Message Service
TCMPC	Total Cost of Mobile Phone Communication
UML	Unified Modelling Language
UMPC	Ultra Modern Personal Computer
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
UNU-IIST	United Nations University – International Institute for Software Technology
UPE	Universal Primary Education
URL	Uniform Resource Locator
USB	Universal Serial Bus
USE	Universal Secondary Education
VoIP	Voice over Internet Protocol
WAN	Wide Area Network
WAP	Wireless Access Protocol
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access (Wireless Broadband)
WLAN	Wireless Local Area Network
WML	Wireless Markup Language
XHTML	eXtensible Hyper Text Markup Language
XML	eXtensible Markup Language
XSLT	eXtensible Stylesheet Language Transformation
ZPD	Zone of Proximal Development

DEFINITIONS OF KEY TERMS AND CONCEPTS

Definition 1: **M-Learning** is a form of e-learning which employs mobile devices, such as mobile phones, to extend and deliver learning to learners (Luis de Marcos *et al.*, 2006).

Definition 2: A **Learning Object** (LO) is a digital educational resource/content which is granulated into units that are reusable, adaptive, and can be re-purposed to different learning styles, knowledge levels and conditions (Wiley, 2001).

Definition 3: **M-Learning Objects** (MLO) are learning objects that can be deployed by and utilised on mobile devices such as mobile phones (Ayala & Castillo, 2008).

Definition 4: **Pedagogy** is the art and science of teaching (Knowles, 1973). Pedagogy is founded on the premise that education aims at transmitting knowledge and skills from the teacher to the learner. Thus pedagogy consists of strategies or styles of instruction that are best suited for providing tuition to a learner in a given context.

Definition 5: A **Framework** or **Development Framework** is a supporting structure around which something can be built (AIS, 2007; Hevner *et al*., 2004; Reeves *et al.* 2005). It provides a generic solution for a set of similar or related problems in an entire domain (Froehlich *et al.,* 1997). In this study, it connotes a competency set of dimensions and sub-dimensions that can be followed to develop sound pedagogic m-learning objects deployment and utilisation applications.

Definition 6: **Deploying** is the act of enabling access to and availing learning objects in appropriate formats onto learners' mobile devices with the intention of causing learning or extending learning support.

Definition 7: **Utilising** is the act of consuming learning objects with the view of achieving a learning experience or experiencing learning support.

Definition 8: **M-Learning Objects Deployment and Utilisation Framework (*MoLODUF*)** is a generic competence set of dimensions and sub-dimensions that can be followed by application developers to create/instantiate pedagogic applications for obtaining access to and utilising learning objects on multi-generation order mobile phones found in different contexts.

ABSTRACT

An increasing desire to port learning on mobile phones (m-learning) exists. However, there is limited understanding on how to pedagogically obtain access to and use learning objects on mobile phones. The limited understanding is caused by a dearth in frameworks for underpinning the development of applications for pedagogically obtaining access to and utilising learning objects on mobile phones. Following Design Research methodology, this research has developed a *Mobile Learning Objects Deployment and Utilisation Framework (MoLODUF*) to address the problem. The framework aims at guiding application developers to instantiate/create pedagogic applications that can enable learners in developing countries obtain access to and use learning objects, delivered over the Internet/other networking technologies, regardless of their proximity to higher education institutions, through the use of mobile phones. To develop the *MoLODUF*, six research questions were answered. In the first research question, we established the current learner contexts, practices and prospects for the development and growth of m-learning. The results have falsified the exiting belief that internal learners are endowed with more learning resources and better learning contexts than distance learners. Association test runs between mode of study and the majority of context variables returned non-significant p-values. For instance, there was no significant association between mode of study with: the learner location (p=0.532), availability of mobile network connectivity (p=0.062), availability of Internet connectivity (p=0.329), availability of power supply (p=0.199), Internet use (p=0.249), mobile phone use (p=0.122), Blackboard LMS use (p=0.148), CDROM use (p=0.266) and computer applications use (p=0.244). There was also lack of significant association between learner's location with mobile network (p=0.136) and Internet (p=0.329) connectivity. Furthermore, power supply was not associated with availability of mobile network connectivity (p=0.301). Significant associations were found between mode of study and noise levels of learner's location (p=0.029), learner's location and its noise levels (p=0.035), learner's location and power supply (p=0.000), power supply and Internet connectivity (p=0.000), learners' digital characteristics and age (p = -0.199) and mode of study and use of e-mail (0.002). As far as current m-learning practices were concerned, there existed limited knowledge about the term 'm-learning' though m-learning was inadvertently being practiced through push and asynchronous text (45.1%) and audio (45.5%) learning objects. Prospects for the development and growth of m-learning lay in the increasing permeation and processing power of mobile phones, increasing coverage of telecommunication networks, favourable government policies on telecommunications investment, existence of e-learning infrastructure and distance learning units in some universities, high mobility of lifelong learners, increasing elitism, existence of other mobile applications and the need to support great student numbers from programmes like UPE and USE. In the second research question, we established seven (7) non-mutually exclusive candidate m-learning processes namely:

Co-Creation of New Knowledge, Knowledge Sharing, Collaborative & Interactive Learning, Reflective Learning, Problem-Based Learning, Academic and Administrative Support and *Communication/Information Exchange*. These learning processes have learning pedagogies underpinned by the social constructivist, conversational, problem-based, reflective and teaching and learning support learning theories. In the third research question, we determined the learning objects that could be used to service the identified learning processes. It was established that amidst the cost and kind of constraints placed by mobile technologies, text and audio based learning objects were feasible. The research however, emphasized the need to leverage different learning object media types in ways that are appropriate to the prevailing circumstances so as to produce the best learning experience. In the forth research question, we adduced from the findings, twelve (12) factors for obtaining access to and utilising learning objects in m-learning. They include the type of: learning objects needed, learning device to be used, learning interfaces at hand, learning connectivity present, learning processes to be accomplished, learning costs involved, learning resources needed, learning contexts available, learning objects user's profile, learning ethics to be abided by, education technology policy in place and learning evaluation mechanisms available. Therefore in the fifth research question, we used the aforementioned factors to develop a competence set of major and sub-dimensions of the *MoLODUF*. Consequently, the *MoLODUF* is composed of twelve (12) major dimensions, which respectively include: *M-Learning Object, M-Learning Device, M-Learning Interface, M-Learning Connectivity, Learning Process, M-Learning Costs, M-Learning Resources, M-Learning Context, M-Learning Objects User, M-Learning Ethics, M-Learning Policy* and *M-Learning Evaluation.* Using expert evaluation, the *MoLODUF* dimensions were found to be highly reliable at a standardized Cronbach's alpha of 0.9227. Using ANOVA, the dimensions were found to be highly valid at a grand mean of 3.6167 for F = 0.6407 and probability of 0.7841 on a four point nominal likert scale of strongly disagree (1) to strongly agree (4). In the sixth research question, the *MoLODUF* was compared with similar learning frameworks to adduce the contribution. The *MoLODUF* extends existing e-learning frameworks with five mobility dimensions, namely: *M-Learning Cost, Learning Processes, M-Learning Objects, M-Learning Policy and M-Learning Context.* It also extends existing m-learning frameworks with five dimensions, namely: *M-Learning Costs, Learning Processes, M-Learning Evaluation, M-Learning Policy* and *M-Learning Ethics* dimensions. In a nutshell, the *MoLODUF* provides a competency set of novel guidelines to be followed when creating/instantiating/developing applications for deploying and utilising learning objects on mobile phones. It can also be used to evaluate existing m-learning environments, products and services. Hence through the MoLODUF, the desire to port learning on mobile devices is made possible.

CHAPTER ONE

1. INTRODUCTION

1.1 Motivation

As a person tasked with the responsibility of integrating ICTs in the distance education student support system at Makerere University, I was challenged by the enormous lack of equity in ICT based support services we were extending to our students. I felt that the distance learners near the city of Kampala were getting more ICT based support than those far off, the reason being lack of access to computers! The ICT infrastructure in the nine student support centres located across the country was far from real. During first year students' briefing meetings, we 'proudly' informed freshmen and women of the "existence of student support centres equipped with state of the art ICT facilities". Inside my inner soul, I new we were not being sincere! The ICT facilities at the centres were obsolete, limited in number, not easily accessible and had no pedagogic applications whatsoever installed on them. Just a few centres had the cumbersome dialup Internet connectivity. Also students had to trek long distance to access these centres. I realised however, that lecturers and administrators were supporting students using mobile phones. The same thing was happening amongst students themselves. This was happening because majority of students and staff owned mobile phones. A visit to the University of Pretoria opened my eyes to the enormous support the Unit of Distance Learning was extending to its students through SMSs. On consulting literature, I realised the e-learning research community was awash with different research areas in using mobile phones for learning and teaching (m-learning). Then I was like, let me pursue research in this democratized new form of e-learning (m-learning) so as to be able to engrain mobile learning in the student support systems of countries with limited 'conventional' e-learning infrastructure and enhance my career by pursuing a PhD academic research.

The Internet and wireless and handheld technologies are converging into ubiquitous/personalized technologies. This convergence is revolutionalizing the electronic learning (e-learning) paradigm. The ability for ubiquitous/personalized technologies to provide "anytime", "anywhere computing", has ignited a paradigm shift from "electronic" to "mobile" services (Luis de Marcos, *et al*., 2006, p.1). Consequently, electronic commerce has given birth to mobile commerce and electronic learning to mobile learning (Traxler, 2007).

The concept of mobile learning (hereafter abbreviated as 'm-learning') has surfaced in the era of personalized wireless, tiny, handheld and portable devices (mobile devices). M-learning is a form of e-learning which employs mobile devices, such as mobile phones, to extend and deliver learning to learners (Luis de Marcos *et al.*, 2006). These devices are able to communicate with each other over the Internet or in a proximal network via Bluetooth or infrared connectivity. Current mobile devices use the IEEE 802.11 (wireless fidelity - Wi-Fi) and IEEE 802.15.1 (Bluetooth) wireless

communication standards to communicate over the Internet and in proximal networks respectively (Caudill, 2007). These capabilities make m-learning a possible and desirable application for mobile devices.

M-learning can personalize learning on-the-go (Ayala & Castillo, 2008), which increases the learner's learning experience and flexibility. Personalized learning requires a learner centred pedagogy and personalized learning content and support.

Personalized learning has eluded 'conventional' e-learning especially for learners in developing countries. 'Conventional' e-learning is that which uses Internet connected desktop computers located in computer laboratories, offices and homes to connect to learning management systems (Motiwalla, 2007). Conventional e-learning is hereafter in this dissertation simply referred to as 'e-learning' or 'online learning'.

In developing countries, the technologies that propel e-learning are not readily available in the midst of the learners (Brown, 2005). Thus e-learning technologies coerce learners to move to fixed locations with Internet connectivity (Caudill, 2007; Goh & Kinshuk, 2006). This requirement removes flexibility needed in personalized learning.

To introduce personalization and hence flexibility in e-learning, personalized learning devices need to be integrated with e-learning technologies (devices) (Caudill, 2007; Luis de Marcos *et al.*, 2006; Motiwalla, 2007). Personalized learning devices come in the form of wireless handheld mobile devices that have ability to connect to the Internet (Caudill, 2007). Such devices include: mobile phones, smart phones, PDAs, iPods, MP3 player, ultra-mobile personal computers (UMPC), tablet and laptops computers (Fisher & Baird, 2007; Low, 2007).

Personalized learning devices should be easy to access and move with. Personalized learning devices should be able to "…fit in the average shirt or jacket pocket and … be carried [anywhere] on a daily basis" (Caudill, 2007, p.2). This definition negates the laptop from the list of personalized learning devices. Though it is portable, a laptop is not mobile in the sense of Caudill's (2007) definition for personalized learning devices.

Personalized learning devices adapt learning to a given learner's context and enhance his/her interaction and collaboration with other learners and tutors (Low & O'Connell, 2006). Context is information which describes the situation of a learner in a given location (Uden, 2007). It "is typically the location, identities of nearby people, objects and changes to objects" (Zhang, 2003. p.7). It implies that a learning device is part and parcel of a learner's context. Context affects learner's ability to learn since learners interface with content which is personalized to their learning

needs and conditions.

Content is personalized by "removing data that are not of users' interest in downloading, converting images to smaller representations [and] determining an appropriate resolution of images or compression rate of video in order to adapt to current network conditions (Zhang, 2003, p.3). Personalization sieves out only useful content from the multitude of content in content repositories and the Internet.

The increasing ability to access Internet via personalized, wireless, tiny, handheld and portable devices means that learning content can be accessed via these devices (Ayala & Castillo 2008). However, the content for delivery on mobile devices has to be "leaner than content prepared for ... e-learning systems" (Low, 2007, p.9). This content is developed in a granular, sequenceable, reusable and contextualiseable form (Ayala & Castillo 2008; Uden, 2007; Zaharieva & Klas, 2005). These are characteristics of learning content that is developed as learning objects.

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" (IEEE, 2010, p.1). This study emphasizes the digital nature of a learning object and thus adopts Wiley's (2001) definition. In Wiley (2001), a learning object is defined as "any digital resource that can be reused to support learning". In all the definitions of a learning object, the size is not emphasized. Hence a learning object can be an SMS message, a webpage, an image, a sound clip and so on. Also most definitions point to the need for reuse of learning objects in the learning process.

Learning objects could be reused if they exist in learning object repositories, the World Wide Web and the mobile web (O'Connell & Smith, 2007; Luis de Marcos *et al.*, 2006). These learning objects warehouses are host to a multitude of learning objects media types. These include: audio, text, video, podcast, PDF, 3-D animations, flash/shockwave, e-learning courseware, full applications, graphic images, HTML/websites, multimedia, photos and PowerPoint slides, or a combination of any of these (Low, 2007). Whereas, most content repositories are warehouses for desktop computer learning objects, the mobile web houses mainly content for use on mobile devices (W3C, 2009). The World Wide Web is to desktop computers as the mobile web is to mobile devices.

One of the unanswered question in the field of m-learning is, how to pedagogically obtain access to, use and re-use the multitude of learning objects in learning objects warehouses using mobile devices, such as mobile phones that are becoming powerful and pervasive especially in developing countries (Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007). The solution lies in developing m-

learning objects applications that are underpinned by pedagogically grounded global m-learning frameworks but such frameworks are in short supply (Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007; Traxler, 2007). This gap provided a basis for this research in which a framework for instantiating applications for obtaining access to and use of learning objects on mobile phones is developed. The development of such a framework is inline with Pettit and Kukulska-Hulme's (2007) call for research into the effective integration of mobile devices into specific contexts of education and Traxler's (2007) call for research into models, frameworks and theories aimed at nurturing the growth of m-learning. It is also inline with Kurubacak's (2007) call for research into the effective utilization of m-learning objects and the need to address the high demand for university education.

M-learning objects are learning objects that can be deployed and utilized on mobile devices (Ayala & Castillo, 2008; Fisher & Baird, 2007; Goh & Kinshuk, 2006; McGreal *et al*., 2005; Nakabayashi *et al*., 2007; Quinn, 2002; Toledano, 2006; Yang, 2007; Zaharieva & Klas 2005). By deploying m-learning objects we mean the act of enabling access to and availing learning objects in appropriate formats onto learners' mobile devices with the intention of causing learning or extending learning support. By utilizing m-learning objects we mean the act of consuming learning objects with the view of achieving a learning experience or experiencing learning support.

The applications instantiated from the m-learning objects framework should be able to help learners access and chose learning objects which adjust to their multiple learning contexts (Uden, 2007). Such a framework should be learner-centred and should embrace the learners' digital learning styles, cultures, habits and preferences if it is to enable them effectively partake of learning objects on their mobile devices (Low & O'Connell, 2006). The framework should permit the constant advancement in mobile technology. It should embrace the different dimensions of global e-learning frameworks such as those in Khan (2001); Mescan (nd) and others, since m-learning is part of e-learning (Brown, 2005). A review of existing e-learning frameworks indicate lack of dimensions for m-learning such as m-learning cost, learning processes that can be met through m-learning (m-learning processes), m-learning objects to be used in m-learning processes, policies to guide the development and practice of m-learning, learner context, access to and use of technology and personalisation of learning. These dimensions can be addressed by m-learning but according to Traxler (2007), Pettit and Kukulska-Hulme (2007) and Kurubacak (2007), not much research has been undertaken developing frameworks for creating/instantiating m-learning environments/applications.

In this research, we develop a framework for creating m-learning object deployment and

utilization applications that takes into consideration the different learning contexts manifesting in higher education in developing countries of Africa. As an artifact intended to improve practice in e-learning, the framework is developed using the Design Research approach (AIS, 2007; Design-based research collective, 2003; Hevner *et al.,* 2004).

1.2 Background

Developing countries are increasingly experiencing high demand for university education. One of the causes of this demand is the rapid population growth that is not matched with equal growth in the brick and mortar infrastructure in the universities. The implementation of the 2nd UN Millennium Development Goal (UNDP, 2006) which requires that girls and boys partake of universal primary education in order to achieve a full course of primary schooling, has also had a contributory role to the high demand for university education. This high demand implies a high need for lecturers, quality content and student support services.

Also, the advent of the market economy coupled with the need for lifelong learning has brought to universities students with varied needs and responsibilities related to academics, jobs, family and society. Such students have limited time to share between these responsibilities. These students want to have access to education packages/services which are of high quality, convenient, cheap and accessible from anywhere at anytime (Rumble, 2000). In other words, a 'take-away' form of learning is being demanded.

Educational planners and curriculum designers are therefore experimenting with a number of education models to address the needs of the learners and the deficiency in physical infrastructure facilities. Open, Distance and e-Learning (ODeL) models are seeing wide acceptability in developing and developed countries. ODeL models are being blended with traditional classroom models to meet the emerging challenges of higher education (Caudill, 2007; Luis de Marcos *et al.*, 2006).

In developing countries, the 'eL' (e-learning) aspect in the ODeL model is constrained by limited access to e-learning facilities, limited funding, limited bandwidth, high ICT illiteracy levels, lack of or intermittent power supply, lack of appropriate e-learning policies and sustainability plans and e-learning contextualization issues (Brown, 2005; Farrell & Isaacs, 2007). These are challenges that were vividly present in Africa's first e-learning project - the African Virtual University (AVU) project (Okuni, 2000).

The AVU was a satellite based distance education project mooted and sponsored by the World

Bank under its Information for Development (infoDev) programme (Okuni, 2000). It was an e-learning project which comprised of a network of Internet facilities with its own Website. It employed a multi-media approach to teaching and learning. The learning package comprised of live or pre-recorded lectures transmitted by satellite at specific times from universities in the United States and Ireland and viewed on television screens in Africa. It also involved handouts, textbooks and other material transmitted electronically (ibid). The AVU model 'pushed' content to learners with little regard to contextual issues related to connectivity, learning needs, preferences, styles, cultures, attitudes, habits and time differences.

Though meant for learners in African universities, it did not fit in an African context because content was developed from universities outside Africa with little or no contextualization to African contexts. For instance, a content developer based in the US could not be in better position than a local content developer to provide a good local example to illustrate a given point in the content. This implies that content did not fit in the learner's context. Learning which fits into a carefully studied learner study pattern is poised to succeed than that which is orchestrated by educators in specific fixed time slots as these might not be convenient to learners (Pettit & Kukulska-Hulme, 2007). Further, there was little involvement of African universities (users) in the conception of the project. Hence because of its top-down implementation approach, the AVU e-learning project could not be sustained in many of its centres beyond the World Bank funding tenure.

As a strategy to put the AVU into an African context, its headquarter was moved from Washington (USA) to Nairobi (Africa) and African scholars were invited to locally develop content for mathematics and science for primary teacher education. The materials are now provided as open education resources on AVU website and CDs. The blending of materials on the website and CDs and use of local content developers was in recognition of the problem of insignificant access to tethered desktop computer Internet in Africa and the need to contextualize content.

World over, the problem of insignificant access to tethered desktop computer Internet is being solved by porting PC based applications onto mobile phones (W3C, 2009). In education, e-learning is being supplemented by m-learning (Traxler, 2007). This is because mobile phones have become powerful and pervasive (Ayala & Castillo, 2008, Traxler, 2007). According to ITU (2007a), 89.7% of the total telephone subscription in Africa was of mobile phones with CAGR of 49.4%. The World CAGR for mobile phones was 23.9% (ibid). This pervasiveness in mobile phones has compelled Internet giants such as Yahoo!, Google, Disney Internet Group, Verizon Wireless, AT&T, CNN, BBC, Apple Computer and Sony to develop content for the mobile web (Fisher & Baird, 2007;

W3C, 2009; Zhang, 2003). The mobile web is host to millions of learning resources that can be tapped for m-learning and e-learning systems (O'Connell & Smith, 2007). In addition to providing learning content, the mobile web is also host to content for mobile commerce, entertainment and news.

Because of the personalized nature of mobile devices, the content developed for use on these devices is tending towards achieving personalizing learning, commerce, entertainment and news. For learning, the content is increasingly being designed and developed as m-learning objects (Ayala & Castillo, 2008; Nakabayashi *et al*., 2007; Yang, 2007; Quinn, 2002) and kept for use and reuse in learning object repositories and the mobile web (Luis de Marcos *et al.*, 2006). Hence there has been significant research in the design and development of learning objects for wireless handheld devices (Ayala & Castillo 2008; Goh & Kinshuk, 2006; McGreal *et al.,* 2005; Nakabayashi *et al,* 2007; Quinn, 2002; Toledano, 2006; Yang, 2007; Zaharieva & Klas 2005). Less research is reported on how to effectively deploy and utilize the already designed and developed m-learning objects in different contexts (Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007) including those of developing countries of Africa. Therefore there is limited understanding on how to obtain access to and utilize existing learning objects on mobile phones. Such an understanding would improve if there were m-learning applications to obtain access to and use learning objects on mobile phones but frameworks to underpin such applications' development are in short supply (Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007). Such frameworks would ascribe meaning to learning in learning objects existing in repositories.

A learning object repository is a warehouse for learning objects (Luis de Marcos *et al.*, 2006). There are thousands of learning object repositories. Some of these are: the Multimedia Educational Resource for Learning and Online Teaching (MERLOT, 2010), Campus Alberta Repository of Educational Objects (CAREO, 2010), Canadian Network of Learning Object Repositories (CNLOR, 2010) and Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE, 2010). All these offer learning objects for PC based systems. Learning object repositories can allow learners to access, use and reuse learning objects through their mobile devices or personal computers. Since access to personal computers in developing countries is limited (Farrell & Isaacs, 2007) and since use and ownership of mobile phones is pervasive (ITU, 2007a, Brown, 2005), it makes sense to promote the mobile phone as one of the devices for accessing learning objects repositories. However, as has already been pointed out, the question remains, how to didactically obtain access to and use learning objects from the multitude of learning object

repositories using a mobile phone. Such access to learning objects must be meaningful because learners need to make "meaningful connections to resources and other people" (Corbeil & Valdes-Corbeil, 2007, p.55). Meaningful connections to resources involves considering the learner's context and comfort.

While emphasizing the need for learner contextualization, Quilter (2000, p.6) observed, "… for e-learning to really work effectively, what it pushes out to every individual must be closely targeted on his or her own specific learning needs. And for this to happen, there needs to be a viable, workable framework, driving the whole system that encompasses people development processes, organizational cultural issues and organizational needs". Quilter's call, though sounded in 2000, has seen little research response especially in the field of m-learning. M-learning research needs identified by Kurubacak (2007), Pettit and Kukulska-Hulme (2007) and Traxler (2007) still call for research into development of models and frameworks for effective utilization of m-learning.

Since m-learning is a subset of e-learning (Brown, 2005), developments in m-learning should be informed by earlier developments in e-learning. It is thus imperative to draw from existing e-learning frameworks as we seek to come up with an m-learning framework. Generally speaking, learning is said to occur if there is an observable change in the learner's behaviour (Skinner, 1968). Thus "the key to learning is retention—remembering and understanding the material in order to implement it" (Mescan, nd, p.2). Any delivery platform, be it traditional classroom or e-learning platforms, must ensure retention of learning materials.

E-learning can aid learners to retain materials because it can help them have multiple access to learning materials, share information with peers and get support from their institution (Brown, 2005). Therefore, the philosophy of e-learning derives from learners being able to retain materials and implementing it after the learning process (Mescan, nd).

In consideration of the materials retention philosophy, Mescan (nd) developed a framework for e-learning with ten dimensions. These include: suitability of the learning environment, dedication of time to e-learning, dedication of resources, being focused on particular learning activity, profiling of e-learners, definition of course levels, allowing for repetition, having engaging presentation, having hands-on participation, having evaluation mechanisms and immediate feedback. In another e-learning framework developed by Khan (2001), effective e-learning is considered to have eight dimensions. They include: pedagogical, technological, interface design, ethical, institutional, evaluation, management and resource support dimensions.

Existing e-learning frameworks are silent on issues related to m-learning such as m-learning

cost, learning processes that can be fulfilled by m-learning (m-learning processes), m-learning objects to be used in m-learning processes, policies to guide the development and practice of m-learning, learner context, access to and use of technology and personalisation of learning. The dimensions need to be infused in existing e-learning frameworks if we are to achieve a full and meaningful integration of m-learning with e-learning.

M-learning can fill the gaps in existing e-learning frameworks (Ayala & Castillo, 2008) but current m-learning frameworks do not address all the required dimensions. In Barker *et al*. (2005), a theoretical framework for m-learning adoption in developing countries has been suggested. This framework addresses only two dimensions, namely: m-learning context (with m-learning and traditional learning environment sub-dimensions) and m-learning policies and guidelines. A lot more dimensions including: m-learning objects, m-learning resources, m-learning costs, learning processes, m-learning evaluation, m-learning devices, m-learning interfaces, m-learning ethics and m-learning users need to be addressed in a pedagogic m-learning framework. Again, while Barker *et al.'s* (2005) framework is on successful adoption of m-learning in general, current research (Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007; Traxler, 2007) is calling for framework that specifically targets creation of applications for obtaining access to and utilising learning objects on mobile phones.

Another framework worth considering is Brown's (2005) framework for m-learning in Africa. The framework zeros down on the mobile phone as the most effective m-learning device for learners in Africa. It is underpinned by the social constructivist theory of learning (Vygotsky, 1978) which posits that learning is a social activity that takes place in a community. The social constructivism theory implores educational institutions to not only concentrate on providing content to learners but also focus on enabling learners to find, identify, manipulate and evaluate existing knowledge, integrate the knowledge in their world of work and life, solve problems and communicate this knowledge to others.

In Brown's (2005) exposition, two progression m-learning models based on skills of ICT use, wireless device infrastructure availability, accessibility and advancement are given. The first model suggests the use of only SMS technologies for administrative support while the more advanced model considers support through SMS, MMS, WAP and Internet. Brown's (2005) model is basically hinged on student support through orchestrated messages created by universities. It is important to advance the usability of mobile phones in developing countries for learning object deployment and utilization. Such a view is derived from Pettit and Kukulska-Hulme (2007) who view mobile devices

as being better suited for content consumption than content creation. As such, the majority of learners and tutors in developing countries who are mainly content consumers than creators can be greatly aided by the m-learning objects deployment and utilization framework. Such a framework needs to be underpinned by sound pedagogical principles that can ensure optimization of learning in the m-learning environment (Brown, 2005; Fisher & Baird, 2007).

Masters (nd) developed a framework for supplementing traditional learning with m-learning in developing countries. The model which was trialed at the University of Cape Town considered existing m-learning philosophy, theory and practice and was situated and learner-centered. Results of this consideration dictated use of low end mobile phones for text messaging as the realistic way of introducing m-learning in developing countries. The framework took stock of the m-learning devices and technologies at the disposal of learners in developing countries then identified the learning needs that could be met by available technologies and employed the technologies to meet the identified learning needs. Masters' framework places a lot of emphasis on use of existing technology to meet learners' needs. Since technology is rapidly developing, it would be good to peep into the future and innovatively introduce new learning technologies as they unfold. This puts developing countries in a better position to innovatively adapt new technologies before they become obsolete in the developed countries. Pettit and Kukulska-Hulme (2007) have argued that the design of technologies for learning should not necessarily be confined to technologies that are familiar to learners but could innovatively and pedagogically introduce new technologies to the learners. A framework for m-learning should project into the future.

1.3 Statement of the Problem

Mobile devices, including mobile phones, are widely being used across the globe for a range of services including learning (Archibald, 2007; Brown, 2005; Goh & Kinshuk, 2006; Keegan, 2005; Traxler, 2007; Veith & Pawlowski, 2005). The range of services is increasing because mobile devices are becoming pervasive and powerful in terms of processing power (Ayala & Castillo, 2008). Consequently, learning content can now be deployed and utilized on these devices (Nakabayashi *et al*., 2007; Yang, 2007). It is for this reason that extensive research is raging on in the design and development of learning objects for mobile devices (Ayala & Castillo, 2008; Nakabayashi *et al*., 2007; Quinn, 2002; W3C, 2009; Yang, 2007). Even if this is the case, there is limited understanding on how to effectively deploy and utilize the already developed learning objects on mobile phones found in different learning contexts (Fisher & Baird, 2007, Kurubacak,

2007; Low & O'Connell, 2006; Pettit & Kukulska-Hulme, 2007; Uden, 2007). This has been attributed to lack of pedagogically grounded applications for deploying and utilising learning objects on mobile phones, which in-turn has been brought about by lack of frameworks to underpin those applications' development (Kurubacak, 2007; Uden, 2007; Low and O'Connell, 2006; Pettit & Kukulska-Hulme, 2007). This calls for research aimed at developing an m-learning objects deployment and utilisation framework.

1.4 Aim

To develop a framework for instantiating/creating pedagogic applications that can enable learners in developing countries obtain access to and use learning objects, delivered over the Internet/other networking technologies, regardless of their proximity to higher education institutions, through the use of mobile phones.

1.5 Objectives

The research is underpinned by four (4) specific objectives each of which are in the context of developing countries.

1. To establish the current learner contexts, practices and prospects for the development and growth of m-learning in Africa.
2. To establish factors that influence learning objects deployment and use on mobile phones
3. To develop a framework for instantiating applications for deploying and utilizing learning objects on mobile phones in different contexts.
4. To validate the framework developed in (3) above.

1.6 Research Questions

1. What are the current learner contexts, practices and prospects for the development and growth of m-learning in Africa?
2. What learning processes can be accomplished through m-learning?
3. What kinds of learning objects can be used to service the identified learning processes amidst the cost and kind of constraints placed on mobile technologies?
4. What are the issues and factors to obtain access to and use learning objects in m-learning?
5. What are the major dimensions and sub-dimensions of a mobile learning objects deployment and utilisation framework and how are they related?
6. Where are the similarities and differences with other similar learning frameworks?

1.7 Scope

The scope of m-learning objects is within the context of higher education learning institutions in developing countries. Most of the research data, especially the survey data was collected in Uganda because it is a developing and progressive country and has characteristics that can be generalized to other developing countries of Africa. Such characteristics include: limited access to e-learning facilities, limited bandwidth, high ICT illiteracy levels, lack of or intermittent power supply, lack of appropriate e-learning policies and sustainability plans and e-learning contextualization issues (Farrell & Isaacs, 2007; Brown, 2005; UNDP, 2006). Comparable positive characteristics that are in Uganda and other countries of Africa are: the telecommunications 'leap-frog' from the outdated landline telephones to mobile phones, adoption of UPE and USE, the increasing need for lifelong learning and rapid development in infrastructure (UNDP, 2006, ITU, 2007a). The similar negative and positive characteristics found in Uganda and the rest of the sub-Saharan Africa justified the choice for Uganda as being the source for survey data. Further, evidence from Nigeria in a study to determine the feasibility of using m-learning in nomadic education programmes (Aderinoye *et al*., 2007) entrench the conclusion that Uganda has similar characteristics that can be generalized to the rest of Africa. However, to increase the infusion of an African picture into the study data, the survey data was triangulated with in-depth interview data collected from e- and m-learning stakeholders from across Africa.

Choosing appropriate learning technology is a crucial aspect in e-learning (Pettit & Kukulska-Hulme, 2007). In Africa, as is similar in most developing nations, the mobile phone has been established as the most suitable device for m-learning because of its high proliferation and acceptance (Brown, 2005). Further, as Caudill (2007) observed, success of any information system depends on its saturation and acceptability amongst its target audience. Based on these two reasons, the target mobile device selected for this study is the mobile phone.

The learning objects for deployment and utilization could be composed by the learners themselves, their lecturers or administrators. They could as well come from open source learning object repositories, the World Wide Web, the mobile web and enterprise learning object databases. Open source repositories are preferred because of the free of charge access implications.

1.8 Significance of the Study

The framework provides a benchmark for instantiating/creating m-learning objects applications. The applications so developed can enable learners to utilize their mobile phones

for learning independent of time and location. This adds value to existing e-learning and classroom models and increases flexibility and personalization in learning, and more importantly, provides learning support and a wider access to education.

The applications instantiated from such a framework can enable higher education learners obtain access to and use learning objects in learning object repositories, the World Wide Web, the mobile web, learning management systems and enterprise databases through the use of mobile devices.

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 & Baird, 2007, p.2) or "digital natives" (Prensky, 2001, p.1), 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 e-learning or distance and traditional classroom learning for these learners. The framework developed in this study is one such effort to tap into the digital learning styles (Fisher & Baird, 2007) of the net generation or digital native learners.

The research provides a contribution to the body of knowledge in the infant field of m-learning. As a young field, scholars such as Keegan (2005), Kurubacak (2007), Motiwalla (2007), Pettit and Kukulska-Hulme (2007), Sharples *et al.* (2005), Traxler (2007), and others, have called for the development of theories, models, frameworks and tools that can enable the field to mature. The m-learning object deployment and utilization framework developed in this research is a novel research contribution to the maturity of the field of m-learning in particular and information systems in general.

1.9 How the Dissertation is Organised

This dissertation has seven (7) chapters. In *Chapter One*, we set the pace for the study by providing the underlying scientific theories from which the research problem is derived. The chapter gives the research problem, objectives and research questions that are addressed in this dissertation. In *Chapter Two,* we review literature that underpins the study. We review literature on m-learning, traditional distance learning, e-learning frameworks, learning theories, learning objects, m-learning objects and m-learning object frameworks. In *Chapter Three*, we present the methodology we used

to execute this study. In *Chapter Four,* the results of the study are presented following the objectives set in *Section 1.5 above*. In *Chapter Five,* results of the study are discussed following the research questions set in *Section 1.6* above. The discussion in *Chapter Five* adduced dimensions and sub-dimensions that were used for constructing the artifact - the *MoLODUF*. In *Chapter Six,* the *MoLODUF* is validated using expert evaluation. The research contributions, their implications to theory and practice and areas identified for future research are summarized in *Chapter Seven*.

CHAPTER TWO

2. LITERATURE REVIEW

2.0 Introduction

The goal of this dissertation is to create a framework for setting up environments for enabling learners in developing countries to obtain access to and use learning objects, delivered over the Internet (or other networking technologies), regardless of their proximity to higher education institutions through the use of mobile phones. The legitimacy of this goal stems from the realization that use of desktop computer Internet in developing countries is by far the least while growth and use of mobile phones has defied prediction in these countries. By 2007, there were only 5.54 desktop computer Internet users as compared to 28.49 mobile cellular subscribers per 100 inhabitants in Africa (ITU, 2007a; ITU, 2007b). These statistics indicate that uptake of desktop computer Internet services in developing countries is still low as compared to mobile phones. In Africa, e-learning is constrained by limited availability of Internet connectivity, lack of or intermittent power supply, low Internet bandwidth, lack of ICT skills and limited financial resources (Farrell & Isaacs, 2007). These constraints can be overcome by m-learning (Brown, 2005). Thus, in Africa, m-learning has a higher potential for growth than e-learning.

In Okuni (2000), the limited availability of Internet connectivity was reported as one of the factors that hampered the smooth running of the African Virtual University (AVU) project in the early years of its formation. The AVU was an e-learning project initiated by the World Bank to address the ever increasing demand in Africa for higher education amidst the limited brick and mortar infrastructure. AVU was thus aimed at augmenting the traditional classroom learning model. This well intentioned project however started facing sustainability problems after the World Bank stopped funding it (Okuni, 2000). These problems may have arisen as a result of lack of proper sustainability plan or they may have arisen as a result of AVU not being contextualized to the African settings. With contextualization, AVU later gained momentum and is now involved in the development and distribution of content for mathematics and science for primary teacher education.

Some other e-learning projects in Africa have suffered similar problems as those of the initial AVU. The African Virtual Open Initiatives and Resources (AVOIR) project was coined amongst eight higher institutions of learning from Kenya, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, and Uganda to develop KEWL.Nextgen Learning Management System (LMS) and build capacity for e-learning in Africa (Farrell & Isaacs, 2007). However uptake of

KEWL.Nextgen has been minimal in these countries (ibid). The target universities in the AVOIR project have instead adopted other LMSs. Makerere University adopted the proprietary Blackboard LMS but later migrated to the open source Moodle due to lack of enough financial resources for the yearly license subscription. The University of Nairobi adopted Wedusoft ELE which was customized to their needs from Chisimba. Even then the uptake of the preferred LMSs is not impressive (ibid). While giving a report on the implementation and impact assessment of e-learning at Makerere University, Tusubira (2006, p.5) said:

> Although the policy drivers are in place, we need to devise mechanisms that will enable implementation on the ground. For instance, while the priority faculties have e-learning infrastructure in place they do not yet have any requirements in place for staff to create online courses. We are going to work with the DVC - Academic Affairs to explore avenues for faculties to define their expectations from staff as regards e-learning.

This exposition provides an indication that even where e-learning infrastructure existed, there was no or little motivation for staff to take on e-learning. It means that access to, and acceptance of, the e-learning infrastructure are pivotal for e-learning success.

It has been noted that personal technologies that are widely accessible and accepted can be used to augment e-learning technologies (Caudill, 2007; Pettit & Kukulska-Hulme, 2007). In so doing, flexibility would be introduced in e-learning and its uptake increased. Personal technologies with wide accessibility, especially in Africa, are mobile phones (Brown, 2005; ITU, 2007a). Mobile phones are not only growing in number but also in processing power (Ayala & Castillo, 2008). Today, there are very many mobile phones, even in Africa, which are GPRS and Wi-Fi enabled, meaning that they can be used to access the Internet. As a result, more and more Internet based services are becoming personal and mobile. A great deal of e-learning services can now be offered as m-learning services.

Internet market leaders such as Google, Yahoo!, Disney Internet Group, Verizon Wireless, AT&T, CNN, BBC, Apple Computer, Sony and others have introduced mobile versions of their applications (Fisher & Baird, 2007). Such applications are increasingly contributing to the richness of the mobile Internet, sometimes referred to as the mobile web (W3C, 2009).

The education sector is also contributing resources/learning objects to the mobile web. Since 2002 to-date, considerable research effort has been taking place in the creation of learning objects for use on mobile phones (Ayala & Castillo, 2008; Quinn, 2002). It should however be noted that most of this research effort is hinged on creating m-learning objects for learners in developed countries. Are these learning objects suitable for learners in developing countries? More important,

no research is evident on the effective deployment and utilization of the existing learning objects on mobile phones for learners in developing countries. This research gap has created a need for a framework to instantiate applications for learning objects deployment and utilization on mobile phones.

The conditions pertaining to learners in developed countries are not similar to those for learners in developing countries especially in Africa. The examples that follow, cement this assertion. According to Farrell & Isaacs (2007) and Brown (2005), African learners own or have access to a myriad of phone types and generations, including entry level, middle level and high end level. Further, Africa has always lagged behind in technological innovations and developments. Broadband mobile Internet is more prevalent in developed countries than in Africa. The attitudes, habits and cultures attached to the use of mobile phones for learning in Africa differ from those in the developed world. Also, African countries have acute shortage of infrastructure and resources (ibid). As such, solutions devised to solve problems in developing countries need to be contextualized in these conditions.

This research addresses the identified research gap by developing a framework for instantiating applications for deploying and utilizing learning objects on mobile phones. The applications instantiated from the framework can provide meaningful learning experiences to learners and extend anytime, anywhere learning support to a wider community of learners in a collaborative and interactive way. Also, the infancy of m-learning requires concerted research effort to enable it to mature (Traxler, 2007; Kurubacak, 2007; Pettit & Kukulska-Hulme, 2007; Sharples *et al*., 2005; Keegan, 2005; Motiwalla, 2007). Further, the framework responds to Fisher and Baird's (2007) call for development of frameworks that can cater for the emerging net generation learners with high affinity for technology supported learning.

This Chapter therefore, is aimed at reviewing the state of art and practice of m-learning. It is divided into the following sections. In *Section 2.1,* the concept of m-learning is reviewed. Since there are no standalone theories for m-learning, *Section 2.2* reviews the contemporary learning theories and establishes tenets in those theories that can benefit from m-learning. In *Section 2.3,* we review the concept of learning objects while in *Section 2.4;* a summary of emerging research issues is given. In *Section 2.5*, we provide a conclusion to the chapter by providing the emerging research gaps.

2.1 M-Learning

Ubiquitous technologies are making it possible for learners not to be tethered in orchestrated fixed classrooms for learning purposes. Such "anytime", "anywhere" computing platforms have ignited a paradigm shift from e-learning models to m-learning models (Luis de Marcos *et al.*, 2006, p.1). Hence increasing research attention is unfolding in the area of m-learning from industrialists, researchers, educationist and policy makers (Ayala & Castillo 2008; Brown, 2005; Caudill, 2007; Laurillard, 2007; Luis de Marcos *et al.,* 2006; Traxler, 2007; Uden, 2007). As a consequence, m-learning has been variously defined. While considering a mobile device as an enabler of learner mobility, Traxler (2007) defined m-learning as learning which takes place at anytime in anyplace using a mobile device. Similarly, Luis de Marcos *et al.* (2006) defined m-learning as a form of e-learning which employs wireless, tiny, handheld and portable devices to extend and deliver learning to learners. A view earlier espoused by Brown (2005) emphasized that m-learning is e-learning which uses mobile devices to deliver learning. 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.

Ubiquitous technologies are revolutionizing not only the education sector but also the commerce, business, banking and entertainment sectors. The convergence of Internet with wireless mobile technologies, has seen the replacement of the prefix 'e-' in the terms e-commerce, e-business, e-banking, e-entertainment and e-learning with the prefix 'm-' (Traxler, 2007). The prefix 'm-' conjures the 'mobileness' brought about by mobile technologies in learning, commerce, business, banking and entertainment. M-learning is more than just the use of mobile devices for learning but the ability for one to electronically learn on-the-go (Traxler, 2007).

M-learning enables learner mobility and as such exposes a learner to different learning environments/contexts. Research has shown that a learner acquires a rich learning experience when exposed to an environment with other learners that have different learning experiences acquired from different contexts (Caudill, 2007; Laurillard, 2007; Uden, 2007). Context relates to information which describes the situation of a learner in a given location (Uden, 2007). Learning from one's known context increases his/her ability to relate what is being learnt to the surroundings, thus increasing learning experience and flexibility in learning. In m-learning, the accumulation of different learning experiences is brought about by the advantages inherent in mobile devices since they facilitate just-in-time and just-in-place interaction and collaboration. In developing countries, contextualized learning is oftentimes lost because of the tethered technologies usually employed in

e-learning. A blend of m-learning and e-learning would suffice to bridge the gaps that exist in each of these models. By implementing m-learning, on-the-go and contextualized learning, flexibility can be introduced in e-learning. However, the extent of development and use of mLearning in different contexts is still embryonic (Uden, 2007).

2.1.1 M-Learning and E-Learning

Electronic learning (e-learning) is learning using an "educational environment which utilizes any electronic media tool as a part of the instruction" (Caudill, 2007, p.3). M-learning is enabled by wireless, handheld and portable devices which are electronic in nature. By implication it means that m-learning is part and parcel of e-learning. This is a view supported by several researchers in m-learning (Brown, 2005; Luis de Marcos *et al.,* 2006). While all m-learning applications could be considered as e-learning applications, e-learning may or may not include mobile applications. E-learning is conventionally implemented in a client-server architecture platform where the server is host to a learning management system and the client is a student with an Internet connected personal computer (Caudill, 2007). This architecture may also be referred to as online learning. In Africa, e-learning faces pertinent challenges related to access and sustainability (Farrell & Isaacs, 2007). M-learning has been fronted as a learning model that can address some of the access challenges (Ayala & Castillo, 2008; Pettit & Kukulska-Hulme, 2007).

As a support model, m-learning provides pedagogies that can compare well with those in an e-learning class. This proposition is depicted in the *Table 2.1* below:

Table 2.1: A Comparison of E-Learning with M-Learning

Pedagogy	**E-Learning (online) class**	**M-Learning class**
Course location	HTML website	WML website
Class materials	Online notes, URLs and presentation slides	URL links to course websites
Class experience	Whiteboards, group touring, virtual demos, chat rooms, discussion boards and e-mail	SMS, alerts, discussion boards, course calendars
Assignments/projects	E-mail attachment or posting with web forms	Instant messaging for project coordination
Student assessment	Online exams, chat room/discussion board participation	Online exams, chat room/discussion board participation

Source: Motiwalla, 2007, p.14

In *Table 2.1*, "the power of m-learning technology can be leveraged by complimenting the existing courses with value-added features such as alerts, personalized agents or communication aids, and

access to interaction or discussion utilities that help users convert their dead-time to productive activity while in transit without access to computers and Internet" (Motiwalla, 2007, p.14). The difference between an e-learning class and an m-learning class can be cited in the existence of learning resources being resident on the server for on demand access in the case of e-learning while for the case of m-learning, messages have to be initiated to transmit information to the client device (Caudill, 2007). In Caudill's view the m-learning class not being able to have content stored on their mobile devices is not good for many but may be good for others because "messages regarding class changes, reminders of upcoming deadlines, or questions and responses involving specific course materials could all be excellent uses of SMS" (p.8).

M-learning is a better catalyst to lifelong learning than online learning because it allows for mobility of the learner, it is flexible and convenient (Traxler, 2007). M-learning provides anytime anywhere learning. "M-learning … makes it possible to learn while you earn on-the-go" (Brown, 2005, p.306). This benefit is particularly vital for lifelong learners who have a multitude of other life obligations related to work, family and society. Anytime anywhere learning requires the integration of m-learning into a learner's daily life (Pettit & Kukulska-Hulme, 2007). On-the-go learning is lost when learners pileup learning activities on their mobile devices and respond to them later on in the day or week. M-learning actively engages learners than e-learning (Uden, 2007).

Since m-learning has several comparable pedagogies with e-learning the growth and nurturing of m-learning should borrow a lot from existing e-learning frameworks.

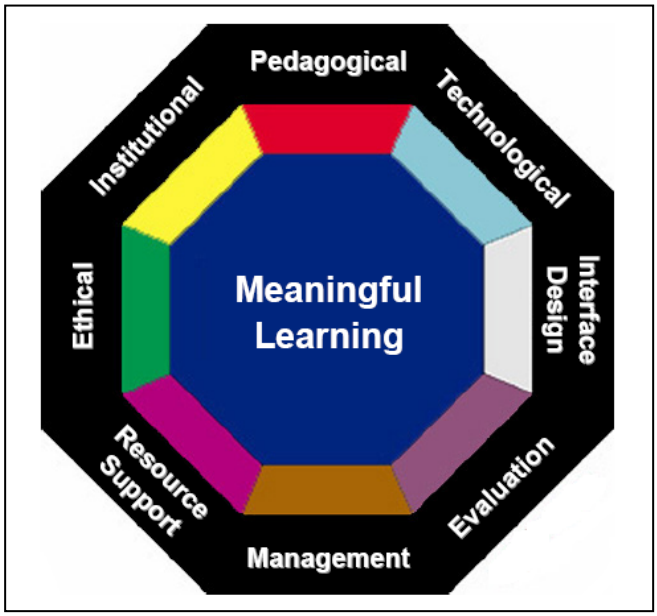
2.1.2 M-Learning and E-Learning Frameworks

M-learning is a form of e-learning (Brown, 2005). In Motiwalla (2007), cross-cutting pedagogies for e-learning and m-learning are given. It follows therefore that existing e-learning frameworks can inform the development of m-learning frameworks. Authors such as Khan (2001) and Mescan (nd) have developed e-learning frameworks with several dimensions and sub-dimensions.

In Khan (2001), an e-learning framework addressing global e-learning issues is presented. The framework has eight (8) major dimensions that are instrumental to meaningful e-learning. These dimensions are shown in Khan's (2001) framework in *Figure 2.1* below.

The eight (8) dimensions in the global e-learning framework are institutional, pedagogical, interface design, evaluation, management, resource support, ethical and technological (Khan, 2001). Each dimension consists of several sub-dimensions as is given below.

Figure 2.1: Global E-Learning Framework



Source: Adopted from Khan (2001, p.1)

The institutional dimension implores institutions wishing to adopt e-learning to examine their administrative, academic and student support affairs. In the administrative sub-dimension, an institution should determine whether it is ready to offer e-learning or not. In the academic sub-dimension, the institution should determine whether the quality of programs to be offered via e-learning meet quality standards similar to those offered through traditional programs. In the student support sub-dimension, the institution should determine that the instructors/administrators are available and ready to support the students during online learning.

The pedagogical dimension consists of the following sub-dimensions, namely: content, audience, goal and objectives, medium, design, organisation and methods. The content sub-dimension requires institutions to determine the type of content that can be delivered over different learning technologies. The audience sub-dimension requires institutions to profile their learners. The goal and objectives sub-dimension requires institutions to provide clear expectations of what the learners are expected to achieve. The medium sub-dimension requires institutions to determine whether they should utilise multiple media content (text, audio, video, graphics or a combination of these) in their delivery. The design sub-dimension determines the role of the instructor. Is it more facilitative than didactic, more didactic than facilitative or a combination of both? The organisation sub-dimension is concerned with whether e-learning provides a sense of continuity in the learning

process. It answers questions related to whether in e-learning, one unit of a lesson builds on the previous unit. The methods sub-dimension asks whether the e-learning environment being proposed provides means and mechanisms for collaboration among learners and learners and their tutors and administrators.

In the interface design dimension are sub-dimensions such as page and site design, content design, navigation, accessibility and usability testing. The page and site design sub-dimension is concerned with the appearance of the web-pages to the learners. Pages must appear good and appealing to learners. The content design sub-dimension implores content developers to follow a 'one idea per paragraph' rule while designing content. The navigation sub-dimension requires an e-learning program to provide structural aids or site map to guide learner's navigation. The accessibility sub-dimension requires that an e-learning program should be designed in such a way as to be accessed by a wider user population. The usability testing sub-dimension requires that an e-learning program provides instant feedback to frequently asked questions in the program itself.

The evaluation dimension considers the assessment of learners and evaluation of instruction and learning environment. The assessment of learners sub-dimension requires the e-learning program to have a mechanism for truly measuring the learner's learning achievements without having loopholes for cheating. The evaluation of instruction and learning environment sub-dimension requires that e-learning program should have mechanism to enable learners to evaluate the content, instructor, learning environment, learning resources, course design and technical support.

The management dimension has two sub-dimensions, namely: content development and maintenance. In content development sub-dimension, a requirement for a project support site for e-learning production team is placed. In the maintenance sub-dimension, a requirement for constant and timely updates within the e-learning program is placed. The updates to the learners could be made through e-mail, announcement page, alert boxes, running footer added to a page or phone call.

The resource support dimension has the online support and resources support sub-dimensions. The online support sub-dimension requires that e-learning should have troubleshooting expertise or helpdesk support. The resources sub-dimension requires the e-learning program to facilitate learning by providing examples of prior work of the student in digitised formats.

The ethical dimension includes the social/political influence, cultural diversity, bias, geographical diversity, learner diversity, digital divide, etiquette and legal issues sub-dimensions. In the social/political influence sub-dimension, an institution should determine whether there are social/political forces that might curtail the implementation of e-learning. In the cultural diversity

sub-dimension, counsel is provided to reduce or avoid the use of idioms, jargons, ambiguous words or cute humour and acronyms. The bias sub-dimension requires that more than one view point be presented to a controversial issue. The geographical sub-dimension requires that e-learning should be provided to learners located in different geographical areas and must therefore take care of different time zones so as to appropriately schedule synchronous communication. The learner diversity sub-dimension recognises that there are slow, medium and fast learners. Therefore an e-learning system must take care of all these learners. The digital divide sub-dimension is important in that it considers access to technology. The system should not disadvantage learners who lack the necessary learning technologies. The digital divide issue should be considered in designing the e-learning content. The etiquette sub-dimension provides guidance to learners on how to behave during e-learning. It provides the dos and don'ts in e-learning. The legal issues sub-dimension requires the e-learning program to seek permission to post on the Web, students' photographs and projects.

The technological dimension has infrastructure planning and hardware and software sub-dimensions. Infrastructure planning requires the institution to ascertain whether it has the necessary personnel who can assist learners to get onto e-learning. The hardware and software sub-dimension is important for profiling the necessary hardware and software requirements for the e-learning program (ibid).

Apart from Khan's (2001) framework, another framework is found in Mescan' (nd) philosophy of e-learning. According to Mescan (nd), learning is accomplished if materials are cognitively retained and applied in solving problems. E-learning can aid learners to retain materials because it provides Brown's (2005) three canonical functions of ICTs in education, namely: multiple accesses to learning materials, sharing of information and providing support services.

In consideration of the materials retention philosophy, Mescan (nd) developed a framework for e-learning with ten dimensions. These include: suitable learning environment, dedicated time, focus, targeted user profile, defined course levels, repetition, engaging presentation, hands-on participation, evaluation and immediate feedback.

Mescan's (nd) dimension for suitable learning environment requires appropriate choice of environment for learning. "A good computer monitor, a quiet room, and adequate lighting should be considered" (Mescan, nd, p.3). This dimension presupposes that learning does not take place on-the-go. "M-learning … makes it possible to learn while you earn on-the-go" (Brown, 2005, p.306).

The dedicated time dimension requires learners to dedicate time to different e-learning modules

in a course. E-learning courses are structured as modules or learning objects that provide flexibility in revision. A learner can revise one or two modules at a time rather than revising the entire course at once. Technologies that can permit timely access to learning modules come in handy in fulfilling this e-learning dimension. The limitations of mobile devices require that mobile content be structured as short sequenceable modules called m-learning objects (Ayala & Castillo, 2008). Such learning objects can be deployed and utilized by the learner at any time they wish. This will integrate m-learning into a learner's daily life (Pettit & Kukulska-Hulme, 2007).

The focus dimension requires that the outline of any training program be focused on the objectives of that training program. The objectives provide a yardstick against which all content are measured.

The targeted user profile dimension is supposed to profile the target audience of the course. This will include the age range, sex and cultural orientation of the learners. Profiling learners helps content developers contextualise content.

Defined course levels dimensions is important for profiling the learners' prior knowledge of the subject, which is in-turn important for determining the level of e-learning course material to be dispensed to that learner.

Repetition dimension emphasises the need to repeat a given concept for it to be retained. E-learning should be able to enable learners to repeat different concepts in a subject being learnt. "Incorporating repetition in an e-learning program helps to drill the important information in the students' minds. Use of text, graphics, sound, and multimedia clips are ways to vary the emphasis of the material" (Mescan, nd, p.4). Materials carried around on a mobile phone have higher chances of being reflected upon than those in e-learning systems since the learner is always with his or her mobile phone.

Engaging presentation dimension requires that an e-learning course should continuously engage and motivate the learner since e-learners are often on their own at homes or anywhere they can access a computer. "If the course does not grab their attention, the students may abandon the course before they ever complete it" (Mescan, nd, p.4). M-learning actively engages learners (Uden, 2007).

The hands-on participation dimension emphasises the need to learn by doing. "The physical action of hands-on participation helps students to better retain and understand a process". In Uden (2007), m-learning propels active learning.

The evaluation dimension provides a measure of successful completion of an e-learning program. It determines what a student should be able to do after they have accomplished a course.

Multiple choice questions could be sent on learners' mobile phones to evaluate an e-learning course.

The immediate feedback dimension requires that an e-learning system should provide immediate feedback to the learners to show them how well they comprehended the material. Because of the repeatability feature in e-learning, if a student gets a negative feedback he/she can quickly repeat part or all of the lessons by replaying the modules.

Mescan (nd) e-learning framework targets the design of an effective e-learning course or program with less regard to other factors such as cost, access to ICTs, ICT skills use and e-learning policy that could influence e-learning uptake.

The framework in Mescan (nd) provides important guidelines for effective e-learning courseware design. That in Khan (2001) provides guidelines for effective implementation of e-learning in general. Existing e-learning frameworks are silent on issues related to m-learning such as m-learning cost, learning processes that can be fulfilled by m-learning (m-learning processes), m-learning objects to be used in m-learning processes, policies to guide the development and practice of m-learning, learner context, access to and use of technology and personalisation of learning. The dimensions need to be infused in existing e-learning frameworks if we are to achieve a full and meaningful integration of m-learning with e-learning. The aforementioned dimensions can be adequately addressed through m-learning (Ayala & Castillo, 2008; Pettit & Kukulska-Hulme, 2007; Uden, 2007). Also, whereas e-learning is tending to m-learning with the convergence of Internet with mobile devices (Luis de Marcos *et al.*, 2006; Traxler, 2007), little focus is given to the integration of m-learning into e-learning. Specifically, no dimensions are included in the existing e-learning frameworks on how to pedagogically deploy and use learning objects on mobile phones. When m-learning frameworks are put in place, they will aid traditional distance learning (Caudill, 2007; Traxler, 2007; Wang & Liu, 2005).

2.1.3 M-Learning and Traditional Distance Learning

Distance learning is the "information transfer process of delivering instructional resource-sharing opportunities to learners away from conventional learning institutions or sites" (Wang & Liu, 2005, p.121). Distance learning can be understood in five dimensions, namely: "separation of teacher and learner, use of media, provision of two way communication, influence of an educational system, and an industrial base operation (Keegan (1990) cited in Wang & Liu, 2005, p.121).

Depending on the level of advancement in educational technology, distance learning is accomplished variously. In resource rich institutions, distance learning is delivered interactively

using technologies such as mail, telephone, fax, video, computer, e-mail, Internet and web-based materials. However in resource constrained institutions such as those in Sub-Saharan Africa countries, the traditional form of distance learning is the most prevalent (Aguti & Fraser, 2006; Kajumbula, 2006).

Traditional distance learning which is sometimes referred to as first generation distance learning, involves supporting distance learners mainly through non-technology support systems (Aguti & Fraser, 2006). The learning materials are usually print based modules. Learners report to their main campuses for residential tuition for specified number of weeks. Examinations and registrations are conducted at the main campuses. Most of the support services are centralized and learners often times physically go to their main campuses to get different support services (ibid). The above description fits the nature of distance education at Makerere University in Uganda (Kajumbula, 2006).

Of recent however, traditional distance learning units are starting to embrace different educational technologies (Aguti & Fraser, 2006; Kajumbula, 2006; van Brakel & Chisenga, 2003). In particular, a blend of mobile telephony with distance learning is providing a future for distance learning (Brown, 2005; Caudill, 2007; Traxler, 2007; Trifonova & Ronchetti, 2006). Traditional distance learning units are devising means and methods of supporting their learners using m-learning. In Brown (2005), it is reported that the Unit of Distance Learning in the Faculty of Education at the University of Pretoria is using SMSs for student support. Similarly, in Kajumbula (2006), it is also reported that SMSs are being used to support distance learners at Makerere University. In SAIDE (2008), a number of m-learning projects for supporting open schooling are enumerated. Thus m-learning is distinguishing itself as a learning model for supporting traditional distance learners.

2.1.4 M-Learning Devices

M-learning is made possible through the use of mobile devices. Caudill (2007, p.5) has defined mobile devices as “electronic devices that are small enough to fit in a shirt or jacket pocket”. Their portable nature enables their users to carry them whenever they go, including even in the toilets! “The old routine of picking up car keys and wallet every morning has for most people expanded to include at least a cell phone, if not a PDA and MP3 player as well” (Caudill, 2007, p.6). When one forgets his/her mobile phone at home on a particular day, he/she will be forced to rush back home for it or will be the first thing to check on as soon as he/she returns home. Mobile devices such as

mobile phones have become part and parcel of our daily lives (Brown, 2005). This constant companionship between mobile devices and their users is important for just-in-time and just-in-place collaboration and interaction. Mobile devices that can be used to extend learning to their users are now called m-learning devices (Caudill, 2007). M-learning devices are in three broad categories, namely: mobile phones, PDAs/smart phones and MP3 players (Caudill, 2007; Traxler, 2007).

The first category of mobile devices, the mobile phones, can be divided into two classes – low and high end mobile phones (Caudill, 2007). Low end mobile phones are of 1st or 2nd generation (1G or 2G) order while high end phones are of 2.5G and 3G generation order (ibid). 1G and 2G phones are basically used for text and voice communication while the 2.5G and 3G phones have additional data services capability such as file transfer, Internet access, and many others.

The second category of mobile devices (PDAs/smart phones), is more versatile than the mobile phones (Caudill, 2007). In addition to having mobile phone functionality, it has an enhanced organizer with ability to access newsgroups and web pages of learning management systems hence making access to learning resources and activities possible. These devices' functionalities are converging with those of notebooks. This is making it possible for them to be used in reading PDF and Office files. With advancement in technology, mobile phones in the 2.5G and 3G range have functionalities similar to those of PDAs.

Another category of mobile devices, the Mp3 players, include all mobile devices which can "store and play digital audio files that, in the case of m-learning are commonly referred to as podcasts" (Caudill, 2007, p.8). This definition suggests as if mobile devices in the mobile phone and PDA categories do not store and play digital audio files. It is a fact that PDAs and 2.5G and 3G mobile phones can record, store and play digital audio and often video files.

The three categories of mobile devices are converging so as to integrate voice/audio, video, graphics and data functionalities. In developing countries, due to the high cost of PDAs and MP3 players, the mobile phones category of mobile devices is more prevalent (Brown, 2005). This explains why most m-learning ventures so far undertaken in developing countries employ mobile phones than any other m-learning devices.

Generally speaking, m-learning devices support the three canonical functions of ICTs in education, namely: access, support and communication (Brown, 2005; Nakabayashi *et al.*, 2007; Toledano, 2006; Yang, 2007). M-learning devices can be used to access content and learning activities in learning management systems. Mobile devices can be used to provide pedagogic support services to learners (Toledano, 2006). Above all, the main purpose of mobile phones is

communication. The choice of a particular mobile device to be employed in m-learning and its level of usage depend on its availability and technical capability. No wonder, due to its wide proliferation, the mobile phone is the device of choice for the few m-learning pilots that have so far been undertaken in Africa (SAIDE, 2008).

2.1.5 Mobile Phones Proliferation

The mobile telephony industry has seen unprecedented growth in developing countries. According to the ITU (2007a), Africa experienced a compound annual growth rate in mobile subscription of 49.4% as compared to Europe's 17% between 2002 and 2007. By 2007 the ITU posited the World percentage of mobile phone to total number of telephone subscribers at 72.6%. Africa had 89.7% of its total telephone subscribers as being from mobile phone users. In Uganda, the ratio of mobile phone subscribers to fixed telephones stood at about 9.7 to 1 (ibid). By March 2010, the mobile tele-density in Uganda was 32 mobile phones per 100 inhabitants (Uganda Communications Commission, 2010). At Makerere University in Uganda, by 2006, 97% of the distance learners owned mobile phones (Kajumbula, 2006). These statistics present a scenario of high mobile phone proliferation not only in the developed countries but also in the developing countries of Africa. This proliferation presents a fertile ground for m-learning growth especially if appropriate mobile networking technologies are available in the midst of learners.

2.1.6 Mobile Networking Technologies

The ability of a mobile device to transmit voice, video, pictures and text depends not only on the capability of the mobile device but also on the mobile networking technologies at hand. M-learning networking technologies are the technologies that enable mobile devices to wirelessly communicate with each other (Caudill, 2007). Mobile networking technologies are at the forefront of making mobility of learners possible. A mobile device should be able to support one or some or all of the existing mobile networking technologies in a given context. It is important to note that text and voice messaging is supported by all the technologies.

Some of the networking technologies available today for local and wide area network mobile devices interconnectivity are Bluetooth (IEEE 802.15.1 standard, for proximal device connectivity) and Wireless Fidelity - Wi-Fi (IEEE 802.15.11 standard, for LAN connectivity) (Caudill, 2007). GSM and GPRS are other networking technologies which respectively support text/voice communication and wireless Internet (Woukeu et al., 2005). Cellular broadband (WiMAX, IEEE

802.16) connectivity offers WAN mobile connectivity (Caudill, 2007). Each of these technologies is reviewed below.

In order to interconnect mobile devices in short ranged distances, the networking technology of choice is the Bluetooth (IEEE 802.11.1 standard) (Caudill, 2007). Bluetooth can enable learners within a short range of 10 meters or 30 feet to share data amongst themselves on their mobile devices hence enabling group discussions.

Networking through Wi-Fi is made possible by a series of points of access termed, hotspots. The hotspots are installed at particular locations in a building or on campus in a wireless LAN (WLAN). Modern laptops come with Wi-Fi enabled network cards. PDAs and some mobile phones known as 'smart phones' have Wi-Fi cards. Mobile devices with no Wi-Fi cards could be made Wi-Fi compatible through the addition of Wi-Fi cards in their SD slots. Wi-Fi follows the IEEE 802.15.11 standard specification (Caudill, 2007). This specification comes in two standards – that which transmits at 11 Megabits per second (IEEE 802.15.11b) and the one that transmits at 54 megabits per second (IEEE 802.15.11g). The devices however in the b and g network categories can interoperate. Wi-Fi technology interconnects wireless communication devices in a WLAN of a campus or an organization (ibid). This implies that m-learning could be extended to on-campus students, say in classrooms, on sports pitches, or other locations where having a wired desktop computer or laptop would be insecure or inconveniencing. Wi-Fi enabled devices with access to a network hotspot and ISP can connect to Internet.

GPRS is an upgrade of the GSM networking technology (Caudill, 2007). GSM communication technology permits cellular phones to interconnect with each other. GPRS allows mobile phones not only to interconnect with each other but also to connect to the Internet. GPRS can afford high data transfer speeds which can enable a learner to be involved in video calls and conferences. It can enable a learner to view and work with Internet websites and applications using a mobile phone. GPRS is available on 2.5G or 3G mobile phones. GPRS is a predecessor to newer mobile networking technologies such as wireless broadband (WiMAX).

The other mobile networking technologies connected to mobile phones are SMS and cellular broadband (WiMAX) (Caudill, 2007). SMS technology requires no hotspots for communication, hence can be received in anyplace anytime. It however requires a service provider. SMS communication is important for students' administrative and academic support (Brown, 2005; Kajumbula, 2006). In addition to text and voice services, cellular broadband (WiMAX) networking technology provides full Internet access on mobile phones (Caudill, 2007). The technology provides

a user with access to Internet connectivity without the need to go through hotspots in a building or on campus. Learners with broadband Internet (WiMAX) connectivity can therefore access content and other information from the mobile web (W3C, 2009) while in any location with broadband connectivity. Wireless broadband (WiMAX) technology uses microwave transmission technology to transmit information.

The capability of existing mobile devices coupled with the power of available mobile networking technologies present vast possibilities and benefits for m-learning as is expositioned in *Section 2.1.7* below.

2.1.7 M-Learning Possibilities and Benefits

"There are growing expectations on the part of educationalists and the media that mobile technologies do have a significant contribution to make in education" (Mitchell & Doherty, 2003, p.3). Consequently, researchers are yet to exhaust the possibilities of m-learning (Ayala & Castillo, 2008; Brown, 2005; Goh & Kinshuk, 2006; Motiwalla, 2007; Uden 2007). It implies that the possibilities of m-learning lie in the hands of the m-learning innovator. All the same, mobile devices being ICTs, their uses in education relate to access, support, and communication (Brown, 2005). Support is a cross cutting imperative of ICTs in education because a learner accessing content or being communicated to by his/her lecturer is being supported. In particular, mobile devices have excelled more as a communication platform than a content provision/access platform (Brown, 2005). Of recent however, there has been increasing research interest in developing m-learning applications for content provision and access (Ayala & Castillo 2008). Further, student support services are being extended using mobile phones (Kajumbula, 2006; Brown, 2005). This implies that the access, support and communication imperatives of ICTs in education are being addressed by m-learning.

In support of the communication imperative, Uden (2007) stressed the pedagogical importance afforded by m-learning through collaboration and interaction. By collaborating and interacting with each other, learners are able to construct their own knowledge (Fisher & Baird, 2007; Uden, 2007; Woukeu *et al*., 2005). Collaboration and interaction are key tenets of a student centered constructivistic learning model. Thus it is pedagogically important to incorporate collaboration and interaction in content based approaches to m-learning. Content approaches in Goh and Kinshuk (2006), Motiwalla (2007), Nakabayashi *et al*. (2007), Toledano (2006), Trifonova and Ronchetti (2006), Yang (2007), and others have embedded the student centeredness inherent in constructivistic learning models.

Having seen that ICTs are majorly used for access, support and communication, we review the possibilities and benefits that m-learning is affording.

i. Idle Time

In education, mobile devices are advantageous in that they help learners to utilize would be idle times, get motivated for learning and communicate with others (Pettit & Kukulska-Hulme, 2007). Additionally, m-learning can save the learner's precious time and effort (Luis de Marcos *et al.,* 2006). Even if mobile devices are constrained for content delivery, the services they provide through simple SMSs can save the learner's time and effort that would be expended in checking notice boards for notices on timetable changes, assignment due dates, deadlines, lecture room changes and a lot more secondary information. The time and effort saved can productively be used for other pedagogic activities hence enhancing learning.

ii Reflection

Relatedly, podcasting devices are able to record voice and play it back. Live lectures can be recorded and stored as podcasts on iPods or PDAs or on some mobile phones and listened to anywhere anytime (Caudill, 2007; Pettit and Kukulska-Hulme, 2007). This makes reflective learning possible.

iii Rich Content

Further developments in mobile networking technologies are making it possible to deliver multimedia content on high end mobile devices. The emergency of the Global System for Mobile communication (GSM) and the General Radio Packet Service (GPRS) networking technologies has made it possible to combine short message services (SMS) with multimedia message services (MMS) so as to deliver and send multiple media content such as audio, text, image and video sequences (Brown, 2005). GPRS enabled mobile devices can as well interoperate with desktop computer e-mail and Internet systems to blend the e-learning mix hence increase flexibility in online learning. The Global Position System (GPS) functionality on some mobile devices can enable learner contextualization and personalization of learning content (Caudill, 2007).

iv Collaboration and Interaction

Bluetooth networking technology can facilitate a group discussion using an adhoc network of

Bluetooth enabled devices within a radius of 10 meters (Caudill, 2007). Learners can interconnect their mobile devices and share files and documents as they discuss. In this arrangement, there is no cost incurred in connectivity since the services of a service provider are not required. Relatedly, the Wi-Fi networking technology could be used to exchange data from one device to another in a WLAN (Caudill, 2007). Additionally, learners using GSM, GPRS or cellular broadband (WiMAX) mobile networking technologies could collaborate and interact with each other over short or long distances. These collaboration and interaction examples indicate that m-learning does not only take place in wide ranging distances but could also take place in short ranging distances. Hence it is not necessarily a mode of learning for learners' on-the-go alone but also for learners stationed in specific places with no wired desktop computing facilities.

v Pedagogic Support

M-learning possibilities are also categorized in Luis de Marcos *et al.* (2006) for pedagogic support activities before, during and after a lesson. Before a lesson, a professor may wish to profile her/his learners. Using a PDA, a professor can poll the class for prior learning, learning styles, job history, qualifications and so on, so as to package appropriate content for the class. During a lesson, learners may use their mobile devices to take quizzes meant to evaluate their learning experiences. After a lesson, the professor may want to undertake follow up activities to gauge the usage of the skills in the field of work (ibid). In Motiwalla (2007), pedagogy related to class materials, class experience, assignments/projects and student assessment is possible with m-learning.

With the possibilities indicated in this section, some institutions are trialing m-learning. *Section 2.1.8* below provides the state of practice in m-learning by reviewing some m-learning case studies in developed and developing countries.

2.1.8 M-Learning Case Studies

Mobile communication technology is becoming an integral part of project-based learning activities in a number of disciplines that involve collaboration and interaction (The New Media Consortium & the EDUCAUSE Learning Initiative, 2008). Several large scale initiatives (e.g. MobiLearn (MobiLearn, 2005), Mlearning (MLearning, 2005) and From e-Learning to MLearning (Ericsson, 2002) have been investigating the potential benefits of this new pervasive approach to learning. Goh and Kinshuk (2006) have cited several m-learning initiatives. These include among others: games-oriented implementation for m-portal (Mitchell, 2003), where interactive pedagogic games are

played on mobile devices; classroom of the future (Dawabi *et al*., 2003), where mobile devices are used in the laboratory environment to support individual learning as well as collaborative learning, and hands-on scientific experimentation and learning (Milrad *et al*., 2004), where mobile and wireless technologies are used to support hands-on scientific experimentation and learning. Others are m-learning system for bird watching (Chen *et al*., 2003), where mobile devices are used for bird watching based on a scaffolding concept and context-aware language learning support system (Ogata & Yano, 2004), where mobile phones are used as language learning support tools.

Several other m-learning projects have been reported at different universities. McGreal *et al*. (2005) reported on a project at Athabasca University for implementing m-learning environments using learning objects. The learning objects were created in form of MP3 and podcasts files. Similarly, a planning, public policy and management course at the University of Oregon uses GIS-enabled mobile devices to collaborate on projects with the community in Eugene (The New Media Consortium & the EDUCAUSE Learning Initiative, 2008). Students work with community members to develop resources such as safe walking route maps, reports of local area conditions, and sidewalk walkability surveys.

SAIDE (2008), in a report for the Commonwealth of Learning on using mobile phones for open schooling, has listed several m-learning projects in Africa. These include among others: M4girls – where Nokia 6300 phones are loaded with learning objects for supporting and improving mathematics performance of Grade 10 girls in NW province in South Africa; MobilED – which supports informal and formal learning of biology at Cornwall Hill College and Irene Middle School, South Africa; Dr. Math on Mxit – for collaborative learning in mathematics using IM; MobiDic – for access to dictionary via SMS in South Africa; Eduvision – for access to satellite distributed content on handheld computers in Kenya, MRSI – for mobile research supervision in Uganda; Mobi Maths – for learning maths in South Africa and mobile technology support at the University of Pretoria – for extending academic and administrative support to distance learners.

Ford and Botha (2009, p.5) have reported on a MobilED project in which learning objects are developed based on the concept of "mobile audio-wikipedia**"** In this concept:

1. A user can search for a term by sending an SMS message to the server.
2. The server then calls the user, and
3. A speech synthesizer will read the article found in the Wikipedia.
4. The user can navigate forwards and backwards or jump to sections by using the cell phone keypad.
5. A user can contribute any information to any section of the article by dictating it to the system.
6. If the term is not found in the mobile audio-wikipedia, then the user can contribute a story by dictating it to the system.

The mobile audio-wikipedia software was developed using open source components based on OpenPhone, an open source interactive voice response (IVR) system. By employing audio learning objects, even low end mobile phones could be able to benefit from the MobilED project (ibid).

Another project in which audio m-learning objects are developed and utilized is the Hadeda project (Butgereit & Botha, 2009). Hadeda is:

> a project where primary school pupils (and even secondary school pupils) are encouraged to practice spelling words or vocabulary words using their cell phone. Hadeda allows the language teacher to create spelling lists or vocabulary lists in English and Afrikaans. Hadeda then generates a fun cell phone application using multiple text-to-speech engines to encourage pupils to practice spelling the words
>
> (Butgereit & Botha, 2009, p.1).

In Uganda, Mayende (2007) developed a mobile application prototype for m-learning. The prototype was developed as a Masters project to facilitate group discussions amongst Bachelor of Education distance learning students at Makerere University. The system transmits, retrieves and stores discussion comments sent by participants in group discussions using their mobile phones. Depending on an institution's definition for a learning object, these comments could pass for m-learning objects. The comments/learning objects are stored in a database hosted on a telecommunication company's server. The link between the mobile phone and comments database is realized via the telecommunication company's GPRS network.

The common thread in all the case studies cited is that they were project implementations aimed at using m-learning to solve a specific pedagogic problem. In Africa, most of the m-learning case studies emanated from South Africa. All the case studies, be it from developed or developing countries, were not underpinned by any development framework because such a framework were lacking. Also, most of the projects involved an element of field or practical study and were implemented on limited scale probably due to the inherent challenges and limitations of m-learning.

2.1.9 Challenges and Limitations of M-Learning

The challenges for m-learning revolve around technical, pedagogical, perception, equity and cost issues.

i Technical Challenges

The immature nature of mobile technologies and resource limitation of mobile devices pause the technical challenge (Grant *et al*., 2007). Also there are a multitude of metadata standards for

packaging learning objects (see *Section 2.3.4*). In addition, most of this standardization effort is mainly targeted at desktop computer learning objects. Most desktop computer learning objects standards follow the SCORM specification (ADL, 2004). The challenge arises because mobile phones and smart phones can not run the java script – ECMAScript which the SCORM run time environment (RTE) specification relies on for communication between SCOs or learning objects and desktop computer based LMSs (Nakabayashi *et al.*, 2007). For interoperability of learning objects between mobile devices and personal computers, the ECMAScript has to be extended.

Still on technical challenges, mobile devices are constrained by their tiny screen sizes, keyboards, memory, processing power and bandwidth (Grant *et al*., 2007). Content meant for them has to be pedagogically sequenced as learning objects but the challenges of doing this are quite enormous (Caudill, 2007; Motiwalla, 2007; Quinn, 2002; Uden, 2007; Woukeu *et al*., 2005; Zhang, 2003)

ii Pedagogical Challenges

The pedagogical challenge arising from the technical limitations of the mobile devices is how to sequence the learning objects on the mobile devices so that meaningful learning can take place (Caudill, 2007). The other pedagogical challenge is swaying the learners to use the resource constrained mobile device instead of the resource rich desktop computer. "It is not possible for someone to take a two-hour course on a [mobile phone]" (Motiwalla, 2007, p.14). There must be significant value gain from using m-learning for it to be justified. Thinking out value added m-learning activities remains a preserve of creative minds. M-learning is not just a matter of delivering e-learning onto mobile devices but what is extended onto the learner's mobile device must add value to their learning experience in a given context (Ayala & Castillo, 2008; Woukeu *et al*., 2005). This implies that m-learning can not be the sole avenue for learning but a supplementary mode of learning meant to add value to other learning models. M-learning pedagogy is still in its infancy and in most cases under development (Corbeil & Valdes-Corbeil, 2007).

iii Negative Perception

M-learning faces several pessimists. Keough (2005), gave seven reasons for m-learning's inability to takeoff. According to Keough (2005, p.1) m-learning as a concept alone is doomed to fail because as a learning model it appears:

- to be technology driven. M-learning alone is a technology driven concept which concentrates efforts on delivering content to mobile devices with little consideration to the rich potential for more interactive learning paradigms;
- not cognizant of market usage: we know too little about what mobile devices are used for;
- yet to adopt discoveries in cyber psychology: we know too little about flow and learning relationships/networks or the transactional analysis of mobile relationships;
- not to change entrenched institutionalized education models: cultures of education and communications reflect government control measures;
- to rely on nascent consumer technology: mobile devices are inherently dissatisfying by never quite meeting every promised need for the consumer.
- to be short on standards to overcome cultural differences: while standards are slow to emerge governments are rapidly regulating and limiting the use of mobile communications technology; and
- to lack a mobigogy: teaching and learning models are needed.

We note from Keough's pessimism that m-learning pedagogy and policy are important aspects for the success of m-learning. It is not only developments in m-learning technology per se which propel m-learning but equal developments must be made in regulatory policies and learning and teaching models.

Others such as Boone (2007) cite examination malpractice as one of the challenges that will make mobile technologies not desirable for learning especially among administrators of educational institutions.

> …schools [in the US] started banning cell phones, realizing students could text message the answers to each other. Now, schools across the country [US] are targeting digital media players as a potential cheating device. … Devices including iPods and Zunes can be hidden under clothing, with just an ear bud and a wire snaking behind an ear and into a shirt collar... Some students use iPod compatible voice recorders to record test answers in advance and play them back (p.1)

With such developments in the minds of school/college/university administrators, it will take considerable effort to lobby for the acceptance of the mobile phone or any other mobile communication devices as a tool for learning. Where they have to be accepted, considerable restrictions will have to be imposed, sometimes to the detriment of learning. Also clear value for their use in learning has to be showcased before they are accepted.

iv Equity

Even if m-learning eases student support access to learning resources, designing m-learning resources and environments that can interoperate in the multiplicity of mobile devices and technologies is quite a daunting task (Caudill, 2007; Woukeu *et al*., 2005). Just like other teaching and learning methods, there is need to ensure equity in learning experiences of learners using low through to high end mobile phones. While showing that inequitable access is not only a preserve of

m-learning, Caudill (2007, p.5) said,

> The need for learners to have equal access to technology is not significantly different from access issues for other teaching methods. A class website is not helpful if none of the students have Internet access, just as course notes distributed on CD are not helpful if students do not have access to computers to access the CD. … the best Short Message Service (SMS) system or podcasting platform is useless if learners do not have access to SMS-capable mobile phones or devices to play MP3 files. Thus, in planning m-learning integration, some difficult decisions have to be made.

The challenge of inequitable access calls for the development of models/ frameworks for equitable access to and utilization of learning objects. Prior to the development of such models/ frameworks, profiling of learners for their mobile devices, networking technologies, location and learning styles is necessary. This amplifies the need for systems requirements elicitation before the design of any information system. Also it raises the need for an appropriate m-learning pedagogy and policy. Further, it calls for mechanisms to mitigate mobile device limitations.

v Cost

The cost of implementing m-learning especially in developing countries is still high (SAIDE, 2008). The cost of bandwidth, high end mobile devices and airtime credit is relatively higher in developing countries than developed ones. Moreover, poverty levels are high in developing countries (UNDP, 2006) and many learners may not be able to afford m-learning. Therefore development of m-learning should go hand in hand with development of appropriate m-learning sustainability plans.

All said, with time, the challenges to m-learning will have solutions. When m-learning devices and technologies mature and m-learning pedagogies, theories, policies, strategies and guidelines are firmly grounded, the challenges and limitations mentioned in this section could be addressed. Technology, cultures, teaching, mindsets and learning models and methods are not static. M-learning just like any immature fields requires time to grow. Besides, advocates for m-learning recognize the fact that it cannot be used alone in its entirety. It has to be blended with other methods of delivery including face-to-face, print and online learning. With ubiquitous computing in sight, we cannot delineate ourselves from m-learning. The truly big challenge for educators and technology developers is to find ways to ensure that this new learning model is highly situated, personal, collaborative and long term; in other words, truly learner-centered.

2.2 Learning Theories and M-Learning

Literature (Motiwalla, 2007, Naismith et al., 2006; Nie, 2007; Sharples *et al.,* 2005) indicates that

existing contemporary learning theories can be adapted to underpin m-learning. Adaptation of the theories is made possible by borrowing from these theories, tenets that are inline with m-learning (Doos *et al*., 2005; Sharples *et al.,* 2005). Naismith *et al. (*2006) and Nie (2007) have singled out the behaviorist learning theory, constructivist learning theory, situated learning theory, collaborative/conversational learning theories, activity theory, informal and lifelong learning theory and learning and teaching support theory as contemporary learning theories which could be used to underpin m-learning. We interrogate each of these theories and eke out avenues where m-learning could be underpinned.

2.2.1 Behaviorist Learning Theory

The behaviorist learning theory has its roots from Skinner's (1968) work on operant conditioning and behaviorism. The theory presupposes the existence of a force in the learning process, which reinforces the relationship between a stimulus and a response (Nie, 2007; Naismith *et al.,* 2006). In behavioral learning theory, it is possible to qualitatively measure a response to a stimulus ignited on a human being or an animal (Skinner, 1968). Once learners are conditioned to an event, any act similar to what conditioned them will trigger the action set in their mind by the condition. The behaviorist learning theory can be illustrated in Pavlov's conditioning experiment. When Pavlov rang the bell before conditioning the dogs, there was no salivating from the dogs. After conditioning the dogs by ringing the bell just a few seconds to serving them with food, the dogs became conditioned that the act of ringing the bell caused them to salivate.

The behaviorist learning theory emphasizes activities that promote learning as a change in learner's observable actions (Skinner, 1968). The learning should invoke a stimulus and a response. In the case of m-learning, an SMS message, for example, invokes a stimulus that may lead to an action as a response. When a message is received on a learner's phone, for example, the learner will be triggered to respond or provide feedback. The message received on the learner's phone presents a problem (stimulus) that requires the learner to solve through a response. In this case, the mobile phone which presented the problem reinforces the relationship between the problem (stimulus) and the solution (response). Moreover, once learners are conditioned to an SMS as a conveyor of educational related messages, they will be conditioned to immediately read them as they are delivered. This abets just-in-time and just-in-place learning.

2.2.2 Constructivist Learning Theory

The theory states that learning is an active process in which a learner constructs new ideas or concepts based on his/her current and past knowledge (Vygotsky, 1978). For one to construct their own knowledge, they must be actively engaged in the learning process, collaborate/converse/interact with others, know their learning goals, contextualize their learning, and reflect on what they are learning (Doos *et al*. 2005; Fisher & Baird, 2007; Lin *et al*., 1999). Active engagement of learners in technology mediated learning, demands that the technology be designed in such a way as to serve the needs of the learners and not the learner serving the needs of technology (Naismith *et al.,* 2006). The technology should be designed with the learner in mind.

The constructivist learning theory takes an individualistic angle that negates the fact that learning occurs in social settings. Consequently, critiques of the constructivist learning theory such as Prawat and Floden (1994) argue for the social constructivist learning theory (Vygotsky, 1978). The social constructivist theory proponents posit that knowledge creation is shared rather than an individual experience. Their position is inline with Goodman's (1986) earlier contentions that knowledge is constructed through interaction of a number of minds and not just one. Hence knowledge is a social product (Prawat & Floden, 1994). Tools and raw materials for creating this social product can arise from technologies that encourage interaction and collaboration. The mobile phone is a good example of such technologies.

With a mobile phone, learners can construct their own knowledge and share it freely with peers at anytime in anyplace. This, in m-learning, is referred to as "participatory simulations" (Naismith *et al*., 2006, p.2). Participatory simulation encourages learners to actively participate in the learning process.

Within the constructivist learning paradigm, mobile devices are capable of engaging learners in learning activities that permit them to reflect and make meaning out of a given learning scenario (Fisher & Baird, 2007; Nie, 2007). This is made possible because mobile devices are personal and portable and can deeply engage learners at all times in their authentic contextual spaces. It is also made possible because, being personal in nature; the technology serves more of the learner's needs than the learner serving the technology's needs.

When the constructivist learning theory is extended to the social constructivist theory, technologies such as mobile teleconferencing and SMS can scaffold learning in communities of practice. "… communities of practice (CoPs) are evolving and beginning to play a significant role in teaching and learning" (Brown, 2005, p.300). Gone are the days when the lecturer was the sage-on-

the-stage. The practice now is for CoPs to generate new knowledge under the moderation of a facilitator. Members of a given CoP and their facilitator (s) may use collaborative and interactive tools afforded by mobile phones to interplay their minds on topical issue so as to generate new knowledge. In this case collaboration and interaction afforded by mobile phones become key tenets for social learning.

2.2.3 Situated Learning Theory

The situated learning theory was originated by Lave and Wenger (1991). The theory posits that "learning is not merely the acquisition of knowledge by individuals, but instead a process of social participation" (Naismith *et al.,* 2006, p.13). The theory presupposes that learning occurs in specific social contexts and communities of practice. It is inline with the socio-cultural theory which permits learners to work collaboratively in groups so as to share learning experiences in their communities of practice (Nie, 2007). It is also inline with the positions of Prawat and Floden (1994) and Goodman (1986) on social constructivist learning. Situated learning theory considers the learner's learning environment as being pivotal to learning (Traxler, 2007). Situating learning in a learner's context increases his/her learning experience because knowledge can be adapted to that learner's specific context. Situated learning is prominently evident in problem-based learning, case-based learning and context-aware learning (Traxler, 2007; Naismith *et al.,* 2006).

The aim of problem-based learning (Koschmann *et al*., 1996) is to develop the learner's higher order cognitive skills by providing him/her with a half defined problem which is synonymous with a real problem he/she will find in the field as a practicing professional. Problem-based learning is not geared towards testing the learner's skills but at developing their practical skills (Naismith *et al.,* 2006). It is a good model for training practical oriented professionals such as doctors and engineers. In problem-based learning, mobile devices provide reference guides to a mobile learner trying to fix or explore a half defined problem in the field (Nie, 2007). As the learner solves a problem, he/she may need to refer to the teacher, reference materials or classmates in order to arrive at the correct solution. The fact that problems are ill-defined means that such problems could sketchily be presented on a mobile phone as SMS text messages.

Students in problem-based learning can interact with each other and with their teachers via SMS and voice calls in order to arrive at a solution to the problem at stake. The teachers in problem based learning, mainly play moderation roles. All these are learning activities that could be rendered on the mobile phone. As an example, through voice or text message instructions, an intern mechanical

engineer on a road project could be provided with on spot guidelines for fixing a problem with particular road equipment. Furthermore, a lecturer could deploy a text message onto learners' mobile phones requiring them to discuss the symptoms presented by a malaria patient. These are some examples where m-learning can play a role. We now look at case-based learning.

Case-based learning was espoused by Kolodner and Guzdial (2000). Case-based learning resembles problem based learning though its aim is to solve mainly wholly defined problems. These well-defined problems may or may not be a replica of what the student will be faced with in the field of work. "Case-based learning is more flexible than problem based learning in that it can be used in small or large classes and can be used as either an assessment exercise or as a catalyst for class discussions and lectures" (Naismith *et al.,* 2006, p.14). Case-based learning is aimed at testing rather than developing skills.

"Context-awareness means gathering information from the environment to provide a measure of what is currently going on around the user and the device" (Naismith *et al.,* 2006, p.14). In context-aware learning, the learner learns by comparing what they are learning with issues in their context. It means that devices that can capture the learner's context can facilitate learning in context.

In context-aware learning, mobile devices that are fitted with global positioning system (GPS) can be used to capture a learner's contextual information (Nie, 2007). The GPS information is useful because it enables the learner to receive learning activities and content that is particularly relevant to them in their given environment. Mobile devices can be found in all contexts hence can be adapted to the various learning contexts (Nie, 2007; Naismith *et al.,* 2006).

In some cases context-aware mobile devices have offered appropriate assistance to learners by offering them context specific information. "The museum and gallery sector has been on the forefront of context-aware mobile computing by providing additional information about exhibits and displays based on the visitor's location within them" (Naismith *et al.,* 2006, p.14).

2.2.4 Collaborative/Conversational Learning Theories

Pedagogically speaking, collaboration and interaction present a vast amount of benefits to the learner (Ayala & Castillo, 2008; Caudill, 2007; Uden, 2007). Collaboration and interaction enable learners to share information in form of data, files and messages. Collaborative learning ensures two way information sharing for the purpose of learning (Mitchell & Doherty, 2003). Collaborative learning theory (Vygotsky, 1978) is related to the conversational theory (Pask, 1975) which requires a continuous two-way conversation and interaction between the teacher and learner and amongst the

learners themselves, if learning is to take place. Learning will take place if the two parties participating in the collaboration can understand each other. As Naismith *et al. (*2006, p.15) observed, learning will take place if "Person A [makes] sense of B's explanations of what B knows, and person B can make sense of A's explanation of what A knows". Collaborative and conversational learning theories emphasize the need for continuous collaboration/conversation with peers and the teacher or a device which subsumes the role of a teacher. In all the conversations however, successful learning will take place when the learner is in controls of the learning environment/activity (Naismith *et al.,* 2006).

When the technology subsumes the role of a teacher, as is the case in the drill and feedback system, there might be limited conversation between the student and the device (Naismith *et al.,* 2006). This is because the dialogue between the person and the device will only be limited to action commands as the device can not be able to perform reflective learning. In this case, face-to-face learner-teacher support is necessary to fill the conversational gap (ibid). In Fisher and Baird (2007, p.8), this is referred to as "seeded serendipity".

In some cases, a shared conversational learning space could be provided by the technology for a single user or a group of users (Naismith *et al.,* 2006). Mobile devices can support mobile computer supported collaborative learning (MCSCL). In MCSCL, learners virtually collaborate with each other in a seamless human to human interaction as opposed to online communication where the human to human interaction is seemingly lost. The fact that the learner owns the mobile device implies that he/she is in control of the learning environment, which is a plus in collaborative learning.

2.2.5 Activity Theory

Activity theory was first espoused by Vygotsky (1978) and Leont'ev (1978). It focuses on understanding human activity and work practices. It integrates the concepts of intentionality, mediation, history, collaboration and development (Nardi, 1996). Its major focus is on the activity being executed. Information systems, communities of practice and education, are among the many fields where activity theory has been employed to analyse activities therein (Uden, 2007).

In activity theory (Vygotsky, 1978), an activity consists of a subject and an object, mediated by a tool. A subject can be an individual or a community involved in an activity. Using tools, a subject executes an activity to get an object (objective), thus effectively transforming it into an outcome (Kuutti, 1996). Tools can be tangible or intangible. Tangible tools may be things like computers,

hammers, spanners, etc. Intangible tools may be aspects like language, culture, ways of thinking, etc. Similarly, an object can be a material thing, less tangible (a plan) or totally intangible (a common idea) as long as it can be shared by the activity participants (Kuutti, 1996).

Activity theory also includes collective activities, community, rules and division of labour that denote the situated social context within which collective activities are carried out (Uden, 2007). A community is made up of one or more people sharing the same object with the subject. Rules regulate actions and interactions with an activity. Division of labour informs how tasks are divided horizontally between community members. It also refers to any vertical division of power and status (ibid). Activities always take place in a certain situation with a specific context (Engeström, 1987).

Learning occurs in situated contexts and is socially mediated (Brown, 2005; Engeström, 1987; Lave & Wenger, 1991). Under the theory of social constructivism, learning is seen as an interactive and collaborative process in which peers help each other to learn (Prawat & Floden, 1994). Vygotsky (1978) depicts learning as an interaction with more capable peers, helping the learner through the zone of proximal development (ZPD). The ZPD is gap between what the learner knows and can do and what the student needs to know (Vygotsky, 1978). Through interaction with other learners and the teacher, mediated by mobile technologies (m-learning), the ZPD emerges. As Vygotsky (1978) put it, this ZPD can be addressed through the interaction and collaboration afforded by mobile devices.

2.2.6 Informal and Lifelong Learning Theory

Eraut (2000) espoused the informal and lifelong learning theory. According to this theory, "learning happens all of the time and is influenced both by our environment and the particular situations we are faced with" (Naismith *et al.,* 2006, p.17). This definition pits the informal and lifelong learning theory to the social constructivist (Prawat & Floden, 1994; Vygotsky, 1978) and situated (Lave & Wenger, 1991) learning theories.

Informal and lifelong learning can occur as a result of intentional or accidental learning episodes that are orchestrated by exchange of information and knowledge (Nie, 2007). Intentional learning episodes occur when learning is planned while accidental learning episodes occur from scenes which have no direct learning intentions, such as experiencing an accident, watching television, engaging in casual conversations, reading a newspapers or even listening to radio talk shows (ibid). It means that accidental learning can occur at anytime in anyplace. Learners carry their mobile phones at all times in anyplace, implying that they can be a source of information for accidental learning.

The informal and lifelong learning theory promotes activities that support learning outside a dedicated learning environment and formal curriculum (Eraut, 2000). Mobile technologies can support informal learning, which may be intentional or accidental (Sharples, 2000). Intentional learning may be acquired through, for example, intensive, significant and deliberate learning efforts, while accidental learning may be acquired through conversations, television and newspapers, observing the world or even experiencing an accident or embarrassing situation. As was found by Vavoula (2005), the majority of learning episodes in adults is informal. While emphasizing the purpose of learning, Naismith *et al., (*2006) summarizes thus:

> … people learn in order to be able to perform a new task, or even to be able to carry out a routine task in a better, more efficient or elegant way. Technology that is used to support learning should be blended with everyday life in the same way that learning is blended with everyday life: seamlessly and unobtrusively. Mobile technologies, with their reduced size and ease of use, provide the potential to support such activities (p.18).

The mobile phone has become part and parcel of our daily lives (Brown, 2005). This companionship makes a mobile phone the number one tool for informal and lifelong learning.

2.2.7 Learning and Teaching Support Theory

Provision of education is not just about providing content and learning activities to learners. It also involves a great deal of coordination of learners and resources (Naismith *et al.,* 2006). Besides, access, communication and support are the three canonical uses of ICTs in education (Brown, 2005). The learning and teaching support theory emphasizes the need for support systems in learning and teaching. The support systems assist in the "coordination of learners and resources for learning activities" (Naismith *et al.,* 2006, p.11). By using SMS and voice calls, a lecturer can be able to coordinate activities of his/her class and organize resources for the class. He/she can be able to support learners through reminders of learning events and provide URLs to reading materials. Learners can also support each other. This theory underpins the SMS student support system at Makerere University (Kajumbula, 2006).

2.3 Learning Objects

The concept of learning objects is at the center of a new paradigm for instructional design of reusable learning content and activities (ASTD & SmartForce, 2002; Ayala & Castillo, 2008; Becta, 2005; Nash, 2005; Sanchez-Alonso & Frosch-Wilke, 2005; Schibeci *et al.,* 2008; Smith, 2004; Wiley, 2001). This paradigm shift has been summarized by ASTD and SmartForce (2002) in their

Learning Circuit series titled 'A Field Guide to Learning Objects', thus,

> For years, the e-learning industry has anticipated the day when learners could personalize; assemble on the fly, and access e-learning on demand. Development teams would be able to build content a single time, store it electronically, reuse it, and deploy it in different formats with a simple button click. A small content piece - a learning object -would establish the foundation upon which these capabilities rest. (p.1)

The e-learning fraternity is now awash with a new phenomenon of content structuring that requires content to be developed as a self contained unit that can be reused in more than one instructional setting. Such content has been referred to as learning objects (Wiley, 2001).

Learning objects have been variously defined. In Wiley (2001) a learning object (LO) is defined as a digital educational resource/content which is granulated into units that are reusable, adaptive, and can be re-purposed to different learning styles, knowledge levels and conditions. In Schibeci *et al.* (2008, p.2) a learning object is defined as "one or more files or 'chunks' of materials, which might consist of graphics, text, audio, animation, calculator, or interactive notebook, designed to be used as a standalone learning experience". Elsewhere, a learning object is "any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning" (IEEE, 2010, p.1).

The multiplicity in definition of learning objects is an indication of lack of a single unified standard definition for learning objects. According to Smith (2004, p.1),

> Learning objects vary so much in terms of size and scope, content, design, and technical implementation that pinning down the essence of 'learning-objectness' is not an easy task. One thing that most descriptions have in common is that they focus on how learning objects are created, used, and stored, rather than on what learning objects look like.

Different institutions and individuals conceptualize learning objects differently. As is observed from the different definitions, the size of a learning object is not emphasized. Hence a learning object could be an SMS message, a webpage, an image, a sound clip and so on. In Ketterl *et al*. (2007), audio podcasts are given as one of the examples of m-learning objects.

Most definitions point to the need to reuse learning objects in the learning process. Learning objects could be reused if they are created and kept in learning object repositories or in the mobile web (Luis de Marcos *et al.*, 2006; O'Connell & Smith, 2007; W3C, 2009).

2.3.1 Creating Learning Objects

The multiple conceptualization of a learning object has been sounded. But the common thread in all the learning object conceptualization is the "focus on how learning objects are created, used and stored rather than […] what learning objects look like" (Smith, 2004, p.1). Creators of learning objects create them with reuse in mind and a sequencing strategy that can allow learning to take place.

Learning objects can be aggregated and disaggregated (Becta, 2005; Smith, 2004). The aggregation or structuring of learning objects must be done in way which meets a learning objective (s). A learning object should consist of a learning objective (s), content which is relevant to that/those objective (s) and an educationally meaningful navigation path for the content in the object (Becta, 2005). The content in a learning object can be documents, pictures, simulations, movies, sound, text or a combination of these (Smith, 2004). Whereas most learning objects are digital, there are also paper based learning objects. Learning objects could be made for desktop computers, mobile devices or both. In *Section 2.3.6*, we delve into learning objects for mobile devices – m-learning objects (mLO). A learning object should be wholly constituted. Smith (2004, p.2) has described the constitution of a digital learning object thus:

> At the minimum, a digital learning object consists of content and an interface. The content is made up of assets, which are the materials or 'blocks' that make up the learning object: images, text passages, videos, etc. The interface is the part of the learning object with which the user interacts. It includes the graphic design, navigational elements, and other controls that the user sees. An interface may be as simple as a single web page that presents text and images, or as complicated as a screenful of controls to set the parameters of a simulated chemistry experiment

From the above description of a learning object, it can be deduced that creating a complete learning object requires time and multiple professional skills. This conclusion is inline with Caudill's (2007) confession that designing interoperable learning objects is a daunting task. It requires a multiplicity of expertise. It requires a domain expert to develop the content, instructional designers to determine how the objects would be educationally sequenced or navigated, graphic designers to design the different media and software programmers to develop interfaces, simulations and animations (Becta, 2005).

Several other issues are important while creating a learning object. These include technical expertise, incorporation of effective pedagogy, intellectual property and copyright issues, author workload and scope of desired learning object (Smith, 2004). Technical expertise related to programming is required to create a learning object. Effective pedagogy needs to be instilled in a learning object in order for learning to take place. Intellectual property and copyright issues have to

be addressed when one is using learning objects with copyright limitations. Issues such as who owns the object? Does the author have the right to aggregate given learning object(s) in his/her new object? Is the object being accessed password protected? Who own the copyright of the finished learning object? These issues get complicated when the number of learning objects to be aggregated into one learning object becomes big. Therefore careful planning and investment of time and money are key pre-requites for learning objects creation.

Dedicated time slots and budget is needed to have quality learning objects. The time is important for planning the asset of the learning object and its sequencing and navigation strategy, otherwise known as the *Organization* in Becta (2005). As if that is not enough, the size and scope of a learning object is another key issue to consider. Determining the appropriate amount of content to be included in a single learning object is not easy. Too much content in a learning object can make it difficult to navigate and can take relatively long time to download. Too little content can de-motivate learners who find it worthless investing time and effort in using the learning object. This calls for effective learning objects design and usability planning.

2.3.2 Why Learning Objects?

Why is the concept of learning object being embraced by content developers? Smith (2004) has identified benefits that digital learning objects offer vis-à-vis traditional learning materials. According to him, learning objects are "flexible, … cost effective and can be combined in customized ways" (p.2). The flexibility afforded by learning objects means that they can be used to meet requirements of learners with different learning styles. Auditory learners are comfortable with audio learning objects and tactile learners prefer learning by doing. A learning object presented for tactile learners should have hands on reflective exercises. Also, a single learning object can be presented differently to the same learner depending on the context of learning. While in a quiet environment, content in a learning object can be presented as audio but while in a noise place the same content could be presented as a text. Again, since learning objects can be reused in the same course but in a different semester or repurposed for other courses, it becomes cost effective to implement learning materials as learning objects. Further, because learning objects are made with reuse in mind, facilitators can choose from a multitude of learning objects existing in the learning object repositories and customize them for use in their own courses (ibid). Ideally, a learning object is supposed to accurately and precisely present content. By so doing, it increases the learning experience and learner satisfaction (Becta, 2005).

2.3.3 Learning Object Utilization

Effective utilization of learning objects by learners is closely linked to how the learning objects were created or designed. Guidelines have been suggested for creating learning objects that can be effectively utilized, accessed, reused and interoperated. For learning objects that can be effectively utilized, Smith (2004, p.12-13) gave the following design guidelines:

1. Be consistent in the use of design elements, language, formatting, appearance, and functionality.
2. Allowing learners to control their interactions; giving them the freedom to choose how to complete tasks.
3. Following established standards of design and use of conventions that are familiar to learners.
4. Simplifying the design wherever possible, and sticking to basic principles of aesthetics.

Nash (2005) has identified seven factors for determining usability of learning objects. These include: relevancy, usability, cultural appropriateness, infrastructural support, redundancy of access, size of object and relation to the infrastructure/delivery. A key factor lacking among these factors is the cost of obtaining access to and utilising a learning object.

For effective learning objects accessibility, the design guidelines offered in Smith (2004) consider designing for device independence, multiple media and allowing for control of moving content. The accessibility imperative must take care of the learning styles of learners.

The other characteristic of learning objects is that they must be reused or propagated for use in other courses. Learning objects thus have to be designed with a reuse property in mind. In Smith (2004, p.14-15) reusability design guidelines include:

1. Solving copyright problem for others who want to reuse the learning objects.
2. Making sure the learning object is self-contained and can stand on its own.
3. Designing learning object so that it may be used by a diverse audience.

For a given learning object to be reused, it means that it is suitable for deployment on the learner's learning device. Before deployment however, it is important that affirmative answers to the following questions are obtained

1. Is the learning object appealing overall?
2. Is the experience of using the learning object a pleasant one?
3. Are the technical requirements easily understood and easily met?
4. Is it easy to find ones way around the learning object?
5. Is the content complete and correct?
6. Are the activities appropriate to the content?
7. Is the scope of the learning object suitable: neither too limited, nor too general for ones purposes?
8. Does it meet the educational goal that one decided upon?

Smith (2004, p.20)

If some of the answers to the question are in the negative, then the learning object is not suitable for

deployment.

Another characteristic suggested by Smith (2004) is allowing for interoperability of learning objects. Learning objects are interoperable if they are portable in various learning management systems. Interoperability is made possible by tagging learning objects with metadata. According to Smith (2004, p.15), metadata ensures that learning objects are:

1. Interoperable — that it can work with other learning objects in other LMSs.
2. Reusable — that others can use ones object, perhaps in different ways than one uses it.
3. Discovered — that ones object can be found by users who need it at the time that they need it.
4. Properly attributed — that ones ownership and attribution rights remain attached to ones learning object, no matter where it goes or how it is used.
5. Durable — the useful lifespan of a LO will be extended because it conforms to metadata standards.

The guidelines given in Smith (2004) relate to desktop computer learning objects. No mention is made on development guidelines for LOs that can be effectively deployed and utilized on mobile devices.

2.3.4 Learning Objects Metadata Standards

Learning objects are tagged with identifiers called metadata (IEEE Computer Society, 2002). Metadata enables the LMS to locate the right learning object. Metadata provides a common nomenclature for learning objects to communicate and exchange with others in a common way (Paivi & Paivi, 2005). It provides such information as: "what the content [of a learning object] is about, who the authors and developers are, who the target audiences are, who owns the object, how it may be used and so on" (Smith, 2004, p.22). Metadata provides information that makes discovery; access; and use of learning objects transparent (Becta, 2005). All in all, metadata is descriptive data about a learning object.

There is no single ratified standard for describing learning objects metadata. Organizations such as IEEE Computer Society, IMS Global Learning Consortium, CanCore, Dublin Core, Advanced Distributed Learning (ADL), Alliance of Remote Instructional Authoring and Distributed Networks for Europe (ARIADNE), Aviation Industry Computer Based Training Committee (AICC) and many others have come up with separate standard specifications for learning objects metadata.

IEEE Computer Society described basic metadata elements for learning objects using the IEEE Learning Object Metadata (IEEE LOM) standards while the content itself is described using the IMS Global Learning Consortium (2004) standards. The IMS provides standards for learning resources metadata, content packaging and sequencing, question and test interoperability or enterprise

integration (IMS Global Learning Consortium, 2004). The XML-based IMS content packaging specification deals with content resource aggregation/packaging, course organization, and metadata (Becta, 2005)

The IMS Global Learning Consortium (2004) standard has nine metadata attributes. These are: general, life cycle, meta-metadata, technical, educational, rights, relation, annotation and classification. The general attribute provides general information about the learning object. This include product code, title, language, keywords, coverage, structure and the level to which content is aggregated such as lesson or topic. Life cycle attribute provides publishing details including publisher's name, author's name, version information and list of contributors. Meta-metadata attribute provides a unique identifier for the metadata schema that has been used. Technical attribute provides technical information about each asset in a learning object, for example the format of the content, its size, its location, resource requirements, installation remarks, requirements for other platforms and asset duration. The educational attribute provides educational values and approaches, the type of learning resource, method of delivery, level of interactivity, the target user of the object, educational level targeted, age range targeted, difficulty level, typical learning time and a description of how the resource is intended to be used. The rights attribute provides the intellectual property rights (IPR) information. The relation attribute provides any relationships with other learning objects. The annotation attribute provides comments on the learning object from independent sources. The classification attribute provides classification of the content according to a given curriculum framework.

The ADL initiative terms the granulated learning objects as the Sharable Content Objects (SCOs) (ADL, 2004). A SCO contains various assets of information, which could be singular web pages, video content, text file or animation file (Iain & Zhijie, 2005). Theoretically, each asset could act as a standalone unit of learning; however, the flexibility of using SCOs becomes apparent when they are linked together via a navigation path within a LMS (Mendes *et al*., 2002). Once SCOs are available, they can be assembled in real time on demand and then delivered to learners in a single environment (ADL, 2004). The SCOs are standardized through the Sharable Content Object Reference Model – SCORM (Becta, 2005).

SCORM is not an accredited metadata standard per se but is a specification which references standards developed by IEEE and IMS (Becta, 2005; Watson & Hardaker, 2005; Godwin-Jones, 2004). SCORM is therefore a generic specification which any creator of learning objects can follow to create and manage interoperable learning objects.

SCORM implements the IEEE Learning Object Metadata (IEEE LOM) specification and IMS content packaging. The IEEE LOM was approved as an IEEE standard in July, 2003, and describes what content is (title, description, keywords), who owns it, what it costs (if anything), the technical requirements for its use, and educational objectives. SCORM provides "specifications for describing, sequencing and joining learning objects; enabling communication between learning objects and learning management systems; and data tracking" (Smith, 2004, p.16).

The foregoing review shows that there is no single ratified metadata standard though the SCORM specification is widely accepted. However, a standardized learning object metadata design should address three aspects related to packaging information for transport purposes (XML), information about the content (IEEE LOM) and the actual content itself (ASCII text, XML, HTML, PDF, video, audio, etc.) (Pankratius *et al.,* 2005). Metadata allow learning objects to be discovered in learning objects repositories which might be of open access or proprietary in nature. Standards for m-learning objects metadata are yet to be developed.

2.3.5 Learning Objects Repositories

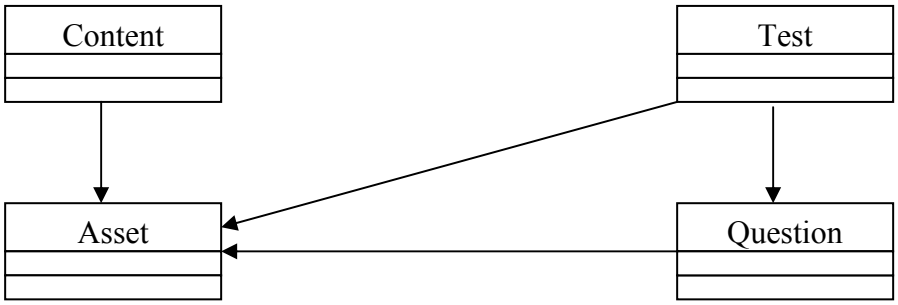
Learning object repositories are stores/databases of digital learning objects (Luis de Marcos *et al*., 2006; Smith, 2004). There are open and closed access learning objects repositories that are host to a multitude of learning objects media types. Media types in learning object repositories include: audio, text, video, podcast, PDF, 3-D animations, flash/shockwave, e-learning courseware, full applications, graphic images, HTML/websites, multimedia, photos, PowerPoint presentations, or a combination of any of these (Low, 2007). With the aid of metadata, learning objects repositories can be searched for specific learning objects. Learning objects repositories are maintained by permitting read and write permissions to owners of learning objects (Luis de Marcos *et al.*, 2006). Similarly new learning objects are added in the repositories from authorized authors.

There are thousands of learning object repositories. Some of these are: the Multimedia Educational Resource for Learning and Online Teaching (MERLOT, 2010), Campus Alberta Repository of Educational Objects (CAREO, 2010), Canadian Network of Learning Object Repositories (CNLOR, 2010) and Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE, 2010). All these offer learning objects for PC based systems.

In *Figure 2.2,* the structure of a learning object repository is depicted. A learning object repository consists of content, assets, questions and tests (Luis de Marcos *et al.*, 2006). Content are the educational materials themselves or the learning objects. Content can be reused. Assets are the

individual indivisible components that make up a learning object. Assets can be reused in different learning objects. Hence a learning object is an aggregation of assets. An aggregation of learning objects would form a course. Questions are elements that form a test or a questionnaire. Tests are the containers of questions. Tests also provide question sequencing information (ibid).

Figure 2.2: The Structure of a Learning Object Repository



Source: Luis de Marcos *et al.*(2006, p.6)

The convergence of Internet with mobile devices has led to the creation of repositories for storing learning objects for mobile devices. These repositories are sometimes referred to as the mobile web (W3C, 2009). Whereas the mobile web may be host to other mobile objects, it can be host to objects for learning. In *Section 2.3.6* below, we delve into the concept of m-learning objects.

2.3.6 M-Learning Objects

The concept of m-learning objects started way back in 2002 (Quinn, 2002). Since then, little research attention was realized until recently when Internet became increasingly accessible via mobile devices. It is now possible to deliver content to learners via their mobile phones (Ayala and Castillo, 2008). However, the content has to be "leaner than content prepared for e-learning systems" (Low, 2007, p.9). The content has to be granular, sequenceable, reusable and contextualiseable (Ayala & Castillo 2008; Uden, 2007; Zaharieva & Klas, 2005). These requirements are a perfect match for the characteristics of learning objects.

Whereas resources are abundantly available for desktop computer 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 m-learning objects (Ayala & Castillo, 2008; Nakabayashi *et al.*, 2007; Quinn, 2002; Toledano, 2006; Trifonova & Ronchetti, 2006; Yang, 2007). A m-learning 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 & Castillo, 2008, p.153). This implies that a m-learning 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. An SMS to a learner providing him/her with a URL to content in the WWW could be regarded as a m-learning object.

Research into the development, deployment and utilization of m-learning objects is ongoing (Ayala & Castillo, 2008; Goh & Kinshuk, 2006; Nakabayashi *et al.*, 2007; Quinn, 2002; Toledano, 2006; Trifonova & Ronchetti, 2006; Yang, 2007; Zhang, 2003). This research is however skewed in favor of developed countries' contexts and is mainly still in trial or prototype phases. Since uptake of mobile phones in developing countries has surpassed industry analyst's predictions, it is important to undertake research into development of frameworks for developing applications for deploying and utilizing m-learning objects in developing countries.

M-learning objects 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 m-learning objects is being short sighted. Designing for learner personalization, collaboration and interaction completes the picture of an m-learning object (ibid). It means even considering the capability of the phone owned by the target learner.

M-learning objects could be delivered in traditional classroom environments, 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 an m-learning object is dependant upon the capacity of the mobile device in question and how a given institution conceptualizes a learning object. Even an SMS sent out to students for academic and administrative support can be regarded as an m-learning object. In Ayala and Castillo's (2008) definition of an m-learning object, a software component is regarded as an m-learning object. In developing countries where learners own mainly low end mobile phones, the SMS based learning objects may be more feasible than resource heavy learning objects such as software modules.

Software modules extending academic and administrative support to students can be run on Java enabled mobile phones. Multiple choice question quizzes, exams and lecture calendars, reminders for important events and frequent errors committed by students in a given subject can be developed as Java midlets and delivered on java enabled mobile phones (Toledano, 2006). The success of m-

learning lies in the need to recognize the limitation of mobile devices so as to deploy learning objects onto them which address pedagogic assistance. Consequently, m-learning objects should be characterized by appropriate pedagogic values. In the section that follows; we review some m-learning objects frameworks.

2.3.7 Some M-Learning Objects Frameworks

As is espoused in *Section 2.3.6* above, m-learning objects and applications have started attracting research attention. Consequently, research into frameworks for m-learning objects design, development and use is beginning to take shape. In *Table 2.2* below, we review some m-learning object frameworks with the view of establishing the state of art in m-learning objects design, development and use.

Table 2.2: Review of Some M-Learning Object Frameworks

Model/Framework	Characteristics/Features	Technologies	Content/LO Standard	Research Gap
Framework for flexible learning using m-learning objects (Quinn, 2002)	- Uses the concept of learning object to personalize learning. - It contextualizes learning	- Context data - Task model - Intelligent support engine - User model - Content repository - Interface	- SCORM - XML - Education Modeling Language - Ontology Web Language	Does not model the limitations of mobile devices Does not consider cost dimension of m-learning Doesn't consider cognitive overload
Framework for Delivery of personalized and adaptive content to mobile devices (Zhang, 2003)	- Uses pull and push models to deliver personalized content on mobile devices - Profiles users, devices and network conditions hence provides learning in context	- Browser enabled mobile devices - WAP/I-Mode gateway - Web server - Multimedia streaming server - Customization module - Push proxy - Wireless applications - Content server - User profile database, - Internet/wireless network/wired network	- WML	The framework is essentially for commercial mobile applications with no pedagogic intentions (lacks m-pedagogy dimension)
Multi-dimensional framework for content adaptation (Goh & Kinshuk, 2006)	- Adapts content to different device types and user profiles using five dimensions which include content, user, capability, connectivity and coordination dimensions	- XSLT - ASP - Mobile devices - PCs - DOM	- XML - XHTML - WML	Lacks a dimension for LO usability and does not take into account m-learning object acquisition issues. Limits pedagogy to content only yet m-learning pedagogy should be an overarching issue in all aspects of m-learning. Leaves out m-learning policy and strategy.

Model/Framework	Characteristics/Features	Technologies	Content/LO Standard	Research Gap
M-learning content hoarding model (Trifonova & Ronchetti, 2006)	- Picks content from the WWW which it transforms into mobile formats and prepares it for online and offline sessions - Uses PDAs as the mobile devices - Caters for intermittency in network connections - Hoards content in the PDA's memory for use during offline sessions	- Web-based content repository - Servers - Web browsers on PDAs - Catching proxy on PDAs	- XML - HTML	Whereas the model addresses intermittency in network condition, something common in developing countries, memory limitations on low and mid range mobile phones makes this model inapplicable in developing countries. Has no costs dimension
J2ME midlets/learning objects access model (Toledano, 2006)	- A model for offering support services to students in a blended learning environment. - Support services are offered using Java midlets - Java midlets because they offer offline access as opposed to WAP pages - Midlets are accessible either via mobile devices or PCs	- Content server - Classroom - PC labs - Student's PC - Student's phone - Bluetooth/infrared/USB cable/WAP	- J2ME - Java midlets	No device and learner profiling is evident in the model. Though they offer pedagogic support the midlets are not interactive, collaborative and contextualized.
Adaptive framework for aggregating m-learning objects (Yang, 2007)	- Provides an approach for gathering feasible e-learning content and adapting it for mobile devices - The framework profiles and contextualizes the learner and the mobile device	- E-learning content analyzer - Mobile content aggregator and editor - Mobile devices - Internet	- No specific standard given	The model assumes one source of learning content – WWW. It is also concerned more with content transformation than deployment and utilization
Push and pull framework for m-learning objects delivery (Motiwalla, 2007)	- Integrates mobile connectivity with e-learning - Is based on the push and pull model for content delivery - Supports pedagogic approaches for content personalization and collaboration	- Internet/WAP - SMS, IM, Alerts - Discussion board, Chart Forums, Pedagogic agents and mentors - PCs and web-enabled mobile phones - System tools and	- WML - Text	Does not profile device and network conditions

Model/Framework	Characteristics/Features	Technologies	Content/LO Standard	Research Gap
		resources, - Scheduling calendars		
Adaptive m-learning environment (Nakabayashi *et al*., 2007)	- Provides an adaptive self-learning environment - It is motivated by the need to use learning objects in mobile and PC based environments - Supports learner adaptation and offline learning using mobile phones - Extended SCORM 2004 to the mobile arena	- Content browser for mobile phones - SCORM based LMS - Protocol transformation server - Manifest file - Learning resources for PC - Learning resources for mobile phone - PC, mobile phone	- SCORM	Limits the source of learning objects only to the SCORM based LMS. The mobile web, WWW, enterprise databases, repositories are other sources for learning objects. No pedagogic agents are evident in the model. Also there is no profiling of network condition in the model
Computational models for m-learning objects (Ayala & Castillo, 2008)	- An m-learning object is not simply that which has been adapted for display on a the tiny screen of the mobile phone. Rather it is one with the following characteristics: ▪ Ability to be displayed on the tiny screens ▪ Ability to be personalized ▪ Ability to inculcate collaboration and interaction - Offers computational models based on learning objects personalization, collaboration and interaction	- Learner and device profiling software - Collaboration scripts - Learners' contribution aggregator - Content rendering software - Software to provide information about available learning objects	- No specific standard mentioned	The models lack a component for profiling network conditions, an aspect which of importance in m-learning in developing countries

As seen in *Table 2.2* above, m-learning object research has been raging on since 2002. The research addresses frameworks for design, development and delivery of m-learning objects. An overview of existing frameworks and models reveal the need for learner and device profiling to enable m-learning objects personalization and contextualization. It also reveals that m-learning abets social learning and therefore calls for attributes in learning objects that facilitate collaboration and interaction. Collaboration and interaction is made possible when learners are connected to each other through online or offline means. The models recognize the presence of databases for learning objects. Further, for interoperability of learning objects, some models front standardized development of learning objects using SCORM, IMS and J2ME. Notably lacking in all the frameworks are dimensions for mitigating devices limitations, high costs of m-learning and cognitive overload. Also dimensions for m-learning policy, learning processes, m-learning ethics are lacking. Further, all frameworks emanate from developed countries with less regard to contexts in developing countries. There is need to undertake research aimed at developing an m-learning objects framework which addresses the relationship between m-learning cost, learning processes, m-learning objects, m-learning context, m-learning devices, mobile devices limitations and m-learning policy.

2.4 Summary

Literature has shown that the convergence of Internet with mobile devices is increasingly abetting the development of mobile applications for different sectors including education (m-learning). At the moment, m-learning is being used as a value addition service to e-learning and classroom learning models because the devices and technologies supporting it are technically and pedagogically constrained. However, with increasing proliferation and processing power of mobile devices, enormous potentials exists for m-learning as is depicted in the number of m-learning projects being implemented. Most authors are optimistic that current challenges and limitations to m-learning will soon fade as m-learning technologies mature and policies, strategies and theories for m-learning surface.

The surfacing m-learning theories ought to be socially constructed, situated, collaborative and supportive to an m-learner. When an m-learning theory has these attributes, it makes learning active. This leads to increased learning experience on the part of the learner. The absence of a standalone theory for m-learning has been mitigated by adapting existing contemporary learning theories. Contemporary learning theories possess attributes that can be borrowed to underpin m-learning. In

particular, the constructivist, social constructivist, behaviorist, collaborative, conversational, situated and networked, activity, informal and lifelong and learning and teaching support learning theories have been singled out as contemporary learning theories with tenets that can be used to underpin m-learning.

Consequently, the current m-learning theories are a cocktail of m-learning compatible tenets from different contemporary learning theories. Such tenets revolve around collaboration and interaction as a means of achieving constructivist, active, situated and supported formal, informal and lifelong learning. When the tenets are blended in appropriate doses as per the learning context, an appropriate m-learning pedagogy can be achieved. Equally so, the development of m-learning frameworks can be underpinned by existing e-learning framework since m-learning is a subset of e-learning.

Little research attention has been put to the development of m-learning frameworks especially for developing countries and that is why m-learning case studies reviewed from developing countries are not underpinned by any m-learning framework.

There is a general paradigm shift from traditional learning content to the notion of learning objects. Learning objects are widely being accepted as a vehicle for exchanging collaborative and interactive learning information. The learning objects notion is orchestrated by the fact that learning objects are reusable, interoperable and can be repurposed for use in different courses and LMSs. Conceptualization of learning objects vary from institution to institution.

Effective utilization of learning objects by learners is closely linked to how the learning objects were created or designed. Also, learning object reuse and aggregation is affected by the intellectual property rights associated with the different assets in the learning object. Learning objects are usually tagged with metadata to uniquely identify them. Though not a metadata standard parse, SCORM is a learning objects metadata standard specification which references the IEEE and IMS standard. Learning objects are stored in open or closed access learning objects repositories.

Learning objects could be developed for use in e-learning systems, m-learning system or both. Research into the development, accessibility and use of learning objects and their associated metadata standards has been mainly focused on learning objects for e-learning systems. Little research has been conducted for developing frameworks for m-learning object application instantiation.

It should be noted however, that m-learning objects frameworks require learner and device profiling to enable for personalization and contextualization. M-learning abets social constructivist

learning and therefore calls for attributes in learning objects that facilitate collaboration and interaction. Collaboration and interaction is made possible when learners are connected to each other or to learning object repositories using online or offline means. Further, for learning objects interoperability to happen, some frameworks front standardized development of learning objects using SCORM, IMS and J2ME.

2.5 Conclusion/Research Gaps

The following research gaps have been derived from the literature reviewed. These include:

1. The need to enhance existing e-learning frameworks with dimensions for m-learning
2. The need for research to enhance the development and growth of m-learning in different contexts
3. The need for research on how to integrate m-learning into e-learning.
4. The need for research into the pedagogic use of mobile phones
5. The need to develop m-learning pedagogies, theories and policies.
6. The need for research on how to adopt and implement m-learning
7. The need for research on learning processes that can be accomplished through m-learning
8. The need for research on the kinds of learning objects that can be used to accomplish the possible m-learning processes.
9. The need to develop guidelines for developing applications for deploying and utilising learning objects on mobile phones
10. The need to develop standards for m-learning objects metadata.
11. The need for research on how to mitigate mobile phones limitations.
12. The need for research on how to mitigate the high cost of m-learning.
13. The need to find ways of sustaining m-learning.

As a young field, m-learning presents several research gaps. In tandem with the aim of this dissertation, we focused on addressing research gaps that directly deal with learning objects deployment and utilisation on mobile phones. Such research gaps were addressed by developing a m-learning objects framework that was underpinned by existing e-learning frameworks and primary research conducted in developing countries of Africa. The research questions derived from the above gaps are presented in *Section 1.6* above

CHAPTER THREE

3. METHODOLOGY

3.0 Introduction

This research is aimed at developing a framework for creating applications for deploying and utilising learning objects on mobile phones. The framework so developed can widen the dissemination of knowledge. Knowledge is a social product (Prawat & Floden, 1994). Research into the design, development and evaluation of artifacts for disseminating knowledge is socially responsible (Reeves *et al.,* 2005). The social responsibility emanates from the belief that such research addresses the needs and aspiration of the masses pursuing an education. It implies that research approaches to be employed in such socially responsible studies must ensure the participation of the masses involved in the knowledge dissemination artifacts design, development, evaluation and use. The m-learning objects framework aimed at in this research is a knowledge dissemination artifact; hence this research is socially responsible.

Design Research has been fronted as the most suitable approach for accomplishing socially responsible studies (AIS, 2007; Design-based research collective, 2003; Hevner *et al*., 2004; Reeves *et al*., 2005; Wang & Hannafin, 2005). Design Research combines research, design and practice (Wang and Hannafin, 2005) and its outputs include: constructs, models, methods/frameworks, instantiations and better theories (AIS, 2007). "Constructs are vocabularies or symbols used to define a problem or solution while models are abstractions and representations of the problem or solution and methods/frameworks are algorithms and practices for implementing the artifact. Instantiations are implementations and prototype systems" (Hevner *et al*., 2004, p.2). Constructs provide building blocks for models and frameworks. A framework is a supporting structure around which something can be built (Hevner *et al*., 2004). Indeed, the framework culminating from this research is inline with the outputs of Design Research.

In this Chapter, we give the methods and techniques used to accomplish the research within the Design Research methodology framework. The Chapter is organized as follows. In *Section 3.1*, we compare design research with similar research methodologies before providing the philosophy of Design Research in *Section 3.2*. In *Sections 3.3,* we show how the Design Research methodology was used to execute this research. In *Section 3.4,* the conclusion to the Chapter is provided.

3.1 Comparison of Design Research Methodology with Similar Methodologies

Design Research has several nomenclatures depending on the field where it is being used. In information systems it is sometimes referred to as Design Science (Hevner *et al*. 2004). In education research, it is sometimes referred to as Design-based Research (Design-based Research Collective, 2003) or Design Experiments (Collins, 1992). Though variously named, the underlying goals and approaches in all these Design-based Research methodologies are similar (Wang & Hannifin, 2005). They for instance embrace iterations and constant interaction between the researcher and research participants and all lead to the same outputs, namely constructs, models, frameworks, methods and instantiations. *Table 3.1* below compares these methodologies and their methods.

Table 3.1: Comparison of Design Research With Other Design-Based Research Methodologies

Methodology	Method
Design Research (AIS, 2007; Edelson, 2002, Reeves *et al.* 2005; Wang & Hannafin, 2005)	• An information systems research methodology • Designs both directly propel the development of practice and improvement in researchers' understanding of a phenomenon • Four characteristics: research driven, systematic documentation, formative evaluation and generalization • Designs generate three types of theories: domain theories, design frameworks, design methodologies • The domain theories go beyond the specific design context
Design Science (Hevner *et al*. 2004 ; Reeves et al. 2004)	• An Information systems research methodology • Considers problem relevancy, research rigor, design as a search process, design as an artifact, design evaluation and research contribution, research communication
Design-based research (Design-Based Research Collective, 2003)	• Often conducted within a single setting over a long time • Iterative cycles of design, enactment, analysis, and redesign • Contextually dependent interventions • Documents and connects outcomes with development process and the authentic setting. • Collaboration between practitioners and researchers • Lead to the development of knowledge that can be used in practice and can inform practitioners and other designers
Design experiments (Collins, 1992)	• Comparison of multiple innovations • Characterizing the messy situation • Multiple expertise in design • Social interaction during design • Flexible design revision and objective evaluation • Developing a profile as findings
Development research (van den	• Begins with literature review, expert consultation, analysis of examples, and case studies of current practice

Methodology	Method
Akker, 1999)	• Interaction and collaboration with research participants to approximate • interventions • Systematic documentation, analysis, and reflection on research process • and outcomes • Uses multiple research methods; formative evaluation as the key activity. • Empirical testing of interventions • Principles as generated knowledge in the format of heuristic statements
Developmental research (Richey *et. al.,* 2003)	• *Type 1* (emphasizing specific product or program) and • *Type 2* (focusing on the research process) • Begin with defining research problem and reviewing related literature. • Different participating populations in Type 1 and Type 2 developmental research during different phases • Various forms of data collection depending on the research focus • Employ multiple research methods, such as evaluation, field observation, document analysis, in-depth interview, expert review, case study, survey, etc • Data analysis and synthesis include descriptive data representations, quantitative and qualitative data analyses • Reports of developmental research are long and can be published in various • types of sources; websites are useful to report massive data sets
Formative research (Reigeluth & Frick, 1999)	• Drawn from case-study research and formative evaluation • Used to improve instructional systems and to develop and test design theory in education • Preferability (i.e., effectiveness, efficiency, and appeal) over validity. Two types: (a) designed case studies and (b) naturalistic case studies

Adapted from Wang and Hannafin (2005)

3.2 The Philosophy of Design Research Methodology

Methodology refers to the study of methods for data collection, processing and reporting, while methods are techniques and procedures used in the process of data gathering, processing and analysis (Cohen *et al*., 2000). This means that methodology is an all embracing philosophy which guides the process of carrying out an investigation or research. As has been justified in *Section 3.0* above, this study followed the Design Research methodology (AIS, 2007; Edelson, 2002). Design Research, also known as Design Science methodology, is well suited for handling socially responsible studies such as studies leading to instructional technology improvement, design, development and evaluation (Reeves, *et al*., 2005).

To fully appreciate Design Research as a scientifically grounded research methodology, one needs to understand the functioning of an information system artifact. Any information system artifact's performance is influenced by three forces, namely: inner and outer environment forces and the interface between those forces (Simon, 1996). Inner environment forces arise from the working

and relationship of the components that compose the artifact while the outer environment forces arise from external forces and effects that act on the artifact. An information systems designer must have "knowledge in the form of techniques and methods for performing [a balanced mapping of inner and outer environment forces and the interface between them]" (AIS, 2007, p.2). This balancing act is called 'design' (ibid). Elsewhere, 'design' means creating or inventing artifacts in an "artistic or highly skilled manner" (Farlex, 2008, p.1). Friedman (2003, p.508) defines 'design' as "the process by which we [devise] courses of action aimed at changing existing situations into preferred ones". These definitions reveal that design involves the creation of new artifacts or modification of existing ones with the purpose of improving them.

Design is a research activity because it involves use of empirical data and scientific techniques and methods for performing relationship mapping of components that form an artifact (AIS, 2007). The process and techniques of acquiring and processing empirical data is an act of research. Thus "… design is embodied in research and research is embodied in design" (Wang & Hannafin, 2005, p.13). Innovative artifact designs are usually a product of research. Research is "an activity that contributes to an understanding of a phenomenon" (AIS, 2007, p.2). Hence Design Research is a good approach for performing research in the design science fields such as the information systems field.

Design Research is variously defined depending on the field of research where it is being used. In information systems research, "Design Research involves the analysis of the use and performance of designed artifacts to understand, explain and very frequently to improve on the behavior of aspects of information systems" (AIS, 2007, p.1). Relating AIS's definition to this study, the artifacts could include, among others, algorithms for learning objects searching, retrieval, deployment and utilization, learning objects caching, learning objects model, learning management system interfaces, learning objects design methodologies and m-learning learner and technology profiling. In education research, Design Research is sometimes referred to as Design Experiments or Design-based Research and in other field it is named Development Research, Developmental Research or Formative Research (Wang & Hannafin, 2005). In educational research, Design-based Research has been defined as:

> … a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories.
>
> (Wang & Hannafin, 2005, p.6)

The common thread in all the nomenclatures and definitions of Design Research is that it is a research paradigm which emphasizes research, design and practice. It also emphasizes iterations in artifact design and development. In Wang and Hannafin (2005, p.6), the artifacts produced from design research can be "contextually-sensitive design principles and theories". This fits in well with the main output of this research, which is, the *MoLODUF* or guidelines for creating m-learning objects applications. The *MoLODUF* is the key artifact from this study.

Design Research is pragmatic, grounded, interactive, iterative, flexible, integrative and contextual (Wang & Hannafin, 2005). Design Research is pragmatic because Design Researchers address practical issues. Practical issues tend to be dynamic hence the need for pragmatism in Design Research. Design Research is grounded because the development of any artifact must be informed by existing theories. Design Researchers have to review literature and examine existing design scenarios to establish underpinning theories and practices. Design Research is interactive because Design Researchers and research participants engage each other in collaboration at all stages of an artifact development. Iterations in Design Research are part of an artifact design or improvement process. Iterations arise from the need to improve existing artifacts informed by the continuous review of existing artifacts. This calls for flexibility in Design Research to allow for the continuous improvements in an artifact. Design Research is integrative because it borrows from the traditional qualitative and quantitative methods of data collection such as survey, expert review, formative evaluation, case study, interview, observation and literature review. This methods integration grounds Design Research firmly as a research paradigm. Design research is contextual because its results ought to be consistent with the context in which the research was conducted (ibid). As such, contextual issues have to be known in advance before commencing the design.

The place of Design Research paradigm in the socially constructed realities can be understood by looking at its ontological, epistemological, and axiological stances. Ontology and epistemology of an artifact relate to the existence (real or unreal) of that artifact and the knowledge held about that artifact respectively, while axiology relates to the values attached to the artifact (AIS, 2007). Through ontological and epistemological studies of an artifact, the researcher becomes aware of that artifact. However, communities of researchers have different ways of knowing about a given object. Epistemologically, Design Research stresses that knowledge is acquired through engaging oneself in making something, say an artifact. Also, more knowledge is acquired by improving on the design of an existing and functioning artifact. For instance, "… an aircraft flew decades before a full understanding of how such flight was accomplished" (AIS, 2007, p.7). Thus Design Research

cherishes continuous improvements in artifacts by permitting iterations in design which lead to revelations in meaning and reality of an artifact (ontology of an artifact).

Axiologically, values attached to an artifact are of a community of practice creation. The value attached to Design Research stems from a shared community belief (AIS, 2007). In other words, we believe in what we believe in because the community around us believes so. Information systems researchers believe in multi-paradigmatic approaches to information system research. In order to produce quality information systems research, information systems researchers are mixing traditional information systems research paradigm (quantitative and qualitative) with the recently evolved Design Research paradigm (Wang & Hannafin, 2005).

In Design Research, the behavior of an artifact is a function of the interactions of the components that make that artifact (AIS, 2007). The artifact's components interact with each other in a dynamic way. Therefore, artifacts designed using Design Research approach can assume "multiple world-states" (AIS, 2007, p.11). As earlier noted, this is evidence of pragmatism in Design Research (Wang & Hannafin, 2005). Since Design Research depends on improving exiting and functioning artifacts, its epistemology is closer to that of natural science than that of either positivist or interpretivist research (AIS, 2007). However, quantitative and qualitative methods are employed in Design Research to collect context data before artifact design.

3.2.1 Justifying the Design Research Approach

In addition to the fact that Design Research combines research, design, and practice, the characteristics of Design Research summarized below engrain it as the best research design approach for the study. Design Research:

- Focuses on broad-based, complex problems critical to higher education
- Integrates known and hypothetical design principles with technological affordances to render plausible solutions to the complex problems
- Requires rigorous and reflective inquiry to test and refine innovative learning environments as well as to reveal new design principles
- Takes long-term engagement involving continual refinement of protocols and questions
- Involves intensive collaboration among researchers and practitioners
- Has a commitment to theory construction and explanation while solving real-world problems.

Reeves *et al*. (2005, p.103)

These characteristics bring out Design Research as a research methodology of choice for instructional system related research. The characteristics compare well with the research requirements in this study. The study involves harmonizing complexities arising from device limitations (m-learning devices), m-

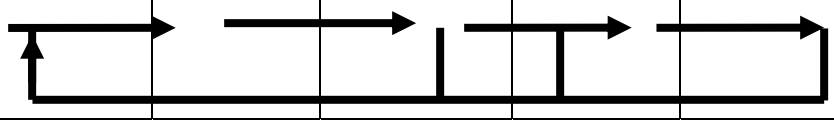
learning cost, learning processes, m-learning objects, m-learning resources, m-learning network conditions, m-learning policies, m-learning evaluation, m-learning interfaces, and the m-learning user. It involves collecting information related to the context of the m-learner and current practices and prospects for the development and growth of m-learning. Thus it involves collaboration with key stakeholders. It involves adapting contemporary learning theories, which is an indication of commitment to using theory in solving the problem of access to and utilisation of m-learning objects in an anytime, anyplace manner. This firmly grounds Design Research as a research approach for this study.

3.2.2 Design Research Process Steps

According to AIS (2007), Design Research methodology has five iterative process steps, namely: 1) *Awareness of the problem, Suggestion, Development, Evaluation,* and *Conclusion* process steps. The Design Research (AIS, 2007; Edelson, 2002; Reeves *et al.* 2005) process steps compare well with those of Design Science (Hevner *et al*., 2004) and Design-based Research (Design-based collectives, 2003; Wang & Hannafin, 2005) process steps. *Table 3.2* below compares the process steps of Design Research, Design Science and Design-based Research methodologies.

Table 3.2: Process Steps of Three Comparable Design Research Methodologies

Methodology	**Process Steps**				
Design Research (AIS, 2007; Edelson, 2002; Reeves *et al.* 2005)	Awareness of the Problem	Suggestion	Development	Evaluation	Conclusion
Design Science (Hevner *et al*., 2004)	Problem Relevancy, Research Rigor	Design as a search process	Design as an artifact	Design Evaluation	Research Contribution, Research Communication
Design-based Research (Design-based collectives, 2003; Wang & Hannafin, 2005)	Analysis	Design	Develop't, Implementatn	Evaluation	Conclusion



Iterations

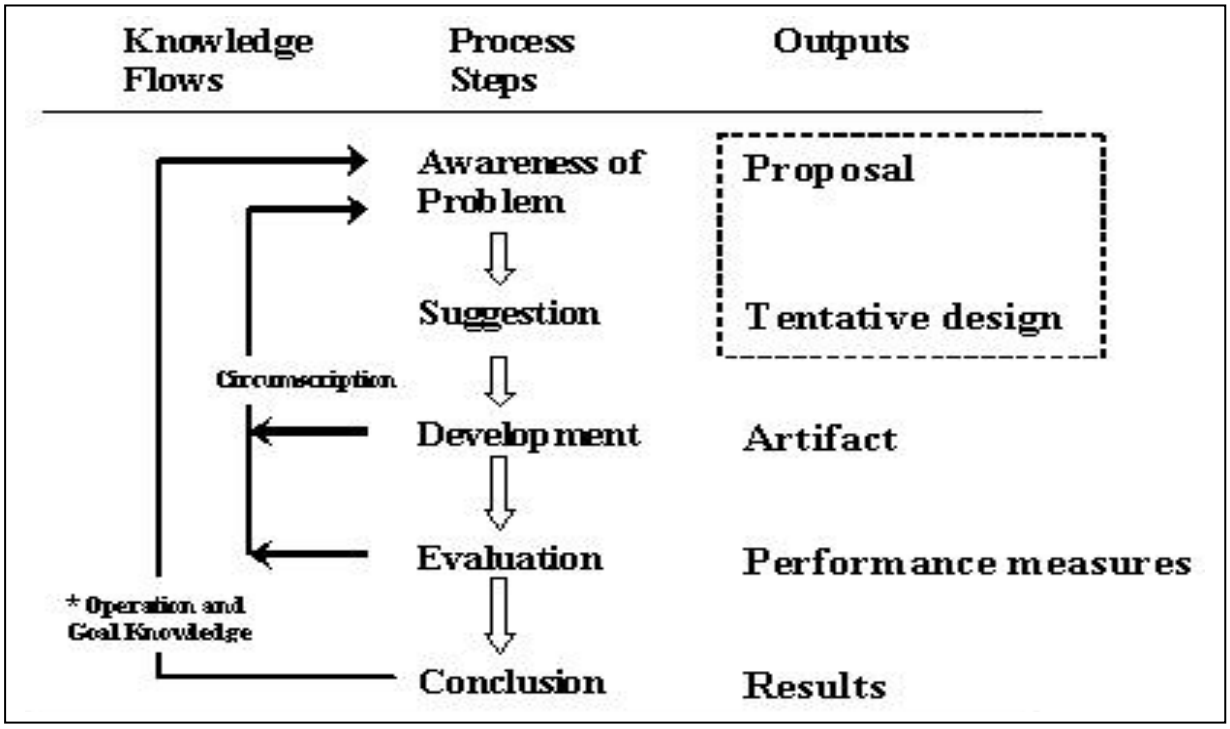
As can be seen in *Table 3.2* above, the process steps for the Design Research, Design Science and Design-based Research are in all ways similar. They involve understanding the problem at stake through rigorous research, designing a solution to the problem, developing an artifact for the

solution suggested, evaluating the developed artifact and generating and communicating new knowledge in the conclusion.

There are many excellent descriptions (and diagrams) of the process of Design Research in information systems such as those in AIS (2007), Hevner, *et al*. (2004), Reeves *et al*. (2005), Wang and Hannafin (2005), and many others. Whereas we were at liberty to adopt any of these descriptions (diagrams), this being an information systems research, we adopted the Association of Information Systems' (AIS) Design Research descriptions (diagram) shown in *Figure 3.1* below and described in *Sections 3.2.2 (i)* through to *Section 3.2.2 (v)* below. We also justify the use of AIS's Design Research diagram because its designs generate three types of theories, namely: domain theories, design frameworks and design methodologies (AIS, 2007). The *MoLODUF* is a design framework or design methodology for m-learning objects applications.

Then in *Section 3.3* below we show how the Design Research methodology was used to execute this study.

Figure 3.1: The Design Research Methodology



Source: AIS (2007, p.13)

i Awareness of the Problem Process Step

All design studies begin with understanding the problem at stake. In the Design Research

methodology this process step is termed *Awareness of the Problem* process step (AIS, 2007). In Wang and Hannafin (2005), it is equivalent to the *Analysis* process step while in Design Science (Hevner et al. 2004); it is equivalent to the *Problem Relevancy* process step. By understanding the problem at stake, a suitable artifact can be designed or existing artifacts can be improved upon to solve the problem appropriately. By appropriately being able to solve a problem, Design Research lends itself well as a problem - solving/performance-improving methodology. The *Awareness of the Problem* process step facilitates the creation of a knowledge or theory base for proposing new or improved artifacts. Hence the output of this process step is a proposal of a problem knowledge based.

The knowledge arising from the *Awareness of the Problem* process step is usually acquired using multiple methods. "In many ways, [Design Research] is intrinsically linked to, and its development nourished by, multiple design and research methodologies" (Wang & Hannafin, 2005, p.6). Alternatively, Design Research can acquire knowledge about a problem in question from results of an evaluation of existing artifacts (AIS, 2007). Design Research employs qualitative and quantitative methods to collect and analyse empirical data so as to demystify the problem at stake (AIS, 2007; Wang & Hannafin, 2005). It for this reason that *Research Rigor* is emphasized at this process step (AIS, 2007; Hevner *et al*. 2004, Wang & Hannifin, 2005; Reeves *et al*. 2005). Hence the methods of data collection in this process step may include: literature review, surveys, interviews and direct observations.

Literature review is a well organized discussion of published research and/or scholarship relevant to an area of study (Goddard & Melville, 2001). A literature review provides the basis and the context for the research to be undertaken. It puts forward an argument for the research one intends to do and points the reader towards ones research. Literature review is a continuous activity in the research process because it informs a number of aspects in the research. However, in addition to informing the study at all stages, *Chapter Two* of this study provides a dedicated discourse of literature on variables related to m-learning.

Another method of data collection for the *Awareness of the Problem* process step is the survey. A survey refers to "any activity which is undertaken for express purpose of gathering information about a particular population in order to draw reliable conclusions about that population" (Calder, 1998, p.638). A survey is a positivistic or quantitative data collection method. Surveys ask standard sets of questions to a representative sample of the population. Surveys are flexible because they can be sent through the post mail or electronically or can be

physically distributed by the researcher. Surveys collect data from sparsely distributed respondents with the view of providing descriptive and/or explanatory statistics. Surveys can be self-administered or can be carried out by an interviewer who notes down the respondent's answers on a form. They can answer questions from both the measurement and understanding perspectives. Survey responses are usually drawn from a sample of a survey population (ibid).

In addition to literature review and survey, interviews provide a good source of information in the *Awareness of the Problem* process step. An interview is "a one-on-one verbal interaction between the researcher and a respondent" (Goddard & Melville, 2001, p.49). Interviews provide data that can be compared and contrasted (triangulated) with that obtained from the literature review and survey. Interviews are important for soliciting for information from key informants in the study. Interviews are an interpretivist or qualitative method of data collection.

To establish the validity and reliability of data collected in other data collection methods and also to be able to study the "actions and behaviors of people and organizations", direct observation method is employed (Robson, 2002, p.309). Observation involves the researcher being in the user area and taking note of different aspects being done. At one extreme, observation can be conducted formally like a work study exercise, and at the other extreme it can be a casual observation during visits of interviews. The most usual form is where the researcher agrees with users to spend a day or more in the user department, perhaps inspecting records and conducting interviews as well as making general observation. Direct observation of an activity is time consuming and difficult. Badly conducted observation can be extremely disruptive and can cause conflict. Observation is seldom used as the sole method of data collection but is an important data collection method for understanding the operations of an organization or information system.

ii Suggestion Process Step

Using quantitative and qualitative data collected in the *Awareness of the Problem* process step, new or improved artifacts are abductively suggested or proposed in the *Suggestion* process step (AIS, 2007). This process step employs abductive reasoning to produce a tentative design of an artifact. The *Suggestion* process step in Design Research is inline with the *Design* process step in Design-based Research methodology (Wang & Hannafin, 2005) and *Design as a Search Process* step in Design Science methodology (Hevner *et al,*. 2004). The *Suggestion* process step is iterative because the researcher has to come out with the best artifact that he/she repeatedly

improves using the requirements identified in the *Awareness of the Problem* process step. The output of the *Suggestion* process step is a tentative design of an artifact. The *Suggestion* step is a key stage in Design Research because it is here where creativity and innovation in artifact functionality are coined "based on a novel configuration of either existing or new and existing elements" (AIS, 2007, p.14). This stage is however criticized for not being repeatable due to inability to repeat a human being's cognitive innovation and creativity. This criticism is not fair because even positivists and interpretivist research methods and techniques embody a certain degree of creativity (ibid). This is also true in Evans and Gruba (2004) who assert that research involves rational and creative thinking.

iii Development Process Step

When a rightful solution is agreed upon, the artifact in the suggested solution is implemented in the *Development* process step (AIS, 2007). This process step employs deductive reasoning to produce an artifact. This step is synonymous with *Development* and *Implementation* process steps in Design-based Research methodology (Wang & Hannafin, 2005) and Design *as an Artifact* process step in Design Science methodology (Hevner *et al*., 2004). "The techniques for implementation will of course vary depending on the artifact to be constructed. An algorithm may require construction of a formal proof" (AIS, 2007, p.14). An expert system embodying novel assumptions about human cognition in an area of interest will require software development, probably using a high-level package or tool. The implementation itself can be very pedestrian and need not involve novelty beyond the state-of-practice for the given artifact; the novelty is primarily in the design, not the construction of the artifact. (ibid)

iv Evaluation Process Step

All Design-based Research methodologies include the evaluation process step. Once constructed, the artifact is evaluated according to criteria that are always implicit and frequently made explicit in the proposal (*Awareness of Problem* process step) (AIS, 2007, p.14). Deviations from expectations, both quantitative and qualitative are carefully noted and must be tentatively explained. That is, the evaluation phase contains an analytic sub-phase in which hypotheses are made about the behavior of the artifact. This phase exposes an epistemic fluidity that is in stark contrast to a strict interpretation of the positivist stance. At an equivalent point in positivist research, analysis either confirms or contradicts a hypothesis. Essentially, save for some

consideration of future work as may be indicated by experimental results, the research effort is over. For the design researcher, by contrast, things are just getting interesting! Rarely, in design research, are initial hypothesis concerning behavior completely borne out. Instead, the evaluation phase results and additional information gained in the construction and running of the artifact are brought together and fed back to another round of Suggestion (refer to the circumscription arrows of *Figure 3.1* above). The explanatory hypotheses, which are quite broad, are rarely discarded, but rather are modified to be in accord with the new observations. This suggests a new design, frequently preceded by new library research in directions suggested by deviations from theoretical performance. (ibid)

Development, *Evaluation* and further *Suggestion* are frequently iteratively performed in the course of the research (design) effort. The basis of the iteration, the flow from partial completion of the cycle back to *Awareness of the Problem,* is indicated by the *Circumscription* arrow in *Figure 3.1 above*. The *Circumscription* process is especially important to understanding Design Research because it generates understanding that could only be gained from the specific act of construction. Circumscription is a formal logical method that assumes that every fragment of knowledge is valid only in certain situations (AIS, 2007).

v Conclusion Process Step

The *Conclusion* step indicates termination of a specific design project. The *Conclusion* process steps give rise to new knowledge production as is indicated in *Figure 3.1* above by the arrows labeled *Operation and Goal Knowledge*. This arrow indicates that the knowledge attained from the design process is useful for understanding other problems in society. It is in this process step that Design Research will generate new research problems. (AIS, 2007)

3.3 Using Design Research Methodology to Execute this Study

The five Design Research process steps shown in *Figure 3.1* above were executed in four phases. In *Phase 1 (Section 3.3.1)* we show how we executed the *Awareness of the Problem* process step. In *Phase 2* (*Section 3.3.2*), we show how we abductively and *deductively Suggested* and *Developed* the m-learning object deployment and utilization framework (*MoLODUF*) from the findings of *Phase 1*. In *Phase 3* (*Section 3.3.3*) we used the *Evaluation* process steps to validate the *MoLODUF*. We then use *Phase 4* (*Section 3.3.4*) to make concluding remarks to the study and future research areas.

3.3.1 Phase 1: Awareness of the M-Learning Objects Deployment and Utilisation Problem

The aim of this research was to develop a framework for instantiating applications that can enable learners in developing countries obtain access to and use learning objects, delivered over the Internet/other networking technologies, regardless of their proximity to higher education institutions through the use of mobile phones. This aim was achieved by first understanding the problem at stake from the learners' and other stakeholders' points of views. Therefore in *Phase 1*, we executed the *Awareness of the Problem* process step of the Design Research methodology. In this *Phase* we sought to establish the context of learners and the current practices and prospects for the development and growth of m-learning in Africa. By so doing, we provided answers to all the research questions stated in *Section 1.6* above. The answers to the research questions provided requirements/constructs for understanding the dimensions and sub-dimensions of the problem of deploying and utilising learning objects on mobile phones.

Since Design Research is multi-paradigmatic in nature (Wang & Hannafin, 2005), the data for *Phase 1* was collected using qualitative and quantitative methods. The methods combined a review of m-learning literature, survey of learners in Uganda for m-learning, interviews with key perceived e- and m-learning stakeholders in Africa and observations of the operations of the distance learning unit at Makerere University. In *Section 3.3.1 (i)* through to *Section 3.3.1 (ii)* we show how each of these methods were used to collect data in the *Awareness of the Problem* process step.

i Review of M-Learning Literature

This was a continuous activity in the research process because it informed a number of aspects in all Chapters of this dissertation. "A full literature study is a far more comprehensive study which is part of the research process itself rather than part of the preparation for research" (Goddard & Melville, 2001, p.19). However, the structure of a PhD dissertation at Makerere University dictates that a dedicated Chapter on *Literature Review* be written. Consequently, *Chapter Two* of this dissertation is wholly dedicated to a review of literature on major variables in this research. The variables include: m-learning, e-learning, m-learning devices, mobile phone proliferation, mobile networking technologies, m-learning possibilities and benefits and m-learning case studies. Others are: challenges and limitations to m-learning, contemporary learning theories; learning objects; learning objects repositories, m-learning objects and m-learning objects models and frameworks. Electronic and paper based textbooks, book chapters, journal articles, newspapers, reports and conference papers formed the literature sources.

ii Survey of Learners in Uganda for M-Learning

A survey was conducted among undergraduate students at Makerere University to determine the state of m-learning in Uganda. An assumption was made that undergraduate learners at Makerere University were representative of learners from other developing countries especially of Africa. Nonetheless, data obtained from these learners was supplemented with that obtained from published literature, interviews and observations to provide a holistic state of m-learning practice in Africa. Survey activities involved: identifying the target survey population, determining the sample size, selecting the survey participants from the population, designing the survey, piloting the survey, determining the survey reliability, conducting the survey and analyzing the survey data.

a. Survey Population

A population is a group of all possible objects of investigation in a given domain (Calder, 1998). These objects form the survey population. The survey population was undergraduate distance learning and fulltime students in developing countries of Africa. Distance learning students were considered on the account that it is them who benefit most from the increased efficiency and flexibility brought about by m-learning through synchronous and asynchronous collaboration (Goh & Kinshuk, 2006; Traxler, 2007). Also a blend of mobile telephony with distance learning is providing a future for distance learning (Brown, 2005; Trifonova & Ronchetti, 2006). It therefore follows that distance learners are expected to be the immediate and major beneficiaries of any m-learning solutions or systems. Fulltime students hereafter in this dissertation referred to as 'Internal' students were also considered because m-learning could as well be used to augment their classroom learning experiences. Learners were considered to be the direct beneficiaries of the *MoLODUF* and therefore drawing the framework requirements from them would create a framework that meets their m-learning needs. As Williams (2002) put it, drawing an information system's requirements from its immediate users breeds acceptability and ownership of such a system.

b. Sample Size

The survey participants are hereafter in this dissertation referred to as learners or students. Usually, because of time and financial resource constraints, a census of all elements in the population is not possible (Calder, 1998). Instead a representative sample of the population is selected using sample selection methods. A sample is a collection of representative research objects drawn from a population (Calder, 1998). The sample size must be big enough and properly constituted to represent

all the characteristics of the population.

The sample size (n) was determined using Calder's (1998) sample size determination formula.

$$n = \frac{(desired\ confidence\ level)^2 * (s\tan dard\ deviation)^2}{(desired\ level\ of\ precision)^2}$$

According to Calder (1998), the standard deviation to be used in his sample size determination formula should be assumed from a standard deviation earlier on calculated on some variable in a related previous study involving the target survey population. Using this assumption, we adopted a standard deviation derived from an evaluation study of the Mobile Research Supervision Initiative (MRSI) at the Department Distance Education, Makerere University. The MRSI was an initiative for using mobile phones to enhance synchronous and asynchronous collaboration between undergraduate research students and their supervisors. MRSI was evaluated as one of the preliminary studies of this PhD research. Results of the evaluation indicated that a standard deviation of four (4) months was computed on the variable that asked students, who collaborated on mobile phones, to provide the duration they took to complete their field research project paper. Since the evaluation of MRSI was a preliminary study to this work and since it involved distance learners who constituted part of the survey population of this study, we used Calder's assumption and assumed a standard deviation of four (4) in the sample determination formula. Then we chose a confidence level of 95% ($P<0.05$) to yield a value of 1.96 in normally distributed data. The desired precision level was set to 0.5. Therefore at a confidence level of 95% ($P<0.05$) and desired level of precision of 0.5,

$$\text{Sample Size (n)} = (1.96 * 4)^2 / (0.5)^2 = 245.86 = 246.$$

The desired minimum sample size was 246. However, surveys have been associated with high non response rates. Survey response rate is estimated at 20% (Burgess, 2001). Therefore, in order to achieve the 20% response rate and be able to achieve the desired minimum sample size of 246, the survey questionnaires were distributed to a sample five times the required minimum size. Thus the questionnaires were distributed to 1230 respondents. At the end of the survey exercise, 446 fully filled in questionnaires were returned, representing a response rate of 36%. This was above the 20% response rate that Burgess (2001) estimated and well above the 246 minimum responses anticipated in Calder's (1998) sample size determination formula.

c. Participant Selection Method

After determining the maximum desired sample size, we then selected the 1230 respondents. Whereas the survey population was undergraduate students in developing countries of Africa, it was not possible to have a representative sample from all universities in developing countries of Africa. Rather, the sample was entirely drawn from undergraduate students at Makerere University in Uganda. It was assumed that Makerere University undergraduate students could feature most of the characteristics reminiscent in dual mode universities in developing countries of Africa. Dual mode universities are those which run both distance and internal programmes of study (Aguti & Fraser, 2006). Further, 97% of distance learners at Makerere University owned mobile phones (Kajumbula, 2006). The assumption was that Makerere University could provide an m-learning context similar to that which could be found in other developing countries of Africa. Further, results in the survey were supplemented with results from in-depth interviews (see *Section 3.3.1*) held with m-learning stakeholders drawn purposively from across Africa.

The 1230 possible respondents were selected using multi-stage sampling method involving cluster sampling at stage one and stratified random sampling at stage two. The population was clustered along the mode of study characteristics. Distance education students formed cluster one while internal students formed cluster two. A cluster is a group of elements that can be identified by a common characteristic (Calder, 1998). Stratified random sampling involves the division of a survey population into different homogeneous groups (strata) from which a sample can be picked using simple random sampling (Calder, 1998). Each of the two clusters were stratified by year of study, that is, year one, year two and year three. The year of study stratification assumed that learning needs, preferences, styles, habits and cultures of each learner were likely to change from one year of study to another. Also it was assumed that as a learner advances from year one through to year three, he/she faces varied exposures to m- and e-learning.

In the year of conducting this research (2008), the population of undergraduate students at Makerere University was 30,000. Of these 6,000 (20%) were distance learners and 24,000 (80%) were internal students. The sample of 1230 students was therefore distributed along the 20% and 80% proportions. This implied that 246 respondents had to be drawn from distance learners and 984 from internal learners.

The sampling frame was obtained from the Academic Registrar's Office. Permission was sought from the Academic Registrar's Office, to generate lists of year one, two and three distance and internal students' names, addresses, telephone and e-mail contacts using the Academic Records

Information System (ARIS). Using simple random sampling, 82 distance learners and 328 internal students were drawn from each year of study in order to achieve 246 and 984 distance and internal students respectively. The chosen respondents were then issued with the self administered survey/questionnaire (*Appendix A*).

d. Survey/Questionnaire Design

Under the survey method, the questionnaire is the most common research tool (McEvoy & Richards, 2006; Calder, 1998). This study employed a semi-structured, self-administered questionnaire to capture data. The survey consisted of open and close ended questions (*Appendix A*).

Open ended questions were of the 'fill-in' type aimed at soliciting respondents' own opinions and suggestions about topical issues in m-learning. Open ended questions were used when all possible answers to the question were not known.

In close ended questions, responses to questions were pre-specified. Close ended questions took any of the following forms: option questions - where respondents were required to either give one response or multiple responses, boolean questions - where respondents were required to either answer Yes/True or No/False, and rated/scaled questions - where respondents were required to rate responses according to a likert scale.

Five point likert scale questions permitted 'neutral' or 'no opinion' or 'not sure' options while four point scale likert scales did not. In five point likert scale questions, the options were: 'strongly disagree', 'disagree', 'not sure', 'agree' and 'strongly agree'. In four point likert scale questions, the options were: 'strongly disagree', 'disagree', 'agree' and 'strongly agree'. Four point likert scale questions were preferred to five point likert scale questions. According to Calder (1998), a five point likert scale question usually has 'not sure', 'neutral' or 'no opinion' option which oftentimes attracts the attention of 'lazy' respondents. When respondents circle more of the 'not sure' or 'no opinion' or 'neutral' options, the data arising from such a survey may not mean much (ibid). Therefore in questions intended to enlist respondents' views, opinions, knowledge, attitudes and feelings, we mainly employed four point likert scale questions. Five point likert scale questions were only used in a section for m-learning institutional issues because the questions therein were probing very recent developments in m-learning. The pilot revealed that some respondents did not genuinely have responses to this particular section.

The questionnaire collected data on m-learning activities, m-learning devices and technologies, m-learning resources/objects, m-learning institutional issues and m-learning environmental issues.

e. *Piloting the Survey/Questionnaire*

The survey was piloted among a few learners at Makerere University, before developing the final survey tool for collecting data. Piloting is necessary to ensure that questions to be asked are significant and not redundant (Calder, 1998). Pilot data was used to refine the survey. Piloting can help to "detect any flaws in your questioning and correct these prior to the main survey" (Burgess, 2001, p.15). Through piloting, some of the open ended questions received categories of responses that enabled the question to be converted to close ended questions. The pilot also enabled "trial [data] analysis" (Burgess, 2001, p.15). Piloting also enabled the reliability of questions in the survey to be measured.

f. *Survey Questions Reliability Test*

One of the purposes of undertaking the pilot was to determine the reliability of the questions (variables) in the survey. Reliability and validity tests ensure that questions in a research instrument are replicable and measure what they are intended to measure (Golafshani, 2003). They ensure that the research instrument can be used again to derive similar results with the same level of accuracy.

Pilot data was entered into SPSS data analysis tool and Cronbach's alpha (Cronbach, 1951) generated for different sets of latent constructs. Questions found to be reliable ($\alpha > 0.7$) were retained and those that were not reliable ($\alpha \leq 0.7$) were dropped. Thus *Appendix A* consists of questions whose Cronbach's alpha was greater than 0.7. Cronbach's alpha test was used to test the reliability of *MoLODUF* major dimensions. Ordinarily, Cronbach's alpha is calculated using the formula;

$$Cronbach's\ alpha\ (\alpha) = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N} \sigma_{Yi}^{2}}{\sigma_{X}^{2}}\right)$$

Where

N is the number of latent variables,

σ_X^2 is the variance of the observed total test scores,

$\sigma_{Y_i}^2$ is the variance of component i

(Cronbach, 1951)

Cronbach's alpha test is used to determine the reliability of latent variables in measuring latent constructs (Cronbach, 1951). Latent constructs are variables that are independently impossible to measure but can be measured by a series of questions (latent variables) (Burgess, 2001). Latent constructs are multi-dimensional in nature while latent variables are one-dimensional (Cronbach, 1951). One-dimensional variables (latent variables) can independently be measured and so effort must be made to have only one-dimensional questions in the questionnaire. The goal in Cronbach's alpha test is to weed out from the questionnaire multi-dimensional variables and include a set of one-dimensional variables that can be used to measure them. As an example, the variable 'digital learning style' was found to be multi-dimensional and could be measured by a group of one dimensional variables including: 'preference for multi-tasking', 'preference for softcopy documents', 'preference for independent learning', 'preference for learning by doing', preference for group learning, preference for reflective learning activities, just to mention but a few.

g. Conducting the Survey

For the purpose of distributing the questionnaire, a list of the 1230 respondents having two columns headed with respondent's name and address was created. The addresses for internal students were their halls of residence and room numbers while for distance learners, it was their postal addresses. For ethical considerations, the respondents were not required to indicate their names on the questionnaire. Further, the list of respondents was deleted and trashed from the computer and hardcopies threaded immediately after distributing the questionnaires to the 1230 respondents.

Each questionnaire had a cover letter explaining the purpose of the survey, treatment of the data being collected and general instructions on how to complete and return the questionnaire. Each questionnaire had a physical and postal return address. The respondents either physically returned the questionnaire to a designated point or mailed it to the postal address given on the cover letter. In addition to the questionnaire, each of the 1230 respondents was given a pre-paid addressed return postage envelop. Respondents used this envelop to post back or return the filled in questionnaire.

h. Analysis

After returning the questionnaire, the data was processed in preparation for analysis. Data were edited by checking the responses in each questionnaire, to ensure that there were no inconsistencies and inaccuracies. An example of an inconsistency could be where a respondent provided answers to questions that he/she was supposed to skip due to a conditional branch on a

given question. In such a case, the responses therein were replaced with a 'not applicable' response and coded appropriately. 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.

Unstructured (open ended) responses were categorized into mutually exclusive groups and coded. Care was taken while grouping open ended responses so as to avoid loss of richness to the data. Categories derived were coded as 1, 2, … n, where n was the number of the last category. Close ended questions integrated the codes within the provided option. In so doing, the survey was inadvertently coded as the respondent ticked or circled away on preferred option(s). Yes/No (True/False) type questions were coded as 1/0 respectively. Four (4) likert scale rated questions were coded as 'strongly disagree' = 1 to 'strongly agree' = 4, while five (5) likert scale items were coded as 'strongly disagree' = 1 to 'strongly agree' = 5. Single response questions were coded as 1, 2…., n where n was the number of the last option. Multiple responses questions had each response represented as a variable and coded with a Boolean code. In this case 1 represented choice of the option while 0 represented non choice of the option. A variable with a missing entry or no response was coded as 8, while that which was not applicable to a given respondent was coded as 9.

The software EPIINFO® was used to create an electronic copy of the questionnaire to capture the paper based responses. EPIINFO® was preferred to other data capture tools because it permits conditional branching during data entry. Conditional branching restricts making entries into 'not applicable' variables. The data captured in EPIINFO® was exported into SPSS® for data analysis.

Descriptive and inferential statistics were generated. Descriptive statistics permitted basic features in the data set to be described. Inferential statistics provided a basis for making analytical inferences from the data. These statistics were a basis for drawing requirements for the development of the *MoLODUF*.

iii Interviews with Key E- and M-Learning Stakeholders

Interviews with key e- and m-learning stakeholders in Africa were conducted to supplement results from the survey of learners at Makerere University, Uganda and literature review. An interview is "a one-on-one verbal interaction between the researcher and a respondent" (Goddard & Melville, 2001, p.49). The interviews which were unstructured, enlisted views, opinions, attitudes and experiences

of stakeholders on m-learning. The interviewing process involved determining interview participants, formulating interview guides, administering the interviews, determining the validity and reliability of interview data and analyzing it.

a. Interview Participants and Selection Method

To obtain a truly African perspective of m-learning, quantitative and qualitative data from survey participants was triangulated with qualitative data from key e- and m-learning stakeholders (interviewees) who were purposively drawn from five regions of Africa, namely: West, Central, North, East and South Africa. From West Africa, Ghana and Nigeria provided 7 interviewees. From Central Africa, 2 interviewees were drawn from Congo Brazzaville. From North Africa, Ethiopia provided 2 interviewees. From East Africa, Kenya and Uganda provided 8 interviewees. From Southern Africa, 7 interviewees came from Lesotho, South Africa, Zambia and Zimbabwe. Interviewees from West, Central, North and South Africa were interviewed at various academic forums, including at the E-Learning Africa 2008 Conference in Accra Ghana, E/Merge 2008 Online Conference, ANSTI/UNESCO e-Content Development Workshop at the University of Nairobi in Kenya and UNU-IIST 1st School on Software Engineering and Formal Methods at University of Cape Town in South Africa. The key e- and m-learning stakeholders included: mobile telecommunications service providers (2 No.), e-learning providers, university administrative and academic staff (12 No.) and instructional designers and content and software developers (12 No.).

b. Interview Guides

There were three interview guides: one for mobile telecommunications service providers (*Appendix B*), second for e-learning providers, university administrative and academic staff (*Appendix C*) and third for instructional designers, content and software developers (*Appendix D)*. Since the interviews were unstructured, the interview guides consisted of only open ended questions. The questions in the interview guide were paused as they were or were re-worded or further explained or new ones were added or even removed depending on the interview circumstances.

c. Administering the Interview

Prior to an interview, contact was established with the interviewee in order to: i) explain the purpose of the research to him/her; ii) seek for permission to have him/her interviewed, and iii) seek for an interview appointment date and time. A cover letter containing the three issues, together with the

interview guide, was sent to the interviewee in advance to enable them prepare. At interview time, interviewee's permission was sought to have the interview recorded. Each interviewee was informed that a summary of key points in the interview would be made and sent to them for verification and clarification before being used in this research. Indeed this was done. For ethical reasons, before the interview transcripts were used, all interviewee contacts were erased and replaced with their designations such as: 'e-learning expert', 'content developer', 'distance education administrator', 'interviewee at E/merge', and so on.

d. Interview Data Reliability and Validity

The meaning of reliability and validity in the qualitative research paradigm differs from that in the quantitative research paradigm. In the quantitative research paradigm, it is all about replicability, repeatability and accuracy of the questions in the research instrument while in the qualitative research paradigm; it is all about precision, credibility and transferability of the data arising from the questions in the qualitative research instrument (Golafshani, 2003). Qualitative research is interpretivist in nature while quantitative research is positivist. In quantitative research the reliability and validity of data collected depends on the research instrument while in qualitative research it depends on the researcher because he/she is the research instrument (ibid).

Following Golafshani's (2003) epistemology for ensuring qualitative data reliability and validity, we subjected the interview transcripts to credibility, precision and transferability tests. How? As experts in the field of information systems and m-learning, supervisors of this dissertation were given the interview transcripts to read through and ensure credibility and precision in them. The researcher also, triangulated data collection methods. Triangulation entailed comparison of qualitative results with related literature and results from the survey and observation. Triangulation ensures "… trustworthiness, rigor and quality in [the] qualitative paradigm" (Golafshani, 2003, p.604). Thus triangulation ensured that reliability and validity of interview data was maximized.

e. Interview Data Processing, Coding and Analysis

The unstructured interviews in this research yielded qualitative data. For any data (quantitative or qualitative) to be of any value it has to be analyzed. Qualitative data analysis involves "noticing, collecting and thinking about interesting things" (Seidel, 1998, p.1). *Noticing interesting things* involves gathering the data and identifying useful things in it. *Collecting interesting things* involves sorting and sifting the identified useful things. *Thinking about interesting things* involves making

meaning out of the c*ollected interesting things* (ibid).

Each transcribed interview was read word by word in order to notice useful things from it. The useful things were either a word or a phrase with thematic meaning. Each new identified theme was assigned a short code. Though short, the code had to be descriptive enough to represent the theme. Each new code was added to a list of codes in a master list (*Appendix E*). The master list of codes provided a repository of codes to be reused for coding the next interviewee's transcript. As new emerging themes received new codes, already identified themes discovered in subsequent interviews were coded using the existing codes in the master list. *Table 3.3* below gives sample codes and interview themes/quotations. The process of collecting qualitative data and coding it is what Seidel (1998) called noticing interesting things.

Table 3.3: Sample Qualitative Data Codes and Themes

Sample Codes	Sample Themes/Quotations From Interview Transcripts
MLearningEnabler	A few times we have used mobile phones for simple messages; there has been a big demand for it. When we stopped using the system due to technical and financial problems, students started asking, 'what happened to the message system?' --- Governments are pushing for competition in the mobile telecommunication sector. This is accelerating mobile tele-density among the populace and reducing tariffs.
MLearningDisabler	M-Learning is costly in terms of airtime --- Young girls may be tempted to acquire high end mobile phones and airtime through immoral ways. For young boys they may indulge in criminal activities to get funds to purchase mobile phones and airtime
MLearningAwareness	I am not aware of any unit in my university using m-learning apart from students calling and being called on their mobile phones --- … we are not using it to its full potential although we plan to institutionalize it. At the moment we use it to send learning events reminders to students --- I have just heard of the concept of m-learning in the conference

Source: Interview transcript

In order to sort and sift the *noticed interesting things*, all interview transcripts and codes in the master list were captured in ATLAS, a qualitative data analysis tool. Using the analysis tool, the codes were mapped onto their respective themes in the transcripts. This mapping facilitated what Seidel (1998) called *collecting of interesting things*.

After the mapping process, meaning was induced from the *collected interesting things*. Seidel (1998) termed the meaning inducement process as *thinking about interesting things.* Here summary statistics such as the number of times a given word appeared in the data, number of times a given

code was applied to the data and grouping of instances of themes under each code were generated. Further, patterns and relationships in the themes within a single interview and across interviews were also generated using network diagrams. Network diagrams depict linkages and sequences between themes (Seidel, 1998). Relationships and patterns led to the formation of scenarios and constructs for the development of the *MoLODUF*.

iv Direct Observation of Learning Processes in a Distance Learning Unit

Literature (Brown, 2005; Goh & Kinshuk, 2006; Traxler, 2007; Trifonova & Ronchetti, 2006), shows that the greatest beneficiaries of m-learning are distance learners. It was therefore important to observe the teaching and learning processes at a distance learning unit in Africa. Direct observation was done at the Department of Distance Education in Makerere University in order to get actual scenarios of how distance learners in a developing country context are supported. The researcher spent one semester of 17 weeks at the Department of Distance Education observing and taking note of:

1. How administrators were extending administrative support information/services to learners
2. How the learners were acquiring administrative support information/services
3. How the lecturers were extending academic support to learners
4. How learners were requesting for academic assistance/information
5. How learners were supplementing classroom lectures/course modules with additional reading materials, and
6. The type of mobile phones owned by learners, lecturers and administrators and how they were using them.

The observation made ensured that the *MoLODUF* is line with the operations and behaviors of distance learning stakeholders. The observations also enabled us to deduce the inherent learning processes that were being accomplished.

The findings of *Phase 1* are presented in *Chapter Four*.

3.3.2 Phase 2: Development of the MoLODUF

Phase 2 was underpinned by the *Suggestion* and *Development* process step of the Design Research methodology. *Phase 2* fulfilled two of the objectives, namely:

1. To establish factors that influence learning objects deployment and use on mobile phones
2. To develop a framework for instantiating applications for deploying and utilizing learning objects on mobile phones in different contexts.

In this *Phase*, the results (knowledge base) obtained from the *Awareness of the Problem* process steps (*Phase 1*) were discussed based on the six (6) research questions (see *Section 1.6*), namely:

1. What are the current learner contexts, practices and prospects for the development and growth of m-learning in Africa?
2. What learning processes can be accomplished through m-learning?
3. What kinds of learning objects can be used to service the identified learning processes amidst the cost and kind of constraints placed on mobile technologies?
4. What are the issues and factors to obtain access to and use learning objects in m-learning?
5. What are the major dimensions and sub-dimensions of a mobile learning objects deployment and utilisation framework and how are they related?
6. Where are the similarities and differences with other similar learning frameworks?

From the discussions, we abductively and deductively drew twelve (12) major dimensions that we used to construct the *MoLODUF*. For each of the major dimensions, we also abductively and deductively drew sub-dimensions therein. The processes of drawing dimensions and sub-dimensions also benefitted from existing e- and m-learning frameworks such as those in Ayala and Castillo (2008), Goh and Kinshuk (2006), Khan (2001), Mescan (nd), Motiwalla (2007), Nakabayashi (2007), Quinn (2002), Trifonova and Ronchetti (2006) and Yang (2007).

The *MoLODUF* is constructed in *Chapter Five* and described in details in *Section 5.5.1*.

3.3.3 Phase 3: *MoLODUF* Validation

Phase 3 was underpinned by the *Evaluation* process steps of the Design Research methodology. We used *Phase 3* to validate the *MoLODUF*. This Phase therefore fulfilled the fourth objective of this research which was aimed at validating the framework developed in *Phase 2*. Validation is an evaluation based on the functional specifications implicit or explicit in the suggestion (AIS, 2007).

i Methods and Techniques for M-Learning Evaluation/Validation

There are no systematic and comprehensive methods and instruments for evaluating m-learning because most work in mobile learning is still in the pilot and/ or trial phase due to the infancy of the field (Magal-Royo *et al*., 2007; Traxler, 2007; Traxler & Kukulska-Hulme, 2005). Therefore "… there is need for a more comprehensive, eclectic, and structured approach to [m-learning] evaluation based on sound and transparent principles" (Traxler, 2007, p.8). In Traxler (2007, p.9), sound and transparent principles of 'good' m-learning evaluation have been suggested. The principles dictate that m-learning evaluation should be:

1 Rigorous, meaning roughly that conclusions must be trustworthy and transferable
2 Efficient, in terms of cost, effort, time, or some other resource
3 Ethical, specifically in relation to the nuances of evolving forms of provision, in terms of standards from:
   - legal
   - to normative
4 Proportionate, that is, not more ponderous, onerous, or time-consuming than the learning experience or the delivery and implementation of the learning itself (bearing in mind earlier remarks about the learners' experiences of mobile learning)
5 Appropriate to the specific learning technologies, to the learners, and to the ethos of the learning – ideally built in, not bolted on
6 Consistent with the teaching and learning philosophy and conceptions of teaching and learning of all the participants
7 Authentic, in accessing what learners (and perhaps teachers and other stakeholders) really mean, really feel, and sensitive to the learners' personalities within those media
8 Aligned to the chosen medium and technology of learning
9 Consistent across:
   - different groups or cohorts of learners in order to provide generality
   - time, that is, the evaluation is reliably repeatable
   - whatever varied devices and technologies are used.

Traxler (2007, p.9)

These principles provide a basis for underpinning the development of m-learning evaluation methods/techniques/instruments/tools. The notion that e-learning evaluation guidelines should work for m-learning evaluation, since m-learning is a subset of e-learning, does not hold any grain of truth. "M-learning can only be delivered with an awareness of the special limitations and benefits of mobile devices, so one cannot simply apply known evaluation methodologies from e-learning into the m-learning context" (Parsons *et al*., 2007, p.1). In some cases, traditional evaluation techniques are being combined with innovative ones that address "in situ" m-learning evaluation in real contexts (Magal-Royo *et al.*, 2007, p.37). In other cases, evaluation methods or techniques for m-learning have largely been driven by the aims and objectives of the m-learning environments/artifact being evaluated. This is attested to thus:

> We can make some progress on the basis that mobile learning pilots and trials each have their own aims and objectives, and that these have driven evaluation in the sense of defining the outcomes sought by the evaluation and hence driving the selection and development of the techniques, instruments and protocols used in evaluation. The outcomes we are interested in are broadly 'educational'. A different evaluation mindset may apply to a project that sets out to test only technical stability or to trial a specific interface design without explicitly addressing its impact on an educational activity.
>
> Traxler & Kukulska-Hulme (2005, p.3)

The *MoLODUF* consists of technical and non technical dimensions. It also consists of endogenous and exogenous dimensions. M-learning ethics, m-learning context, m-learning policy, m-learning costs and m-learning resources are exogenous dimensions while m-learning devices, m-learning objects, m-learning interfaces, m-learning objects users, learning processes, m-learning evaluation and m-learning connectivity are endogenous dimensions. A framework consisting of both endogenous and exogenous dimensions is best evaluated using expert evaluation technique (Traxler & Kukulska-Hulme, 2005). Such a framework should be evaluated by eliciting domain experts' opinions and attitudes about its different constituent parts through an expert evaluation (ibid; Hillstone, 2003; Nielsen & Mack, 1994). Hence the domain expert evaluation technique was used to validate the *MoLODUF*. Domain expert evaluation provides one way of testing the usability of an artifact (Laitinen, 2006). In Design Research/Design Science methodology, artifact usability is a must do activity (Hevner *et al*. 2004).

A domain expert evaluation is a descriptive design evaluation method that can be used "…. to build a convincing argument for the artifact's utility" (Hevner *et al*. 2004, p.18). Domain experts' views are elicited mainly using "… questionnaires, interviews and focus groups, supplemented by observation of the [beneficiaries] or analysis of system data" (Traxler & Kukulska-Hulme, 2005, p.6). The questions in the questionnaire, interview or focus groups must be "ideally *built in*, not *bolted on*" the m-learning artifact being evaluated (Traxler & Kukulska-Hulme, 2005, p.2).

ii Instruments/Tools for MoLODUF Evaluation/Validation

Truly "m-learning evaluation [instruments/tools] that are sympathetic to the ethos and technologies of mobile learning … are slow to emerge" (Traxler & Kukulska-Hulme, 2005, p.7). An Internet search for *built in* instruments/tools that could be used with domain experts to particularly evaluate the *MoLODUF* yielded zero results. This state of affairs dictated that a *built in* evaluation instrument/tool underpinned by Traxler's (2007) nine (9) principles for m-learning evaluation be developed from scratch. Such a tool/instrument was developed (see *Appendix F*). The questions in the tool (interview guide) were designed in such a way as to elicit opinions and attitudes about the

dimensions and sub-dimensions of the *MoLODUF* from e- and m-learning experts. For each major and sub-dimension, four point nominal likert scale questions rated as strongly disagree (1), disagree (2), agree (3) and strongly agree (4) were paused to elicit opinions/attitudes from experts on their inclusion in the *MoLODUF*.

iii. Selections of Experts for the MoLODUF Validation

To ensure rigour and repeatability of the validation process, five (5) e- and m-learning experts were scientifically selected. Five (5) experts were considered a sufficient sample size because, according to Nielsen and Mack (1994), the sample size for evaluating the validity of an artifact ought to be small (3 to 7) as a large size will only result into dismal improvements in rate of fault detection. The five (5) experts were drawn using stratified random sampling technique. As is seen in *Section 3.3.1* above, the five categories of interviewees that were considered during data collection for the *Awareness of the Problem* process step also formed the categories for data collection during the *Evaluation/Validation* process step. However, due to logistical constraints this time round, only experts from Uganda were considered. The categories included: e-learning experts, software developers, e-content developers, distance education administrators/academics and telecommunications service providers. Each of these aforementioned categories constituted a stratum from which one expert was chosen using simple random sampling. In effect therefore, the five domain experts included an e-learning expert (1), a software developer (1), a content developer (1), distance education administrator/educator (1) and a telecommunications service provider (1). An in-depth face to face interview was then held with each of the selected expert using the interview guide in *Appendix F*.

iv Conduct of MoLODUF Validation Interviews

For each interviewee, the researcher described the aim of the *MoLODUF* in general and the different guidelines for m-learning objects deployment and utilisation in each of the twelve dimensions and their respective sub-dimensions. After a thorough explanation of the *MoLODUF* to the interviewee, the researcher then paused questions in the interview guide (see *Appendix F*). The questions required the interviewee to provide his/her level of agreement to the inclusion of a given dimension and its respective sub-dimension in a mobile learning framework. This exercise was repeated for all the twelve dimensions. Also, in a single question, interviewees were asked to provide their level of agreement to the twelve dimensions as being those that constitute a

framework for deploying and utilising learning objects on mobile phones.

v Reliability and Validity of the MoLODUF

The data obtained from the in-depth face to face interviews was analyzed using Cronbach's alpha (Cronbach, 1951) and ANOVA statistics to establish the reliability and validity of the twelve dimensions of *MoLODUF*. Also, frequency runs where carried out on each and every sub-dimension to determine their validity based on level of acceptance of experts on their inclusion in the *MoLODUF*.

vi Other M-Learning Validation Methods/Techniques

Other than the domain expert evaluation validation technique, there are other framework validation methods and techniques. In Parson *et al*. (2007), validation of a design requirements framework for m-learning environments was done by comparing its dimensions with four successfully implemented and pedagogically grounded m-learning application. Though an ideal validation method, it was not practical in our contexts because of lack of successfully implemented pedagogic m-learning applications. The m-learning applications available in developing countries of Africa were of trial or pilot nature and were not built based on sound pedagogical principles (Brown, 2005; Kajumbula, 2006; SAIDE, 2008).

Frameworks in Ayala and Castillo's (2008), Goh and Kinshuk (2006), Motiwalla (2007), Nakabayashi (2007), Quinn (2002), Trifonova and Ronchetti (2006), Yang (2007) and Zhang (2003) were validated using prototype systems. Prototype system validation (Buranathiti *et al*., 2006) however, requires ample time and financial resources to be accomplished yet Traxler (2007, p.9) has guided that an m-learning evaluation method must be "efficient, in terms of cost, effort, time, or some other resource".

The *MoLODUF* validation findings are detailed in *Chapter Six.*

3.3.4 Phase 4: Conclusion

Phase 4 was underpinned by the *Conclusion* process step of the Design Research methodology. The Chapter provides a summary of findings, a conclusion with the major contributions and future research work, important recommendations, limitations to the study and publication so far made from this PhD work. The conclusion to the dissertation is presented in *Chapter Seven*.

3.4 Conclusion

This research aimed at developing a framework for instantiating applications that can enable learners in developing countries obtain access to and use learning objects, delivered over the Internet/other networking technologies, regardless of their proximity to higher education institutions through the use of mobile phones. This aim was achieved by adopting the Design Research Methodology to provide answers to six (6) research questions.

Design Research methodology, which entails five process steps, suited this kind of study because it incorporates research, design and practice and a framework is one of its outputs. The five process steps of Design Research methodology were executed in four phases.

Phase 1 which was underpinned by the *Awareness of the Problem* process step of the Design Research methodology, involved getting the context of the learners and the current practices and prospects for m-learning development and growth in Africa. This was done through literature review, survey of university students in Uganda, interviews with e- and m-learning stakeholders in Uganda and other parts of Africa and observations. The survey was piloted and reliability of questions therein tested using Cronbach's alpha test. After the field research, four hundred forty six (446) questionnaires were returned representing a response rate of 36%. With the help of SPSS, descriptive and inferential statistics were generated from survey data. As for qualitative data, it was analyzed by noticing, collecting and thinking about striking aspects therein. The validity and reliability of qualitative data was ensured by critical checks from the supervisors of this dissertation and triangulation with literature review, survey and observation data.

Phase 2 which was underpinned by the *Suggestion and Development* process steps of the Design Research methodology, involved discussing the results and abductively and deductively drawing dimensions and sub-dimensions for constructing the *MoLODUF*.

Phase 3 which was underpinned by the *Evaluation* process steps of the Design Research methodology, involved validating the *MoLODUF* using expert evaluation method

Phase 4 which was underpinned by the *Conclusion* process step of Design Research methodology involved giving concluding remarks to the dissertation. It involved giving the summary of findings, the conclusion with contribution to the fund of knowledge and future research work, key recommendations, limitations to the study and the publications from this PhD work.

CHAPTER FOUR

4. RESULTS

4.0 Introduction

In this Chapter, the results of the study are presented. The Chapter accomplished the *Awareness of the Problem* process step of Design Research methodology and *Phase 1* of the research strategy. It seeks to present results that underpin the research problem of this study. It fulfills the first two objectives (see *Section 1.5* above) of this study as well as providing results for answering all the research questions (see *Section 1.6 above*) of this study. The answers to the research questions provide the knowledge base for designing and developing the *MoLODUF*. Data that provided the results in this Chapter was collected using both qualitative and quantitative techniques, namely: literature review, survey and in-depth interviews as is espoused in *Section 3.3.1* above.

The Chapter is organized as follows. In *Section 4.1*, the context of survey respondents is presented. In *Section 4.2,* the study presents the current practices and prospects for the development and growth of m-learning in Africa. In *Section 4.3*, observations regarding the distance learning and teaching processes at Makerere University are presented. In *Section 4.4*, the preferred m-learning objects and media types for different learning processes are presented. The implications from the results are given in the chapter concluding remarks in *Section 4.5.*

4.1 Context of Survey Respondents

In information systems design and development, system users are important for the success of any information system (Gasson, 1999). It was therefore necessary to profile the users who would benefit from the *MoLODUF*. A profile of the users (learners) was achieved by characterizing them on three key variables with a bearing to m-learning. These included: the learners' background information (*Section 4.1.1*), learners' usual learning environment (*Section 4.1.2*) and digital learning characteristics of learners (*Section 4.1.3*). The results in this section provide various issues and factors for obtaining access to and using learning objects in m-learning. Indeed, the results in this section provided some of the dimensions and sub-dimensions of the *MoLODUF.*

4.1.1 Learners' Background Information

Learners' background information related to their gender, age, category of programme of study, mode of study, year of study, marital status, employment status and last level of education prior to

joining university. This information provided the context of learners for use in building the *MoLODUF*.

Participants (N=446) in the survey were distributed as 62.3% male and 37.7% female. Regarding respondents' age, the minimum age recorded was 18 while the maximum was 46 with a mean age of 24.7 and mode of 21. The minimum age (18) was recorded from amongst the internal students who constituted 51.1% of the survey sample while the maximum age (46) was recorded from distance learners who constituted 48.9% of the sample. Forty three percent (43.0%) of the learners surveyed were pursuing science related programmes while 57.0% were pursuing humanities related programmes. Learners were drawn from all years of study including 1st year (15.9%), second year (32.3%), third year (35.2%) and fourth year (16.6%). Most of the students were unemployed (67.5%) and not married (79.8%). They joined university after attaining A' level (70.2%), diploma (26.9%), grade III teacher certificate (1.1%), degree (1.1%) or other qualifications (0.7%).

4.1.2 The Learners' Usual Learning Environment

In situated learning theory (Lave & Wenger, 1991), the learners' learning environment is pivotal to the success of their learning. Since the sample included distance (48.9%) and internal (51.1%) students, it was important to determine the conditions of the environment in which each of the two categories of learners operated.

The study set to find out whether the environments were rural, urban or semi-urban, whether they were always quiet, sometimes noisy or always noisy, whether mobile network and Internet connectivity was always available to the learner and whether the learners had constant power supply at all times. The mode of study was cross-tabulated with the learners' usual learning environment, noise levels of the learners' usual learning environment and availability of mobile network connectivity, Internet connectivity and power supply.

Using Pearson Chi-square test, an association was established between learners' usual learning environment and noise levels, mobile network connectivity, Internet connectivity and power supply. By making the comparison (through variable cross tabulation) and undertaking the association tests (using Pearson Chi-square), we were able to determine the context in which internal and distance learning students operated. Results are presented in *Tables 4.1 through to 4.11*. Note that in all the tables, n is used to represent the frequency of occurrence of a particular response while N stands for the total number of responses. Where N is less than 446, it implies that there was a non-response equivalent to the difference.

Table 4.1: A Cross-Tabulation of Mode of Study with Location of Learners' Usual Learning Environment

Mode of study	Location where learning activities are usually conducted			Total
	Rural	Urban	Semi-urban	
Distance	21.1% (n=46)	55.5% (n=121)	23.4% (n=51)	n=218
Internal	4.4% (n=10)	75.0% (n=171)	20.6% (n=47)	n=228
Total	12.6% (n=56)	65.5% (n=292)	22.0% (n=98)	N=446

Percentages are calculated row wise and p=0.532

Whereas it has always been the general belief that most distance learners in Uganda are based in rural areas, findings in *Table 4.1* have proved otherwise. The majority of distance learners (55.5%) were based in urban settings and only 21.1% were based in rural areas. Semi-urban areas such as trading centers were a base for 23.4% of the distance learners. The study having been conducted in an urban setting of Makerere University, which is located in the city of Kampala, Uganda, explains the large proportion of internal students (75.0%) who were based in urban settings. The 20.6% and 4.4% of internal students who reported as having been in semi-urban and rural environments respectively are a case of students who commuted to Makerere University on a daily basis from surrounding districts and suburbs of Kampala. A p-value of 0.532 in *Table 4.1* above confirms that there was no significant association between study mode and the location of the learners' usual learning environment.

Whether the learners' usual learning environment, in terms of noise levels, mobile network and Internet connectivity and power supply, was conducive for learning, constituted other issues for investigation. These issues are investigated in *Tables 4.2, 4.3* and *4.4* respectively.

Table 4.2: A Cross-Tabulation of Mode of Study with Noise Levels of the Learners' Usual Learning Environment

Mode of study	Noise levels of learners' usual learning environment			Total
	Is always quiet	Is sometimes noisy	Is always noisy	
Distance	39.0 (n=85)	59.2 (n=129)	1.8 (n=4)	n=218
Internal	37.7 (n=86)	59.6 (n=136)	2.6 (n=6)	n=228
Total	38.3 (n=171)	59.4 (n=265)	2.2 (n=10)	N=446

Percentages are calculated row wise and p=0.029

Learning concentration often requires quiet learning environments. Moreover, voice communication via mobile phones may some times be unacceptable in environments with high noise levels. In *Table 4.2* above, a p-value of 0.029 was generated in a cross-tabulation of mode of study with noise levels

of the learners' usual learning environment. This p-value (0.029) indicates that the mode of study is significantly associated with the noise levels in the learners' usual learning environment. *Table 4.2* above further shows that there were slightly more internal students (62.2%) in sometimes noisy or always noisy locations than distance learners (61.0%). This was because more internal students were based in urban or semi-urban areas (95.6% (see *Table 4.1* above)) that tend to be noisier than rural areas as is depicted in *Table 4.3* below.

Table 4.3: A Cross-Tabulation of Location of Learners' Usual Learning Environment with Noise Levels

Location of learners' usual learning environment	Noise levels of learners' usual learning environment			Total
	Is always quiet	Is sometimes noisy	Is always noisy	
Rural	48.9% (n=23)	51.1% (n=24)	0.0% (n=0)	n=47
Urban	39.1% (n=136)	58.0% (n=202)	2.9% (n=10)	n=348
Semi-Urban	23.5% (n=12)	76.5% (n=39)	0.0% (n=0)	n=51
Total	38.3% (n=171)	59.4% (n=265)	2.2% (n=10)	N=446

Percentages are calculated row-wise

From *Table 4.3* above, it is evident that urban or semi-urban settings are noisier than rural areas. Indeed no respondent from a rural setting reported having a usual learning environment which was always noisy. There was an almost equal distribution of respondents from rural areas who reported having an environment which was always quiet (48.9%) or sometimes noisy (51.1%). The majority of learners (60.9%) from urban settings reported that their environment was sometimes noise (58.0%) and always noisy (2.9%). Similarly the majority (76.5%) of learners who hailed from semi-urban settings sometimes experienced noisy learning environments. Urban or semi-urban settings are nosier than rural settings. This conclusion is justified by the Chi-square test results obtained from a cross-tabulation of the location of learners' usual learning environment and noise levels in those environments as is seen in *Table 4.4* below.

Table 4.4: Comparison of Location of Learners' Usual Learning Environment and Noise Levels

Test Statistic	Value	Degrees of Freedom	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.318[a]	4	0.035
Likelihood Ratio	12.643	4	0.013
N of Valid Cases	446		

[a] *2 cells (22.2%) have expected count less than 5. The minimum expected count is 1.05.*

A p-value of 0.035 at 4 degrees of freedom in *Table 4.4* above indicates that noise levels are significantly associated with the location of the learners' usual learning environment. This finding is collaborated with findings in *Table 4.3* above which also indicate that urban settings are noisier than rural ones. This could be attributed to the more traffic, people and economic activities found in urban settings than rural settings.

There was also need to establish the level of mobile network and Internet connectivity at learners' disposal so as to gauge the feasible e- and m- learning applications that could be extended to learners. Results on these variables are presented in *Tables 4.5* and *4.6* below.

Table 4.5: A Cross-Tabulation of Mode of Study with Mobile Network Connectivity Availability

Mode of study	Mobile network connectivity is present at all times				Total
	Strongly disagree	Disagree	Agree	Strongly agree	
Distance	9.8% (n=21)	20.5% (n=44)	43.7% (n=94)	26.0% (n=56)	n=215
Internal	10.5% (n=24)	17.1% (n=39)	41.7% (n=95)	30.7% (n=70)	n=228
Total	10.2% (n=45)	18.7% (n=83)	42.7% (n=189)	28.4% (n=126)	N=443

Percentages are calculated row-wise and Chi-square p=0.062

From *Table 4.5* above, 69.7% and 71.4% of distance and internal students respectively agreed or strongly agreed that mobile network connectivity was present at all times in their areas of aboard. It means that distance and internal students are almost equally served with mobile network connectivity. This is also evidenced by p-value of 0.062 in *Table 4.5* above which indicates that learners' mode of study has no significant association with availability of mobile network connectivity. This is a good context for m-learning because both internal and distance learning students can equally be reached by m-learning. To determine permeation of mobile network connectivity in rural, semi-urban and urban settings we associated the location of learners' usual learning environment with the availability of mobile network connectivity in *Table 4.6*.

From *Table 4.6* below, 42.7 % agreed and 28.4% strongly agreed that mobile network connectivity was present at all times in their areas of aboard. This implies that 71.1% of the learners surveyed had constant mobile network connectivity. Whereas the urban-based learners reported slightly higher availability of mobile network connectivity, *Table 4.6* above indicates that there was almost equal level of agreement among rural (41.3%) and urban (42.8%) based learners to the question that mobile network connectivity was available at all times in their areas of aboard.

Table 4.6: A Cross-Tabulation of the Location of Learners' Usual Learning Environment with Mobile Network Connectivity

Location of learners' usual learning environment	Mobile network connectivity is present at all times				Total
	Strongly Disagree	Disagree	Agree	Strongly Agree	
Rural	15.2%(n= 7)	23.9% (n=11)	41.3% (n=19)	19.6% (n=9)	46
Urban	9.5% (n=33)	16.8% (n=58)	42.8% (n=148)	30.9% (n=107)	346
Semi-urban	9.8% (n=5)	27.5% (n=14)	43.1% (n=22)	19.6% (n=10)	51
Total	10.2% (n=45)	18.7% (n=83)	42.7% (n=189)	28.4% (n=126)	443

Percentages are calculated row-wise and Chi-square p=0.136

A p-value of 0.136 in *Table 4.6* above indicates that there is no significant association between location of the learners' usual learning environment and availability of mobile network connectivity. We can conclude then that mobile network connectivity has permeated almost equally in urban, semi-urban and rural areas of Uganda. However, Internet connectivity permeation was limited as is presented in *Tables 4.7* and *4.8* below.

Table 4.7: A Cross-Tabulation of Mode of Study with Internet Connectivity Availability

Mode of Study	Internet connectivity is present at all times				Total
	Strongly disagree	Disagree	Agree	Strongly agree	
Distance	43.3 (n=93)	38.6 (n=83)	14.0 (n=30)	4.2 (n=9)	n=215
Internal	26.3 (n=60)	46.1 (n=105)	20.2 (n=46)	7.5 (n=17)	n=228
Total	34.5 (n=153)	42.4 (n=188)	17.2 (n=76)	5.9 (n=26)	N=443

Percentages are calculated row-wise and Chi-square p=0.329

From *Table 4.7* above, it is evident that Internet connectivity was present at all times to just a few learners. In *Table 4.7* above, 14.0% and 4.2% of distance learners agreed and strongly agreed to the contention that Internet connectivity was present to them at all times. Still in *Table 4.7* above, it is seen that 20.2% and 7.5% of internal learners agreed and strongly agreed to the contention that Internet connectivity was present to them at all times. Generally speaking, Internet connectivity was always available to only 23.1% of the learners. When this is compared with mobile network connectivity in *Table 4.6* above, it can be concluded that mobile network connectivity was more readily available to learners than Internet connectivity. However, neither distance nor internal learners were advantaged over the other in terms of access to Internet. This is evidenced by the p-value of 0.329 in *Table 4.7* above which indicates that there was no significant association between mode of study and availability of Internet connectivity. Since mobile connectivity is more pervasive

than Internet connectivity, m-learning applications are more likely to permeate to many learners in Uganda than those based on e-learning which depends heavily on Internet connected computers.

We then compared the location of the learners' usual learning environment and availability of Internet connectivity so as to determine in which learning environment learners had ready access to Internet. The results are presented in *Table 4.8* below.

Table 4.8: A Cross-Tabulation of Location of Learners' Usual Learning Environment With Availability of Internet Connectivity

Learners' usual learning environment	Internet connectivity is present at all times				Total
	Strongly Disagree	Disagree	Agree	Strongly Agree	
Rural	76.1% (n=35)	10.9% (n=5)	10.9% (n=5)	2.2% (n=1)	n=46
Urban	28.0% (n=97)	47.4% (n=164)	17.3% (n=60)	7.2% (n=25)	n=346
Semi-urban	41.2% (n=21)	37.3% (n=19)	21.6% (n=11)	0.0% (n=0)	n=51
Total	34.5% (n=153)	42.4% (n=188)	17.2% (n=76)	5.9% (n=26)	N=443

Percentages are calculated row-wise and Chi-square p=0.329

Contrary to the common belief that urban based learners have readily available Internet connectivity, the statistics in *Table 4.8* have indicated otherwise. A p-value of 0.329 in *Table 4.8* above indicates no significant association between location of learners' usual learning environment and availability of Internet connectivity. Thus all rural, semi-urban and urban based learners experienced similar availability or non-availability of Internet connectivity. About 78% of the learners either strongly disagreed (34.5%) or disagreed (42.4%) to the contention that Internet connectivity was available to them at all times. For those who had Internet connectivity, it was skewed more towards urban and semi-urban settings, that is to say, areas with electricity. This is explained by the strong association (p = 0.000) between electric power supply and Internet connectivity as seen in *Table 4.9* below.

Table 4.9: Chi-Square Tests Between Power Supply and Internet Connectivity

Test Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	119.913[a]	9	0.000
Likelihood Ratio	96.788	9	0.000
N of Valid Cases	442		

[a] 1 cells (6.3%) have expected count less than 5. The minimum expected count is 2.71.

Interestingly, availability of power supply was not significantly associated with availability of mobile network connectivity (p=0.301). In a preliminary study we carried for this study, it was

found out that m-learning can overcome the constraints that lack of electricity imposes on e-learning. This is because telecommunications companies have set up transmission masts in rural areas that are powered by diesel generators and mobile phones users in areas with no electricity can charge their mobile phone batteries using solar power, cars, batteries and generators.

Further an investigation was carried out to determine whether mode of study was significantly associated with availability of power supply. Results are indicated in *Table 4.10* below.

Table 4.10: A Cross-Tabulation of Mode of Study with Availability of Power Supply

Mode of Study	Power supply is availability all the time				Total
	Strongly Disagree	Disagree	Agree	Strongly Agree	
Distance	30.2 (n=65)	40.5 (n=87)	20.5 (n=44)	8.8 (n=19)	n=215
Internal	15.8 (n=36)	39.5 (n=90)	32.9 (n=75)	11.8 (n=27)	n=228
Total	22.8 (n=101)	40.0 (n=177)	26.9 (n=119)	10.4 (n=46)	N=443

Percentages are calculated row-wise and p=0.199

From *Table 4.10* above, there was no significant association (p=0.199) between mode of study and constant availability of power supply. This means that both internal and distance learning students faced similar conditions in as far as power supply was concerned. Power load shedding in Uganda is a common phenomenon. Rosters of power load shedding are published daily in local newspapers. However, intermittence or non-availability of power supply was more common in rural or semi-urban areas than urban ones. This is evidenced by the significant association between location of learners' usual learning environment and power supply availability in *Table 4.11* below.

Table 4.11: Cross-Tabulation of Location of Learners' Usual Learning Environment with Availability of Power Supply

Location of learners' usual learning environment	Power supply is availability all the time				Total
	Strongly Disagree	Disagree	Agree	Strongly Agree	
Rural	58.7% (n=27)	15.2% (n=07)	15.2% (n=07)	10.9% (n=05)	n=46
Urban	17.6% (n=61)	42.8% (n=148)	28.3% (n=98)	11.3% (n=39)	n=346
Semi-urban	25.5% (n=13)	43.1% (n=22)	27.5% (n=14)	3.9% (n=02)	n=51
Total	22.8% (n=101)	40.0% (n=177)	26.9% (n=119)	10.4% (n=46)	N=443

Percentages are calculated row-wise and p=0.000

From *Table 4.11* above, a p-value of 0.000 was generated in a cross-tabulation of location of

learners' usual learning environment with availability of power supply. This p-value (0.000) indicates that the location of the learners' usual learning environment is strongly significantly associated with availability of power supply. *Table 4.11* above shows that power supply was more available in urban (39.6%) and semi-urban (31.4%) settings than rural (26.1%) areas. However, even where power was available, its supply was intermittent as 62.8% of the learners surveyed either strongly disagreed (22.8%) or disagreed (40.0%) to the statement that power supply was available to them at all times.

4.1.3 Digital Learning Characteristics of Learners

This section presents results of findings on the digital learning characteristics of learners who participated in the survey. Digital learning characteristics relate to how learners use digital technology to learn (Fisher and Baird, 2006-2007). In this study the digital learning characteristics were determined using 25 latent variables (see *Question 25* of *Appendix A*) adapted from Prensky's (2001) 'digital natives and immigrants' and Fisher and Baird's (2006-2007) 'net generation' frameworks for learner digital characterization.

Using only complete responses with no missing values (N = 396) and the 25 latent variables, Cronbach's alpha of 0.7371 was generated from an SPSS reliability analysis run. A Cronbach's alpha of 0.7371 signifies that the 25 latent variables were reliable enough to measure and generate a new variable, in this case, the digital learning characteristic (DLC) variable. The DLC variable was generated from variables that were measured on a four point likert scale of strongly disagree (1), disagree (2), agree (3) and strongly agree (4). It follows therefore that DLC was also of a four point likert scale. DLC was populated with values derived from the mean values of the likert scales of the 25 latent variables. A descriptive statistics analysis run on DLC generated results indicated in *Table 4.12* below.

Table 4.12: Descriptive Statistics for Digital Learning Characteristics (DLC) Variable

	N	Minimum	Maximum	Mean	Median	Std. Deviation
DLC	396	1.52	3.64	2.6064	2.6	0.3391
Valid N (list-wise)	396					

On a 4 point likert scale of 1 to 4, a mean value of 2.6064 shown in *Table 4.12* above indicates that the learners were almost equally divided between two groups, namely the digital natives (those who agreed (3) or strongly agreed (4)) and digital immigrants (those who disagreed (2) or strongly

disagreed (1)). Digital natives are people who were introduced to digital technology as soon as they were born while digital immigrants are those to whom technology was introduced later in their lives (Prensky, 2001).The results in *Table 4.12* above are collaborated with results in *Table 4.13* below depicting the learners' computer use skills levels.

Table 4.13: Knowledge of Computers and their Use

Computer Use Skills Level	Frequency	Percent
Excellent	22	4.9
Very Good	69	15.5
Fairly Good	173	38.8
Basic	135	30.3
No Knowledge	47	10.5
Total	446	100.0

Table 4.13 above shows that 4.9% of the learners had excellent skills levels of using computers while 15.5% had very good skills. In effect about 20.0% of the learners had proficient (excellent plus very good) knowledge in use of the computer. On the other hand, 10.5% of the learners had no knowledge at all. About 38.8% of the learners had fairly good knowledge and 30.3% had basic knowledge. These statistics are a testimony to the presence of a digital divide amongst learners in terms of ICT skills. The statistics are a further proof of the existence of both digital natives and immigrants amongst learners in Uganda as was espoused in the learners' DLC identified in *Table 4.12* above.

The learners' DLC were found to be highly influenced by their age. A Bivariate correlation between Age and DLC was significant (p=-0.199) at the 0.01 level in a two tailed distribution as is seen in *Table 4.14*. Older learners (25 and above) are more likely to fall under the digital immigrants classification while relatively young ones (18-25) are likely to be in the digital natives category.

Table 4.14: Influence of Age on Digital Learning Characteristics

		Age	DLC
Age	Pearson Correlation	1.000	-0.199**
	Sig. (2-tailed)	.	0.000
	N	446	396
DLC	Pearson Correlation	-0.199**	1.000
	Sig. (2-tailed)	.000	.
	N	396	396

** Correlation is significant at the 0.01 level (2-tailed).

We also measured the association between mode of study and use of different ICTs for learning. This measure was important for it was used to determine the level of usage of ICTs by distance and internal learners. The results are presented in *Table 4.15* below.

Table 4.15: Association Between the Different ICTs and Frequency of their Use for Learning

ICTs	Frequency of use of ICT for learning												P-Value
	Never		Irregularly		Once a Week		2-3 Times a Week		4 Times a Week		5 or More Times a Week		
	Distance	Internal	Distance	Internal	Distance	Internal	Distance	Internal	Distance	Internal	Distance	Internal	
Internet	30.6%	16.5%	34.7%	33.5%	16.2%	11.2%	11.6%	25.9%	2.8%	4.9%	4.2%	8.0%	0.249
Mobile Phones	25.7%	22.4%	23.4%	21.1%	4.2%	7.2%	10.3%	6.7%	5.6%	4.0%	30.8%	38.6%	0.122
E-Mail	42.9%	29.4%	32.9%	31.7%	12.4%	14.0%	8.1%	13.6%	2.4%	2.7%	1.4%	8.6%	0.002
Blackboard LMS	36.7%	27.1%	17.9%	20.8%	3.4%	7.7%	9.2%	6.8%	9.7%	8.6%	23.2%	29.0	0.148
CDROM	64.2%	43.8%	25.5%	27.6%	3.4%	6.0%	3.4%	11.1%	2.9%	5.1%	0.5%	6.5%	0.266
Computer Applications	51.7%	31.7%	27.3%	28.0%	8.3%	13.3%	7.3%	13.3%	2.4%	3.7%	2.9%	10.1%	0.244

N=446

From *Table 4.15* above, there was no significant association between mode of study and frequency of use of Internet (p=0.249), mobile phones (p=0.122), blackboard learning management system (p=0.148), CDROMs (p=0.266) and computer application (p=0.244) for learning. E-mail was the only ICT found to have significant association (p=0.002) with mode of study. Several factors could explain these findings. First, a big proportion of learners, be thy distance or internal, never or irregularly used Internet, Blackboard LMS, CDROMs and computer applications for learning as is seen in *Table 4.15* above. Secondly, the relatively young internal students – digital natives (see *Table 4.16*) were more likely to use e-mail than the relatively much older distance learners – digital immigrants. An association of mode of study with learners' age is given in *Table 4.16* below.

Table 4.16: Association of Mode of Study With Age

Mode of Study	Age			Total
	18 - 25	26 -33	34 and above	
Distance	45.9% (n=100)	35.3% (n=77)	18.8% (n=41)	n=218
Internal	93.4% (n=213)	5.7% (n=13)	0.9% (n=02)	n=228
Total	70.2% (n=315)	20.2% (n=90)	9.6% (n=43)	N=446

As can be seen from *Table 4.16* above, internal students fell mainly in the age range 18 - 25. It has already been established in *Table 4.14* above that relatively young learners (18 - 25) are more likely to be digital natives than relatively older ones (26 and above). It implies that internal students were most likely to be classified in the digital natives category while distance learning students could be classified as digital immigrants. As such the revelation that e-mail use was significantly associated with mode of study (p=0.002) in *Table 4.15* above arises from the fact that digital natives (internal students) were more likely to use e-mail than the digital immigrants (distance learners). The other ICTs were not significantly used in activities associated with learning because both distance and internal students faced similar huddles of accessing Internet and therefore Blackboard LMS, CDROMs and computer applications. As for mobile phones, both distance and internal students had limited knowledge about the use of mobile phones for learning. This finding is reported on in *Section 4.2.1* below.

To establish the place where learners mainly accessed Internet from, we asked them to tick on the location where they mainly had access to Internet from. The results of a cross tabulation of mode of study with place where learners accessed Internet from is shown in *Table 4.17* below.

Table 4.17: Association of Mode of Study With Location of Internet Access

Mode of Study	Internet is usually accessed from				
	Home	University	Workplace	Internet Café	Friend's Office/Home
Distance	3.2% (n=07)	47.7% (n=104)	11.0% (n=24)	45.5% (n=97)	5.0% (n=11)
Internal	11.0% (n=25)	73.7% (n=168)	2.6% (n=06)	46.9% (n=107)	7.5% (n=17)
Total	7.2% (n=32)	61.0% (n=272)	6.7% (n=30)	45.7% (n=204)	6.3% (n=28)
P-value	-0.150	-0.266	0.167	-0.024	-0.050

Table 4.17 above shows that the university where a student studied was the biggest provider of Internet services not only to internal students (73.7%) but also to distance learning students (47.7%). This was followed by Internet cafes, used by 46.9% and 45.5% of internal and distance learners respectively. Other than workplace Internet access (p=0.167), there was significant association between mode of study with home (p=-0.140), university (p=-0.266), Internet café (p=-0.024) and

friend's office/home (p=-0.05) Internet access. The lack of association between mode of study and workplace Internet access (p=0.167) can be explained by the fact that a whooping 67.5% of the learners were unemployed (see *Section 4.11*)

4.2 Current Practices and Prospects for the Development and Growth of M-Learning in Africa

This section presents the current practices and prospects for the development and growth of m-learning in Africa. It answers the research question, 'what are the current practices and prospects for the development and growth of m-learning in Africa?' The results in this section are presented in seven (7) sections. In *Section 4.2.1,* the m-learning epistemology is presented. In *Section 4.2.2,* current activities, location and time for m-learning are presented. Out-of-classroom learning activities that may benefit from m-learning are presented in *Section 4.2.3.* The favorable factors for and barriers to m-learning are presented in *Sections 4.2.4* and *4.2.5* respectively. The state of m-learning resources is presented in *Section 4.2.6.* Finally, the m-learning stakeholders' perceptions and opinions towards m-learning are presented in *Section 4.2.7.*

4.2.1 M-Learning Epistemology

Epistemology is knowledge held about something (AIS, 2007). In a question requiring learners to indicate whether they had ever heard about the term 'm-learning' or not, 94.0% of them indicated they had never heard about it while 6.0% of them had ever heard of it. This implies that the term 'm-learning' was quite a new term to the majority of the learners surveyed. The research was also intent to establish whether learners were practicing any form of m-learning. Thus two option type questions requiring learners to state the purposes for which they placed text messages and voice calls were asked. The results are presented in *Table 4.18* below.

Table 4.18: Purpose for Placing Text Messages and Voice Calls

Purpose	Text Messages	Voice Calls
Leisure/entertainment	48.7% (n=217)	44.2% (n=197)
Learning/education	45.1% (n=201)	45.5% (n=203)
General communication	80.7% (n=360)	85.2% (n=380)
Transacting profit oriented business	16.6% (n=74)	19.5% (n=87)
Participating in lottery	4.3% (n=19)	3.1% (n= 14)
Participating in radio/TV talk shows	13.0% (n=58)	12.1% (n=54)
Others (specify)	2.2% (n=10)	1.8% (n=8)

N=446. Learners who never owned phones sent or made calls from borrowed phones or payphones

In *Table 4.18* above, you should note that the totals in the 'Text Messages' and 'Voice Calls' columns do not add up to 100% because a single respondent could select more than one purpose for placing text messages and voice calls. As any one would expect, T*able 4.18* above, indicates that learners mainly used their mobile phones for the orthodox purpose of general communication. In the first position, general communications constituted 80.7% and 85.2% of the text messages and voice calls placed respectively. In the second position was leisure/entertainment, which was achieved through 48.7% and 44.2% of text messages and voice calls placed respectively. Learning/education took the third position with 45.1% and 45.5% of text messages and voice calls placed respectively. The fact that learning or education was one of the reasons for placing text messages and voice calls implies that m-learning was being practiced, albeit inadvertently, since earlier results have indicated that the majority (94.0%) of learners knew nothing about the term, 'm-learning'.

M-learning was not engrained in the majority of universities in Africa. In a question paused during in-depth interviews with e-learning providers and university administrative and academic staff (N=12) on how their universities were using m-learning, 8 out of the 12 (66.7%) interviewees in this category, indicated that m-learning was not actively being practiced in their universities. "… there are no policies for institutionalizing m-learning and as such there are no coordinated efforts for m-learning implementation", said a distance education administrator at Makerere University. "… I have never heard or seen any m-learning application in my university", said an e-learning provider. To some interviewees, the interview presented their very first time to hear about the concept of 'm-learning'. Such interviewees could not be able to tell whether calling students and having them call others on their mobile phones to discuss learning related issues constituted m-learning. "… I am not aware of any unit in my university using m-learning apart from students calling and being called on their mobile phones", said one of the interviewees. The later response indicates a case of limited epistemology of the concept of m-learning among some university staff.

On the other hand, 4 out of 12 interviewees (33.3%) in the category of e-learning providers and university administrative and academic staff were knowledgeable about the concept of m-learning. One of these interviewee said, "… we are not using m-learning to its full potential although we plan to institutionalize it. At the moment we use it to send learning events reminders to students". Where some instances of m-learning were acknowledged, it had caused a lot of excitement and demand amongst learners. An interviewee said,

> … a few times we have used mobile phones for simple messages; there has been a big demand for it. When we stopped using the system due to technical and financial problems, students started asking, 'what happened to

> the message system?' Students found it a very cost effective and exciting way of collaborating with each other and their Department …

In the few (33.3%) reported instances where it was being used, m-learning presented itself as a good platform for collaborative and interactive learning and learner support. However, as it is expositioned in the interview response above, technical and financial constraints curtailed the success of m-learning in some universities. With institutionalization, m-learning could be made one of the universities budget items.

Though m-learning is a good platform for collaborative and interactive learning, the few reported instances of m-learning were of a push nature. Information was majorly unidirectional towards the learners' side. With exception of voice calls, limited bidirectional synchronous and asynchronous collaboration via text messages was reported. "We only use text messages to pass on reminders of learning events. The text messages are broadcast to learners with no requirement for feedback", said an interviewee. In other words, the text messages were more informative than collaborative.

At organizational level, m-learning was mainly practiced through SMS messaging. "Our department uses SMSs through the mobile research supervision initiative and mobile broadcast system to extend research supervision and administrative support services respectively to our learners", said a distance education administrator at Makerere University. The administrator explained, "… research supervisors use SMS messages to reach out to their students in the field and set face to face meeting appointments". The preference for SMS is probably caused by the limitations of existing mobile phones. "Most of our learners have very basic entry phones", answered a university administrator when he was asked to explain why supervisors were only using SMSs. SMS messages are however constrained by the 160 character limitations. Thus voice calls are better placed to deliver more information than SMSs.

In instances where voice calls were placed for the purpose of learning, an interviewee reported that, "… more information is conveyed in a bidirectional synchronous way since there are no limitations to the amounts of words and characters spoken". Text messages are limited to a length of 160 characters and are sometimes more expensive than voice calls. One of the interviewees with this view testified thus, "… in some instances when telecommunications services providers offer promotional call tariffs, a voice call per minute is cheaper than a 160 character SMS message". Hence in such promotional periods, m-learning can benefit more from voice calls than text messages.

4.2.2 Current Activities, Location and Time for M-Learning

In *Section 4.2.1* above, the study has revealed that m-learning was inadvertently taking place, though on very limited scale and in very few universities. In *Table 4.18* above, it was established that 45.1% and 45.5% of the learners placed text and voice calls respectively for learning/education purposes. It is now important to present the learning activities that learners were accomplishing on their mobile phones and the location and time such learning activities were accomplished. In an option type question, possible learning activities were listed and learners asked to select the ones they partake of on their mobile phones. The findings are presented in *Table 4.19* below.

Table 4.19: Learning Activities Currently Undertaken by Learners on their Mobile Phones

I have ever used my mobile phone to:	**Yes**	**No**
Be in touch with classmates	77.7% (n=338)	22.3% (n=97)
Send/receive reminders of learning events	66.7% (n=290)	33.3% (n=145)
Send/receive coursework advice to/from classmates	56.6% (n=246)	43.4% (n=189)
Be in touch with university officials	39.3% (n=171)	60.7% (n=264)
Receive guidance on learning activities from lecturers	30.1% (n=131)	69.9% (n=304)
Send/receive examination/test tips to/from classmates	28.3% (n=123)	71.7% (n=312)
Receive administrative messages from the University	24.6% (n=107)	75.4% (n=328)
Discuss topics covered in a given course	23.2% (n=101)	76.8% (n=334)
Access/deliver online learning material/content	16.3% (n=71)	83.7% (n=364)
Supplement print based learning materials/content	12.4% (n=54)	87.6% (n=381)
Undertake simple multiple choice quizzes	10.8% (n=47)	89.2% (n=388)

(N=435 because 11 participants did not own mobile phones)

Findings in *Table 4.19* above are a further testimony to the fact that m-learning was inadvertently taking place amongst the learners. Most learning activities undertaken on the learners' mobile phones could be categorized as learner support activities. For instance, to the majority (77.7%) of the learners in *Table 4.19* above, the mobile phone enabled them to be in touch with their classmates. This means collaborative learning could be made possible through m-learning. Also since the survey participants consisted of distance learners among others, a mobile phone helping 77.7% of the learners to be touch with their classmates reduced the loneliness that is usually associated with distance learning. Generally speaking, learners enjoyed administrative and academic support services on their mobile phones from several locations and at anytime as is seen in *Tables 4.20* and *4.21* respectively.

Table 4.20: Location Where Mobile Phones Were Used for Learning Activities

I use my mobile phone for learning when I am…	True	False
At home	58.2% (n=253)	41.8% (n=182)
Anywhere	46.4% (n=202)	53.6% (n=233)
Traveling	31.0% (n=135)	69.0% (n=300)
In my workplace	23.0% (n=100)	77.0% (n=335)
In classroom	16.8% (n=73)	83.2% (n=362)
In the library	13.8% (n=60)	86.2% (n=375)
In meetings	6.9% (n=30)	93.1% (n=405)

(N=435 because 11 participants did not own mobile phones)

In the location dimension, *Table 4.20* indicates that m-learning took place at home (58.2%), anywhere (46.4%), while traveling (31.0%), in workplaces (23.0%), classrooms (16.8%), library (13.8%) and in meetings (6.9%). This implies that m-learning happened at various locations.

Table 4.21: Time When Mobile Phones Were Used for Learning Activities

Time when mobile phone is used for learning	Frequency	Percentage
Anytime of the day or night	276	63.5%
7:00pm to 11:59pm	46	11.4%
7:00am to 1:59pm	46	10.6%)
2:00pm to 6:59pm	50	10.6%)
12:00am and 6:59am	17	3.9%
Total	435	100.0%

(N=435 because 11 participants did not own mobile phones)

In the time dimension, *Table 4.21* above shows that the majority (63.5%) of learners used m-learning at anytime of the day or night. About 11.0% of the learners used m-learning between 7:00pm and 11:59pm. An equal proportion of learners (10.6%) used m-learning between 7:00am to 1:59pm and 2:00pm to 6:59pm while 3.9% reported having used m-learning between 12:00am and 6:59am.

4.2.3 Out-of-Classroom Learning Activities and M-Learning

After establishing the learning activities that were currently being accomplished on learners' mobile phones, it was important to establish all possible learner support services that could be extended onto learners mobile phones. This would help precipitate the development and growth of m-learning. Literature (Ayala & Castillo, 2008; Caudill, 2007; Luis de Marcos *et al.*, 2006) indicates that m-learning is mainly good for out-of-classroom learner support services. Thus, in an open ended question, respondents were asked to provide learning activities that learners engaged in while

outside the classroom environment. An analysis of these out-of-classroom learning activities would then be made to determine whether they possess learning processes that could be ported for m-learning. The activities as provided by the learners are summarized in nine (9) themes and ranked in order of most frequent (1 being the most frequent, 2 the second most frequent, and so on) to least frequent in *Table 4.22* below.

Table 4.22: Out-of-Classroom Learning Activities that Learners Engage In

Activity	Frequency	Rank Order
Participating in collaborative learning	41% (n=122)	1
Engaging in co-curricular/extra-curricula activities	20% (n=60)	2
Undertaking independent research	16% (n=46)	3
Completing theoretical, practical and field courseworks and assignments	8% (n=23)	4
Watching/listening to educative and entertaining music, news and movies	6% (n=19)	5
Engaging in work related activities	4% (n=11)	6
Consulting lecturers	2% (n=07)	7
Acquainting oneself with the university's environment	1% (n=04)	8
Taking computer lessons	1% (n=03)	9

Only 295 responses were received for this open ended question

It can be seen from *Table 4.22* above that outside the classroom, the majority of learners (41%) participated in collaborative learning. "I participate in group discussions of courseworks with my classmates", said one of the learners. "I chat with my colleagues using my mobile phone, Internet, e-mails and face to face interactions", said another learner. Another learner said, "I participate in conferences, seminars and tutorials organized at the university". These were some of the responses received under the collaborative learning theme. High end mobile phones can be used in collaborative learning. They are capable of placing and receiving e-mails, SMSs, MMSs, voice and video calls. Also, low end mobile phones can place and receive text messages and audio calls. It should there be possible to set up mobile chatting forums where students can collaborate with each other. The chatting capability of mobile phones can aid learners at a distance to contribute to conferences, seminars and tutorials. While providing out-of-classroom learning activities engaged in, a learner testified, "… I have ever participated in a mobile teleconferencing session with my classmates during a free calls promotion period by [one of the telecoms in Uganda]. It was generally good, exciting, convenient and cost effective". The learner who participated in the mobile teleconference only did so during a free calls promotion period. This indicates that m-learning can thrive under conditions of subsidized or no tariff on education related communications.

Still in *Table 4.22* above, the second (20.0%) most important out-of-classroom learning activity

undertaken by learners surveyed was engaging in co-curricula/extra-curricula activities. A number of responses were received under this theme and a few are presented here. “I play educative games like chess and darts”, went one of the responses. Another response was, “I carry out guidance and counseling”. Another stated, “I participate in debates, spiritual/religious work, politics, drama and sports”. Another said, “I participate in income generating activities like gardening, poultry farming, and vegetable growing”. Another response said, “I participate in social clubs, cooking, drinking alcohol, taking a nap/rest, writing letters, community work, solving home challenges and visiting friends”. The mobile phone is host to several educative games such as chess, darts, football and many others. It can also be a source of information for farming tips, bible scriptures, and other co/extra curricular activities. M-learning applications could be developed to provide information on all the aforementioned co/extra curricula activities.

Furthermore results in *Table 4.22* above indicate that the third (16.0%) most important out-of-classroom learning activity mentioned by the learners was undertaking independent research. “I undertake independent research by reading classroom notes, text books, newspapers, magazines and novels” said one of the learners. “I visit the Internet and supplement course notes with materials from the Internet”, said another learner. Indeed, if learners have GPRS enabled mobile phones; they could use them to obtain access to and utilize Internet based learning materials for independent learning.

Results in *Table 4.22* above further revealed that 8% of the learners used time outside the classroom to complete theoretical, practical and field courseworks and assignments. Through collaborative avenues presented by mobile phones, learners could collaborate on a class assignment and courseworks.

Also *Table 4.22* above shows that 6.0% of the learners watched educative and entertaining TV documentaries, videos, news, music, games and sports and listened to radio. These are all applications that are possible on mobile phones.

Other out-of-classroom learning activities in *Table 4.22* above include: engaging in work related activities (4%), consulting lecturers (2%), touring the university’s environment (1%) and taking computer lessons (1%). A mobile phone could be programmed to provide tips for generalist ICT skills.

E-learning providers and university administrative and academic staff (N=12) were asked, in an interview, to suggest out-of-the-classroom learner support services that could benefit from m-learning. Responses from these interviewees suggest that mobile phones could be used to support

learners in out-of-classroom learning activities. “The mobile phone can be used to consult lecturers by learners asking questions after a lecture for further clarification” said one of the interviewees. Another said, “we could use m-learning to share different conflicting views that emerge from a classroom discussion”. “GPS enabled mobile phones can be used to support campus-wide tour applications that can aid fresh students during orientation to acquaint themselves with the different locations in their universities”, said an e-learning provider. Another e-learning provider suggested the need for a comprehensive m-learning support system to support out-of-classroom learning activities. He said,

> We need an m-learning support system capable of providing summaries for what was discussed in the classroom, lectures and examinations timetable changes, information about venues for lectures and examinations, administrative and academic counseling, announcements and reminders and motivational messages. The system should also be in position to provide reference lists, hints on approach to questions, requirements for attending a given lecture, staff/student interaction, self evaluation via sequenced multiple choice quizzes hosted on a telecom’s server, alerts about overdue library books, new reading materials and where they can be found, research supervision and group discussions. The system should permit users to ‘ping’ it for definitions, learning tips and events organized by the university and checking on a distance learner’s status and situation specifically when the university has not heard from him/her for long.

One of the distance education academic while providing out-of-classroom learning activities that learners can be involved in said,

> … classroom/laboratory activities can be simulated and provided to students on their mobile phones for reflection while outside the classroom environment. If the simulation is not possible video clips could be employed. Audio lectures could be recorded on iPods/MP3 players and played back after class. This can arouse interest in learning and forestall boredom faced by students outside classroom environment …

Even when out-of-classroom learning activities presented above could be accomplished through m-learning, all (100%) the interviewee counseled that m-learning should only be embraced as a supplementary rather than a fully fledged learning platform because of the limitations still inherent in mobile devices. “M-learning is a good platform for getting into the sharp corners of learning that e-learning methods can not adequately reach, but not all areas of learning”, said an one of e-learning providers. “Do not hype the mobile devices technology for learning. Mobile devices have tiny screens and keyboard”, said another interviewee.

Though m-learning is mainly good for out-classroom learning activities, some interviewees also mentioned some areas where they were using m-learning in the classroom. This was in response to the question, ‘what classroom learning activities do you think could benefit from m-learning?’ An e-learning provider from South Africa, said, “… in the classroom, we use voting devices to solicit

anonymous answers and/or questions from students who are shy or afraid to talk before their colleagues. Also short demonstration are installed and played on learners' mobile phones while in the classroom". In another response, a software developer said, "… we can create an adhoc network of mobile phones using Bluetooth and use it to share files in the classroom".

Though helpful, some e-learning and distance education providers were negative about in-classroom m-learning. One of them said,

> I wouldn't encourage the use of mobile phones in the classroom because they cause a lot of disruptions. Mobile phones disrupt rather than really encourage learning because the classroom setting requires order and silence. One person should be contributing as the rest listen in. Now if everybody is busy punching their mobile keyboards, sending/receiving text/audio messages/calls with fancy ring tones and browsing Internet, there will be total chaos in the classroom.

This particular interviewee's fears are similar to those of another interviewee who said, "mobile phones in the classroom would lead to unacceptable behaviors among girls and boys and would facilitate test and examinations cheating".

All the above negativity need to be addressed if m-learning is to be favored.

4.2.4 Favorable Factors for M-Learning

To determine factors that can provide fertile grounds for m-learning development and growth, all the interviewees (N=26) were asked the question, 'what do you think are the favorable factors for m-learning?' Numerous responses were received and coded around six (6) themes. The six themes were then ranked from the most frequent (1 being the most frequent, 2 the lesser frequent, and so on) to the least frequent. The themes are presented in *Table 4.23* below.

Table 4.23: Favorable Factors for M-Learning

Favorable Factors to M-Learning	Frequency	Rank Order
Increasing permeation of mobile phones amongst the populace	67.7% (n=18)	1
Increasing coverage of mobile telecommunication networks	64.6% (n=17)	2
Government policies on telecommunication investments	57.4% (n=15)	3
Existing e-learning infrastructure	44.8% (n=12)	4
Surfacing of distance learning units in conventional universities	21.3% (n=06)	5
The harsh economic and political situation in Africa	4.5% (n=01)	6

(N=26)

Table 4.23 above shows that the number one factor (67.7%) that was favorable to m-learning was the increasing permeation of mobile phones amongst the populace. Eighteen out of twenty six

responses (67.7%) chorused the high rate of mobile phone permeation as being a favorable factor for m-learning. This finding is collaborated by findings from a question in which learners in the survey were asked to state whether they communicated on mobile phones they owned or borrowed from other people. Over 96% of the learners said they communicated using their own mobile phones, while 3.8% said they used someone else's mobile phone. This indicates that all learners (100%) were able to obtain access to a mobile phone service. This trend mirrors itself in the general populace as well. People from all walks of life are embracing mobile telephony. As one of the respondents put it, "even my grandmother who is not able to read and write can be able to call me". Also mobile phones are starting to permeate into areas where they were traditionally prohibited. An interviewee, especially from South Africa said, "… some secondary schools in South Africa have begun letting students carry mobile phones to school". All these attributes are likely to favor the development and growth of m-learning.

Furthermore, *Table 4.23* above reveals that m-learning favorable factor number two (64.6%) was the increasing coverage of mobile telecommunications networks. For instance, at the time of this research, Uganda had five mobile network service providers, namely: MTN, Uganda Telecom, Zain, Warid Telecom and Orange Telecom (Uganda Communication Commission, 2008). The MTN network alone had a geographical coverage of 72.0% of Uganda's territory by January 2009 (MTN, 2009). Mobile network growth was not static. A telecommunications services provider said, "… with increasing competition in the telecommunications sector, new areas will increasingly be switched on by the different service providers". This will strengthen and expand the backbone for m-learning.

In position number three (57.4%) of m-learning favorable factors in *Table 4.23* above was favorable government policies on telecommunication investments. "Governments are pushing for competition in the mobile telecommunication sector and this is accelerating mobile tele-density among the populace and reducing tariffs", said a telecom service provider. Further, a one of the e-learning providers said, "… new telecommunications companies are being licensed into the mobile telecommunications business". The increasing number of telecommunications companies switching on their services provides favorable condition for m-learning.

Table 4.23 above placed the existing e-learning infrastructure as number four (44.8%) m-learning favorable factor. Structures and resources for ICT and e-learning support are in place in some universities. "At Makerere University we have a Directorate for Information and Communication Technology Support (DICTS) responsible for providing ICT technical support to all

Makerere University units", said an e-learning provider. The e-learning provider added, "… there is also an e-learning unit and an e-learning research group at Makerere University which can undertake more research in m-learning". E-learning infrastructure also exists at other universities in Africa. "For us at the University of Nairobi, we have an ICT Centre which is responsible for providing ICT services to entire University. M-learning is an ICT service and I guess it can be subsumed in our centre," said an e-content developer from the University of Nairobi. An e-learning provider from South Africa said, "… at the University of Cape Town (UCT), there is a Centre for Educational Technology (CET) responsible for providing all educational technology services to the UCT and we have been doing some research in m-learning". Another interviewee from West Africa added, "... in most universities in West Africa, we have campus wide optic fiber computer network backbones terminating into our universities' server rooms". This e-learning infrastructure and resources can be adapted to support m-learning since m-learning is a subset of e-learning.

Still drawing from *Table 4.23* above, the surfacing of distance learning units in conventional universities was number five (21.3%) factor that could favors m-learning. In this factor, one of the distance education academics said, "… many universities in Africa have setup distance learning and teaching units whose students could immediately benefit from m-learning". Another said, "… there is m-learning enthusiastic staff in departments of distance learning who have started their own personal initiatives to use mobile phones to support their learners". Further with increasing adoption of distance learning, "… university administrators, lecturers and students have started having a clear understanding of distance education thus making it easy to front m-learning as distance learner support platform", said a distance education administrator.

Surprisingly, *Table 4.23* above points to the harsh economic and political situations in Africa as being number six (4.5%) m-learning favorable condition! "… the harsh economic and political conditions force people to move from one place to another in 'search for economic survival' and yet at the same time going back to school". Another interviewee said, "… there are some instances of political instability in some countries in Africa and as such some people are always on the move yet they are studying". The nomadism brought about by the economic and political instabilities in Africa requires m-learning if the people involved are to be supported in their learning quest.

4.2.5 Barriers to M-Learning

To determine constraints that may infringe on the successful development and growth of m-learning, all interviewees (N=26) were asked the question, 'what do think are the barriers to m-learning in

universities?' Numerous barriers were received and coded around eight (8) themes. The eight themes were then ranked from the most frequent (1 being the most frequent, 2 the lesser frequent, and so on) to the least frequent. The themes and are presented in *Table 4.24* below.

Table 4.24: Barriers to M-learning

Barriers to M-learning	Frequency	Rank Order
High cost of m-learning	96.9% (n=25)	1
Technological limitations of mobile phones	89.7% (n=23)	2
Lack of policies and guidelines for m-learning	85.2% (n=22)	3
Negative mindsets to m-learning	70.2% (n=18)	4
Limited knowledge of use of all features of a mobile phone	54.9% (n=14)	5
Limited or lack of mobile network connectivity in some areas	45.7% (n=12)	6
Resistance from environmentalists	7.6% (n=02)	7
Political instability	4.5% (n=01)	8

(N=26)

The most important (number one) barrier to m-learning, as is shown in *Table 4.24* above, was the high cost of m-learning. Almost all (96.9%) the responses mentioned the high cost of m-learning as being a barrier to m-learning. The costs arise from technical, financial and human resource needs for implementing m-learning. One of the interviewees said, "… m-learning could be resented because of the high costs associated with it". Another said, "… sometimes the cost of a 160 character SMS is higher than the cost of a one minute voice call so m-learning may fail". A distance education administrator at Makerere University said, "… the implementation of our mobile broadcast system hit a snag because of the high cost of airtime and personnel to maintain the system. Therefore cost can hinder the success of m-learning". Regarding the cost of GPRS enabled mobile phones and mobile Internet, a telecommunication services provider said, "… the cost of GPRS enabled mobile phones and mobile Internet are still on the higher side for many students yet these are the main ingredients of m-learning". Thus cost is an important barrier to m-learning. A presentation of findings on the financial implications of using m-learning is made later on in *Section 4.2.6 (v)* ahead.

The second most important barrier to m-learning as is shown in *Table 4.24* above was the technological limitations of mobile phones. In *Table 4.24* above, 89.7% of the responses contended that m-learning would face a huge barrier arising from technological limitations of mobile phones. An e-content developer said, "… the inherent limitations of mobile phones and networking technologies at play determine how much content to be deployed on any mobile device. So we may not be able to deploy content on some families of mobile phones". Also, learners own a myriad of

mobile phones from low through to high end ones as was discovered from the results of a question in the survey which asked learners to indicate the networking technologies that were accessible on their mobile phones. In this question, it was established that, on average, only 32.0% of the learners owned mobile phones with high end features such as GPRS, Bluetooth, Wi-Fi, GPS and RFID. A big percentage (68.0%) of learners only owned low end mobile phones (see *Table 4.27* below). These findings are collaborated by a response from one of the interviewees, who said, "… phones brought into Africa are of low quality, low life span and low capability". It means that learning activities requiring intensive computational power may not be possible on such low end mobile phones. This presents quite a significant barrier to m-learning especially if resource rich computers are readily available. For instance, an interviewee from a resource rich university in South Africa said, "… m-learning is difficult to justify where all students own desktop or laptop computers and have access to Wi-Fi Internet at their university campuses". He asked, "… what will such learners want from such little tiny devices"?

The third most important barrier to m-learning as is shown in *Table 4.24* above was lack of policies and guidelines for m-learning. In *Table 4.24* above, 85.2% of the responses contended that m-learning would face a huge barrier because policies and guidelines for its development and growth are lacking in almost all universities in Africa. "… there is no way m-learning can thrive under the current conditions were there are numerous restrictions imposed on the use of mobile phones in secondary schools, classrooms, libraries, etc., without enabling policies and guidelines", said an e-learning provider. Another interviewee said, "… existing ICT policies are not adequate enough to address the unique requirements of m-learning. If the status quo is left as is, m-learning will fail". One of the distance education administrators said, "… there is a lot of red tape in our conventional universities which might hinder the success of this innovation". There is therefore need for an enabling m-learning policy.

The fourth most important barrier to m-learning as is shown in *Table 4.24* above was the general negative mindset to m-learning from people. In *Table 4.24* above, 70.2% of the responses contended that m-learning would face resistance due to negative mindsets towards it. Almost all educated people have been taught through the conventional classroom system and yet they are the ones in positions of responsibility in universities and colleges. They may not readily accept a mobile phone as a tool to learn with. One of the responses in this theme went as follows, "… I only trust graduates from face to face classroom learning environments. I can not be comfortable with a doctor who graduated through m-learning performing an operation even on a boil in my leg"! Another

respondent said, "… through m-learning, we shall produce half baked graduates". Another said, "… people perceive a mobile phone as a device to talk with and not to learn with". These fears in people's mindsets are an important force to reckon with and therefore must be allayed if m-learning is to be accepted.

The fifth most important barrier to m-learning as is shown in *Table 4.24* above was the limited knowledge of use of all features of a mobile phone. In *Table 4.24* above, 54.9% of the responses indicated that limited knowledge on how to use all the features of a mobile phone could be a hindrance to m-learning. Limited knowledge about ones mobile phone was blamed on numerous causes. According to one of the interviewees, one of the causes was, "poor reading culture". The interviewee added, "… most people do not read user manuals of their mobile phones due to lack of interest or failure to secure one at the time of mobile phone purchase. Most second hand mobile phones sold in Africa do not come with their user manuals". Another interviewee expressed the mobile phone use 'illiteracy' as follows, "... children are more literate in mobile phone usage than their parents who own the mobile phones. The children of today are digital natives while their parents are digital squatters". The limited knowledge on how to use mobile phones enslaves them to their orthodox uses of placing and receiving text messages and voice calls only. Related to the limited knowledge on how to use mobile phones is the factor of lack of appropriate human resources. "…. m-learning can be hindered by lack of m-learning technical staff, limited staff enthusiasm, commitment and confidence and general ignorance about m-learning", said a software developer.

The sixth most important barrier to m-learning as is shown in *Table 4.24* above was limited or lack of mobile network connectivity in some areas. In *Table 4.24* above, 45.7% of the responses indicated that limited or lack of mobile network connectivity in some areas could hinder m-learning. In this study, 10.2% and 18.7% of the learners strongly disagreed and disagreed respectively to the contention that mobile network connectivity was available at all times in their usual learning environments (see *Table 4.5* above). This finding is collaborated by a response from a telecommunications services provider thus, "… our telecommunications network does not cover each and every inch of Uganda. Therefore there is possibility that a mobile learner can find him/herself in an area with no mobile network connectivity, which may hinder m-learning".

The seventh barrier to m-learning as is shown in *Table 4.24* above was resistance from environmentalists. In *Table 4.24* above, 7.6% of the responses indicated that industrial action from environmentalists may bar m-learning. One of the respondents said, "… environmentalist could

demonstrate against the introduction of m-learning on account of lack of proper disposal policies and plans for the mobile waste". Another interviewee asked, "… how can we dispose off the mobile phones waste that will result from the sustained use of m-learning? These barriers may only be solved if there is a proper and operational electronic waste disposal policy and plan.

The least (eighth) barrier to m-learning mentioned by 4.5% of the responses in *Table 4.24* above was political instability. One of the interviewees said, "… political instability in some African countries may hamper m-learning because learners may loose their mobile phones in the process of scampering for safety". Another interviewee, said, "… there will be disruptions in m-learning during times of war as mobile network connectivity might be cut off".

4.2.6 State of M-Learning Resources

M-learning just like any other learning models requires technical, human and financial resources to thrive. In this section, we present the available m-learning resources vis-à-vis the required ones in order to gauge the level of development of m-learning resources in Africa. On the technical side, since the mobile phone has been found to be the number one resource for m-learning in Africa (Brown, 2005), we first profile its permeation statistics in *Section 4.2.6 (i)* and then in *Section 4.2.6 (ii),* we establish the capabilities and limitations of learners' mobile phones. In *Section 4.2.6 (iii)* and *Section 4.2.6 (iv)* the human and infrastructural resources available for m-learning and those that are needed to support it are respectively presented. The financial implications of using m-learning are given in *Section 4.2.6 (v)*

i Mobile Phones Permeation Statistics

In a question to establish the ownership of the mobile phone that a learner frequently used for communications, it was established that over 96% of learners always used their own mobile phone while only 3.8% always used someone else's mobile phone. These findings indicate a high rate of mobile phone permeation and use amongst learners. A similar trend is evident in the mobile phone permeation statistics of Africa as a whole as is shown in *Table 4.25* below.

Table 4.25: Mobile Phone Permeation Statistics in Africa

Country	2002 ('000)	2007 ('000)	CAGR (%) 2002 - 2007	Per 100 Inhabitants	As % of Total Tel Subscription
Congo Brazzaville	221.8	1,287.6	42.2	34.17	97.2
Ethiopia	50.5	1,208.5	88.8	1.45	57.9
Ghana	386.8	7,604.1	81.4	32.39	95.3
Kenya	1,187.1	11,349.4	57.1	30.23	97.7
Lesotho	138.0	456.0	27.0	22.71	87.1
Nigeria	1,569.0	40,395.6	91.5	27.28	96.2
South Africa	13,702.0	42,300.0	25.3	87.08	90.3
Uganda	393.3	4,195.3	60.5	13.58	96.3
Zambia	139.1	2,639.0	80.1	22.14	96.6
Zimbabwe	338.8	1,225.7	29.3	9.14	78.1
Africa	36,923.8	274,623.9	49.4	28.49	89.7

Source: Extract from ITU (2007a)

The rate of mobile phone subscription growth or permeation, measured by the International Telecommunication Union (ITU) using the Compound Annual Growth Rate (CAGR), posits a rosy picture for Africa. Compound Annual Growth Rate (CAGR) is the year over year growth rate applied to an investment or other part of a company's activities over a multiple-year period (ITU, 2007a). In this case, the CAGR is the year over year growth rate or permeation of mobile phone subscription. *Table 4.25* above presents the permeation statistics of mobile phones in selected African countries and Africa as a whole. The countries in *Table 4.25* above are those from which interview participants were selected (see *Section 3.3.1)*.

Table 4.25 above shows that by 2007, the majority of inhabitants in Africa had mobile phones, represented by 89.7% of the total telephone subscription. In particular, from the countries considered in *Table 4.25* above, mobile phones contributed 97.7% (highest) and 57.9% (lowest) of Kenya's and Ethiopia's total telephone subscription respectively. However, in Africa as a whole, mobile phones constituted 99.9% of the total telephone subscription in the Democratic Republic of Congo (highest) and 57.9% in Ethiopia (lowest) (ITU, 2007a). These statistics indicate that landline telephone subscription is by far very minimal in the majority of African countries. Under such circumstances, e-learning solutions based on mobile phones connectivity can reach a bigger population than those based on landline phone connectivity. The World mobile phone permeation statistics is not any different from that in *Table 4.25* above as is seen in *Table 4.26* below.

Table 4.26: Mobile Phone Permeation Statistics in the World

Continent	2002 (000)	2007 (000)	CAGR (%) 2002 -2007	Per 100 Inhabitants	As % of Total Telephone Subscribers
Africa	36,923.8	274,623.9	49.4	28.49	89.7
Americas	355,451.3	666,133.3	21.1	73.22	70.5
Asia	443,937.4	1,514,586.4	27.8	38.10	70.8
Europe	405,447.7	896,597.2	17.2	111.14	73.3
Oceania	15,458.9	27,011.5	11.8	79.39	69.2
WTI	1,257,219.1	3,378,952.4	23.9	50.51	72.6

Source: Extract from ITU (2007a)

From *Table 4.26* above, it is evident that Africa had the highest CAGR of 49.4% and the Oceania, the least of 11.8%, between 2002 and 2007. In the entire World, Africa was number one in as far as mobile phones as a percentage of total telephone subscription (89.7%) was concerned. This puts Africa as the continent with the highest mobile to landline telephone ratio of about 9 mobile phones to 1 landline phone. However, *Table 4.26* above shows that Africa had the least (28.49) number of mobile phone subscribers per 100 inhabitants. Whereas the growth rate of mobile phones subscription is highest in Africa; many inhabitants in Africa are yet to subscribe to a mobile phone service. For the mobile telecommunication companies, this is a big untapped market assuming that the unsubscribed inhabitants have the financial means to purchase and maintain a mobile phone. In Europe, *Table 4.26* above shows that there were 111.14 persons per 100 inhabitants with a mobile phone. This means that some inhabitants in Europe owned more than one mobile phones.

The individual country mobile phone permeation rates as is seen in *Table 4.25* above and World permeation rates as presented in *Table 4.26* above indicate that mobile phones have surpassed the landline phones as tools for communication. Consequently, applications (such as e-learning) that used to be a preserve for landline telephone can now be extended to the mobile phone. With the flamboyant mobile phone growth statistics in Africa, m-learning is poised to thrive. However, the varied capabilities and limitations of mobile phones owned by learners in Africa have to be leveraged and mitigated for successful m-learning. In the following section, the study presents the capabilities and limitations of mobile phones owned by learners.

ii Capabilities and Limitations of Learners' Mobile Phones

The extent of use of a mobile phone for m-learning depends on its capabilities and limitations

(Caudill, 2007, Grant *et al.,* 2007). All mobile phones, including low end mobile phones, can place and receive text messages and voice calls using the GSM protocol. This means that GSM networking technology is compatible with all generations of mobile phones. It was therefore important to establish whether learners' mobile phones had additional features compatible with high end mobile phone networking technologies. Features investigated included: GPRS, Bluetooth, WAP, GPS and RFID. Learners were asked to indicate whether their mobile phones could access the above mentioned mobile networking technologies (see *Section 2.1.6* for a detailed review of these technologies*).* The findings on the compatibility of learners' mobile phones with high end mobile networking technologies are presented in *Table 4.27* below.

Table 4.27: Capability of Learners' Mobile Phones

Networking Technology	Available	Not Available	Not Sure
GPRS	56.3% (n=245)	34.3% (n=149)	9.4% (n=41)
Bluetooth	28.0% (n=122)	55.9% (n=243)	16.1% (n=70)
WAP	33.6% (n=146)	53.8% (n=234)	12.6% (n=55)
GPS	18.9% (n=82)	56.3% (n=245)	24.8% (n=108)
RFID	23.4% (n=102)	48.7% (n=212)	27.8% (n=121)
Average	32.0%(n=139)	49.8%(n=217)	18.2%(n=79)

(N=435 because 11 participants did not own mobile phones)

For learners to be able to connect to the Internet and access m-learning objects and services using their mobile phones, the GPRS feature is the most important and relevant of all features on the phone. From *Table 4.27* above, it can be seen that 56.3% of the learners surveyed had the GPRS feature on their mobile phones. About 34% of the learners did not have the GPRS feature while 9.4% were not sure whether their mobile phones had a GPRS feature. Learners who were not sure of the presence of GPRS on their mobile phones are a case of persons who never bother to explore their mobile phones for other features other than those used for placing and receiving calls and text messages. On average, 18.2% of the learners were not sure of the presence of GPRS, Bluetooth, WAP, GPS and RFID features on their mobile phones. Such a scenario calls for mobile phone user education. Also concerted efforts to encourage learners to acquire mobile phones with comparable and vital m-learning capabilities are necessary because only 32% of the learners had mobile phones with high end features.

We further established the capabilities of mobile phones in terms of what learners could do on their mobile phones. The results are presented in *Table 4.28* below. *Table 4.28* below shows that all (100%) learners who had mobile phones, could place and receive voice and text messages. These are

functionalities which cut across the continuums of all mobile phone generations, brands and families. *Table 4.28* below also indicates that high end mobile phone functionalities were possible on mobile phones of between 15.9% and 43.2% of the learners as is shaded in *Table 4.28* below. Indeed, this range accommodates the average of 32.0% of the learners who had mobile phones with high end mobile networking technologies as is shown in *Table 4.27* above. Again, if m-learning utilizing high end mobile phone functionalities were to be introduced under the prevailing circumstances, over 50% of the learners would be disadvantaged. These learners would need to acquire high end mobile phones and partake of mobile phone user education.

Table 4.28: Possible Functionalities on Learners' Mobile Phones

With my mobile phone I can …	True	False
Make/receive voice calls	100% (n=435)	0.0% (n=0)
Send/receive text messages	100% (n=435)	0.0% (n=0)
Record audio and play it back	43.2% (n=188)	56.8% (n=247)
Access the Internet	42.1% (n=183)	57.9% (n=252)
Send/receive e-mails	41.6% (n=181)	58.4% (n=254)
Take/send/receive a photograph	40.5% (n=176)	59.5% (n=259)
View documents and images	34.3% (n=149)	65.7% (n=286)
Use Bluetooth technology	27.8% (n=121)	72.2% (n=314)
Record and view movies	22.3% (n=97)	77.7% (n=338)
Install mobile applications on it	19.3% (n=84)	80.7% (n=351)
Interact with the applications installed on it	18.4% (n=80)	81.6% (n=355)
Read, edit and handle computer files	15.9% (n=69)	84.1% (n=366)

(N=435 because 11 participants did not own mobile phones)

From *Tables 4.27* and *4.28* above, it is evident that learners own a myriad of mobile phones ranging from low end through to high end generation order. It is also evident that some learners are unaware of the features on their mobile phones. An m-learning pedagogy benefiting from these devices should be that which blends the m-learning services onto low through to high end mobile phones. Some learners (18.2%) being unaware of the existence of high end features on their mobile phones, is an indication of the need for mobile phone user education. Further, fewer learners (56.3%) having mobile phones with the GPRS (most important for Internet connectivity) feature calls for encouragement of the learners to acquire mobile phones with this feature.

Mobile phone ownership and capability parse are not enough to complete the m-learning resources equation. Human and infrastructural resources are also necessary. In the section that

follows, we present the result of an investigation into the human and infrastructural resources available for m-learning.

iii Human and Infrastructural Resources Available for M-Learning

In *Sections 4.2.6 (i)* above, we have shown that technical resources such as mobile phones are available in Africa for m-learning. These resources need to be augmented with m-learning human and infrastructural resources if m-learning is to happen. It was therefore important to establish the human and infrastructural resources available for m-learning. E-learning providers, university administrative and academic staff, instructional designers and content and software developers (N=24) were asked the question, 'what resources have you put in place in your organization to enable the development, deployment and utilisation of m-learning objects?' We chose to establish available resources for m-learning object development, deployment and utilisation because m-learning thrives on exchange of information cum learning objects via mobile devices. The findings are presented in *Table 4.29* below:

Table 4.29: Available M-learning Human and Infrastructure Resources

Resources	Available	Not Available
Human + infrastructure resources for m-learning objects development, deployment and utilisation	12.5% (n=03)	87.5% (n=21)
Financial resources for m-learning objects development, deployment and utilisation	12.5% (n=03)	87.5% (n=21)
Human + infrastructure for e-learning objects development, deployment and utilisation	83.3% (n=20)	16.7% (n=04)

(N=24)

From *Table 4.29* above, it is evident that there were very limited (12.5%) human, infrastructural and financial resources specifically put in place to support m-learning object development, deployment and use. What was commonly available in some universities were some human and infrastructural resources for e-learning objects development, deployment and use (83.3%). One of the interviewee said, "… we do not have any human or infrastructural resources for m-learning because m-learning is non-existent in my university. We only have some resources and infrastructure for e-learning". Another said, "… we have never budgeted for m-learning in my university". The few interviewees (12.5%) in *Table 4.29* above, who indicated that there were some resources for m-learning mainly hailed from Uganda and South Africa. A software developer from Uganda said,

> At Makerere University, in the Faculty of Computing and Information Technology, we have a mobile computing laboratory for mobile computing software development. The department involved in this endeavor is the Department of Software Innovation. This Department has a donation of a mobile computing laboratory from Nokia. The laboratory has 15 Nokia N95 programmable mobile phones and is manned by three mobile applications developers. The laboratory has inter-networked desktop computers each installed with Python software for developing mobile applications. The laboratory benefits a host of students and staff carrying out projects in mobile applications software development.

Whereas the efforts in the above response are not aimed at m-learning per se, they could be adapted to benefit m-learning. Another trickle of evidence of m-learning objects development, deployment and utilisation human resource and infrastructure was found at the Department of Distance Education at Makerere University, Uganda. A distance education administrative staff said,

> We have a mobile research supervision initiative and a mobile broadcast system, all of which depend on SMS based learner support mechanisms. However, the mobile broadcast system is not presently working because of technical and financial reasons. We outsourced a company to develop and maintain it yet the department was financially constrained. When the money ran out, its developers disabled it. However, funds are being solicited and mechanisms for maintenance put in place to have the system brought back to life.

The above response amplifies the evidence in *Table 4.29* above which indicates that human, infrastructural and financial resources for m-learning were in very limited supply.

Further in *Table 4.29* above, 83.3% of the interviewees said there were some human and infrastructural resources for e-learning objects development, deployment and use in some universities. Since m-learning is a subset of e-learning, some universities were using the e-learning infrastructure to support m-learning. One of the distance education administrators at Makerere University said,

> Even in the absence of the mobile broadcast system, its legacy can be seen amongst the staff of the department. Members of staff have continued using the free Internet to mobile phone text messaging services to reach out to distance learners. Using their office desktop computers, they send to students' mobile phones academic and administrative support SMSs. What staff are missing in the switched off mobile broadcast system is its ability to keep a database of the SMSs sent out and ability to support more than one mobile networks.

Another distance education administrator said,

> … in some instance we support our learners through voice calls. Any lecturer who wishes to get in touch with a particular student or group of students is free to ask the receptionist to call such a student (s). In other instances, lecturers use their personal mobile phones to communicate with their students.

In addition to learners' mobile phones and the general e-learning infrastructure, the above findings imply that staff personal mobile phones are part and parcel of the infrastructure that is needed for

institutional m-learning. Consequently, as institutions plan for learners' mobile phones, they ought to plan for those of staff as well and put in place appropriate human and infrastructural resources for m-learning.

In as far as human, financial and infrastructural resources for learning objects development, deployment and utilisation were concerned; the study noticed a somewhat bigger stride in that direction in South Africa. An e-learning provider from the Centre for Education Technology, at the University of Cape Town said, "… we have for a long time experimented with m-learning. So we have some resources set aside for it. We even have a professor in m-learning". Another interviewee from South Africa, said, "… at the University of Pretoria, the Distance Learning Unit has invested heavily in an m-learning student support system". Literature (SAIDE, 2008) has also indicated heavy investments in m-learning projects at various secondary schools in South Africa (see *Section 2.1.8* above).

iv Human and Infrastructural Resources Needed for M-Learning

Having seen the dearth in m-learning resources, it was important to establish exactly what resources were needed for m-learning object development, deployment and use. This information was provided by answers to the question, 'in your opinion, what human and technological infrastructure resources are needed to enable the development, deployment and utilisation of mobile learning objects?' This question was paused to e-learning providers, university administrative and academic staff, instructional designers and content and software developers (N=24). Several resources were mentioned and coded around five (5) themes as can be seen in *Table 4.30* below. The themes were ranked from most frequent, ranked as 1, to the next frequent, ranked as 2, and so on, until the least frequent.

Table 4.30: Necessary M-learning Resources

Resources	Frequency	Rank Order
Flexible managers, administrators, lecturers and learners	100% (n=24)	1
Financial resources	91.7% (n=22)	2
Mobile technological infrastructure	83.3% (n=20)	3
Technical m-learning staff	79.2% (n=19)	4
Enabling policy	45.8% (n=11)	5

(N=24)

Table 4.30 above indicates that flexible m-learning policy makers and users are the number one

needed resource for m-learning's success. All the interviews (100%) indicated that flexible managers, administrators, lecturers and students are needed for m-learning's success. One of the interviewees said,

> A rigid university staff stifles curriculum innovations. Hence a flexible university management and academic and administrative staff willing to adopt/adapt to innovations in core educational practices is at the core of human resources that are needed for m-learning. Further, flexible learners that are willing to experiment with technological innovations are an important ingredient in the successful implementation of m-learning. M-learning thrives best in flexible learning environments.

Another interviewee said, "… it is incumbent upon the university management to fund learning innovations. If they don't fund m-learning, it won't take off. The lecturers should undertake research in new teaching innovations while the learners should accept the innovations".

The second (91.7%) most important resources needed for m-learning as is indicated in *Table 4.30* above are financial resources. "… once financial resources are available, all other m-learning resources can be obtained", said one of the content developers. "… m-learning is a costly venture therefore financial resources are needed", said another interviewee. A presentation of results on the financial implications of using m-learning is given in *Section 4.2.6 (v)* below.

The third (83.3%) most important resource needed for m-learning as is shown in *Table 4.30* above is the mobile technological infrastructure. One of the interviewees said, "… we need computers, fast Internet connectivity, e-mail, high end mobile phones, mobile network connectivity, learning management systems, local area networks (wired and wireless) and mobile applications development software". In this research we have deduced that the lecturers' mobile phones are part and parcel of the m-learning infrastructure that an institution should plan for.

The fourth (79.2%) most wanted resources for m-learning as is shown in *Table 4.30* above are technical m-learning staff. This staff is responsible for the development and nurturing of m-learning. One of the e-learning providers said,

> M-learning technical staff should include: m-learning researchers, systems analysts, mobile applications programmers, technicians, instructional and graphic designers, content developers and domain experts. This human resource could be part of a one stop e-learning centre where e- and m-learning applications, research and innovations are churned out for the benefit of the entire university community. The staff in the e-learning centre should be able to offer continuous support for content development and train staff and students of the university in e- and m-learning best practices.

Though not a human or infrastructural resource, as is required in *Table 4.30* above, an enabling m-learning policy was mentioned by 45.8% of the interviewees as a needed resource for supporting the

development and growth of the right m-learning human and technological infrastructure. "… you can not commit resources for m-learning without an underpinning enabling policy", said one of the interviewees. Another said, "… e-learning has failed to take off in many universities in Africa because of lack of appropriate policies. If this state of affairs is extended to m-learning, it will also fail".

v Financial Implications of Using M-Learning

In *Section 4.2.5* above, it was established that high cost of m-learning was its number one barrier. In this Section, we provide the financial implications of using m-learning by presenting the total cost of mobile phone communication (*TCMPC*) for an m-learner and a m-learning cost sustainability plan (*MLCSP*) as were suggested by respondents.

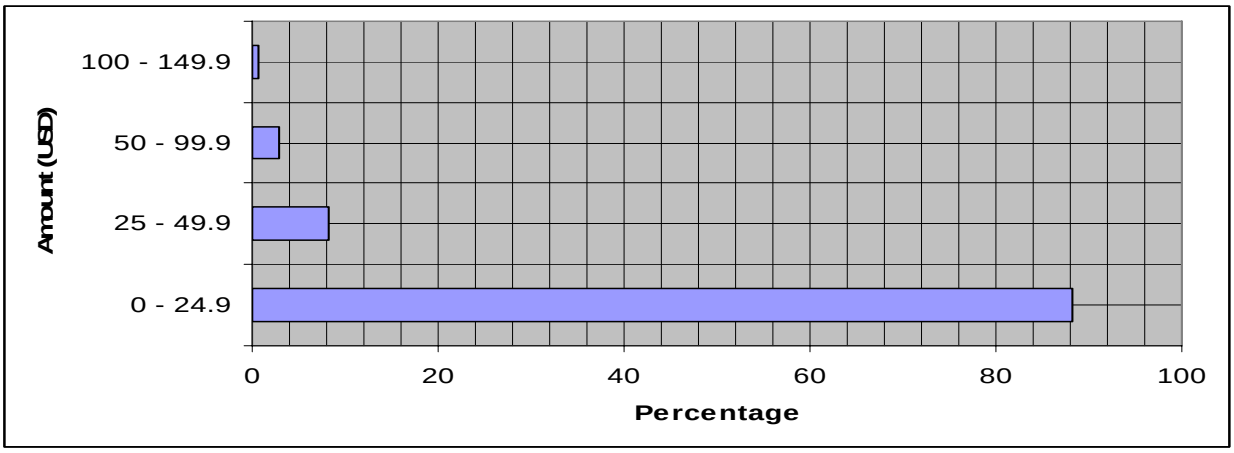
a. Total Cost of Mobile Phone Communication

M-learning costs emanate from the cost of acquiring and maintaining m-learning equipment, infrastructure, content and personnel. Additionally, it is also engrained in the cost of communication or the cost of mobile phone credit commonly referred to as 'airtime' in Africa. In the rest of this dissertation, we refer to mobile phone credit as 'airtime'.

Also in this same study, it has been reported that the mobile broadcast system installed at the Department of Distance Education, Makerere University, was not working (refer to *Section 4.2.6 (iii)* above) because its developers had disabled it due to non payment by the user department. Cost is therefore a central factor in m-learning. We therefore asked learners the question, 'who pays the bulk of your mobile phone bills?' This question was important for establishing the source of funding among learners for airtime. It was established that the majority (88.5%) of learners footed their own airtime bills. Some 9.2% of the learners had their bills met by their parents while only 1.8% of the learners had their bills met by their spouses or partners. A paltry 0.5% of the learners had their bills met by their employers. These statistics indicate that the burden of footing communications costs fell directly on the learners' shoulders.

To determine how much cost they incurred for mobile phone communication, learners were asked to provide their average monthly mobile phone bill (airtime cost). The results are presented in *Figure 4.1* below.

Figure 4.1: Learners' Monthly Airtime Costs



Source: Survey Questionnaire. The cost herein is at January 2009

An analysis of learners monthly airtime cost established a range USD 0 to 129 in expenditure on airtime by learners. However, from *Figure 4.1* above, the majority of learners (88%) were able to afford airtime worthy between USD 0 to 24.9 per month, implying that this was the modal class. On average, a student in Uganda spent USD 13 per months on airtime. Results further indicated that a USD 0 expenditure on airtime was experienced by 9.4% of the learners and the maximum of USD 129 by just one learner. An airtime expenditure of USD 0 means that the 9.4% of the learners owned mobile phones but did not top them up with airtime. They used their mobile phones to only receive calls and SMSs. Also, the average monthly airtime expenditure of USD 13 was on the lower side for sufficient collaboration and interaction during the learning process. A lot more money would be required for airtime in order to partake of m-learning.

With an average monthly airtime expenditure of USD 13, a learner subscribing to the MTN network in Uganda with a tariff plan of USD 0.19 per minute of voice call and USD 0.08 per text message (Uganda Communications Commission, 2008), would have 68 minutes of voice calls or 162 text messages in a month. This airtime is insufficient especially if one recognizes the fact that m-learning competes with other non m-learning communications needs. In *Section 4.2.1, Table 4.18* above, we established that education/learning was not the only purpose for placing text messages and voice calls. Whether it is for learning or not, airtime credit is spent when one makes a call, sends a text message or transmits data on his/her mobile phone. It can therefore be deduced that the total cost of mobile phone communication (*TCMPC*) for a learner participating in m-learning is made up of two components, namely: the m-learning and non m-learning cost components (*refer to Figure 4.2* below). Following from this deduction, we have come up with an equation for calculating the

total cost of mobile phone communication (*TCMPC*) for a learner involved in m-learning in a specified period of time.

Figure 4.2: The Total Cost of Mobile Phone Communication Equation for an M-Learner

		M-learning communications costs		Non m-learning communication costs
TCMPC	=	$L_{call}T_{call} + L_{sms}T_{sms} + L_{data}T_{data}$	+	$O_{call}T_{call} + O_{sms}T_{sms} + O_{data}T_{data}$

Where

TCMPC = Total Cost of Mobile Phone Communication

L_{call} = Call duration in minutes used for m-learning purposes

T_{call} = Tariffs per minute of voice call

L_{sms} = Number of SMS sent for m-learning purposes

T_{sms} = Tariffs per SMS sent

L_{data} = Amount of data downed/uploaded for m-learning purposes

T_{data} = Tariffs per unit of data downed/uploaded

O_{call} = Call duration in minutes used for non m-learning communication purposes

O_{sms} = Number of SMS sent for non m-learning communication purposes

O_{data} = Amount of data downed/uploaded for non m-learning communication purposes

Note: The equation does not include the cost of acquiring a mobile phone

Expressed in another way;

$$TCMPC = Call(L, O)T_{call} + SMS(L, O)T_{sms} + Data(L_{du}, O_{du})T_{data}$$

Where

$Call(L, O)T_{call}$ = Total cost for calls made for learning and other purposes in a given period

$SMS(L, O)T_{sms}$ = Total cost for SMS made for learning and other purposes in a given period and

$Data(L_{du}, O_{du})T_{data}$ = Total cost for data downed/uploaded for learning and other purposes

Assume a learner subscribed to the MTN network and used 60 minutes daily for 30 days in teleconferencing sessions discussing with group members on how to solve different learning

problems. At the MTN tariff of USD 0.19 per minute of voice call (Uganda Communications Commission, 2008); such a m-learner would require USD 342 to participate in the daily 60 minutes teleconference for 30 days. He/she would require USD 1,268 for a semester of 120 days (4 months). Note that the latter and former m-learning costs are for an m-learner who did not send any SMSs, down/upload data and make any call for non m-learning activities. The costs would go higher if the m-learner participated in non m-learning activities as well. By all standards, these are very astronomical costs for a Ugandan student whose per capita income is only USD 340 (ITU, 2007c). Likewise, other learners on the African continent would find such costs as being unaffordable. Poverty levels in Africa are high (UNDP, 2006). The costs would only go down if the learner communicated less on his mobile phone, a thing which is detrimental to m-learning. If it were not for cost reasons, an m-learner would require unlimited use of his/her mobile phone. Therefore the high cost of communication affects the learners' ability to freely interact with each other and their lecturers on their mobile phones. This calls for an m-learning cost sustainability plan.

b. M-Learning Cost Sustainability Plan (MLCSP)

The high cost implication for developing, accessing, delivering and utilizing m-learning requires a proper sustainability plan. Survey and interview respondents were asked in an open ended question to suggest the most sustainable way for implementing m-learning activities in educational institutions? The results from the survey are presented in five (5) themes/plans in *Table 4.31* below and triangulated with interview results as they are presented. The five themes/plans are ranked from the most frequent (ranked as 1), to the lesser frequent (ranked as 2), and so on until the least frequent.

Table 4.31: M-Learning Cost Sustainability Plan (*MLCSP*)

Suggestion/plan	Frequency	Rank Order
Provide user friendly billing and payment mechanisms	30.3% (n=73)	1
Empower individual learners to meet their own m-learning bills	24.5% (n=59)	2
Subsidize m-learning services	20.3% (n=49)	3
M-learners should adopt cheaper communications strategies	12.9% (n=31)	4
Provide toll free m-learning services to registered students	12.0% (n=29)	5

241 responses were received for this open ended question in the learner survey

In *Table 4.31 above,* the number one m-learning sustainability plan as suggested by the majority of learners (30.3%) was providing user friendly billing and payment mechanisms for mobile

telecommunications services. One of the learners wrote, "… telecommunications companies should charge flat bills for a given period and permit unlimited calls". Another learner indicated, "… there should be contractual billing where mobile phone users sign a contract to call freely for a given period of time". Another learner wrote, "… telecoms should allow several methods of credit topping up such as using ATM cards or automatically deducting airtime costs from a student's bank account or availing fixed period call cards".

The second (24.5%) most important plan for sustaining m-learning as is shown in *Table 4.31* above was empowering individual learners to meet their own m-learning bills. M-learning personalizes learning (Caudill, 2007) and therefore it is used at learner's own convenience. Learners accepted to meet their own m-learning costs on conditions that they are empowered to do so. "It is appropriate for me to manage my own learning in m-learning and as such I need to pay my own bills. What I need is to be provided with enough financial resources from my sponsors", said one of the learners. The sponsors might be parents, guardians, employers or scholarship institutions. Another student wrote, "… let us be given part-time jobs in and around campus to boost our incomes then we will pay for m-learning". Another said, "… provide us with airtime loans guaranteed by the university".

The third (20.3%) most important plan for sustaining m-learning as is shown in *Table 4.31* above was subsidization of m-learning services. Students invited subsidies for m-learning services from m-learning stakeholders who include: governments, telecommunications companies, universities, learners, parents and donors. While showing how governments can subsidize m-learning, one of the learners said,

> Governments could subsidize m-learning by reducing or removing taxes levied on educational related communications and providing conducive investment environments for telecommunications companies to invest in all parts of the country so as to create competition which breeds low costs and efficient services.

Within the theme of subsidizing m-learning as is shown in *Table 4.31* above, another learner wrote about how telecommunications companies could subsidize m-learning, thus,

> Telecommunication companies can subsidize m-learning services by reducing or removing tariffs on educational related communication services as part of their social corporate responsibility. For instance, telecommunication companies can provide concessions for a given period of time to telephone numbers in a certain range calling each other. The telephone numbers can be reserved for learning purposes and only be given to registered university students. On completion of their studies, the telephone numbers can be withdrawn and assigned to new students. Similarly, prominent mobile phone sellers in the country can be asked to provide subsidized mobile phones of a specific type and family that can be issued to students on their first registration in a university. This will avoid the

> complications that are inherent in extending m-learning to different phone types and families and ensure equity amongst learners. The telecommunication companies can as well permit use of their network infrastructure for hosting m-learning materials and systems and routing voice and data communications.

The pivotal role of telecommunications companies in subsidizing m-learning was echoed among some interviewees as well. While responding to an m-learning sustainability question the researcher asked during the E/merge 2008 online conference, a respondent wrote:

> … you may need to make a case with the different service providers so that they can pledge their support to the education of this generation as a pay back to the community. They should in their policies have a really small fee, for such communication. Borrowing the example of the copyright laws, we could have one on fair use.

The case being referred to by this respondent relates to the need to show case the business value of m-learning to the telecommunications companies or the need to package m-learning as social corporate responsibility obligation. Universities could initiate negotiations with telecommunications services providers and justify the business value of m-learning to them. Such negotiations could result into memorandums of understanding which spell out each party's contribution, behavior and expectations.

Another avenue telecommunications companies could employ to subsidize m-learning is by use of promotional schemes. A student wrote, "… telecommunications companies could subsidize m-learning through promotional schemes such as mega airtime bonuses, free SMSs and calls for a given amount of airtime credit and call discounts such as those provided in 'MTN Zone[1]', 'Warid Family and Friends[2]' and others". To establish whether there were any promotional schemes that learners had ever benefitted from, the study asked two questions in the survey which required learners to indicate the bonus airtime and free text messages (if any) that were included in their payment plan per month. Results indicated that some learners were already benefiting from some promotional schemes. On average, learners had four (4) free text messages and USD 0.5 worth of bonus airtime included in their payment plans per month. The range for free text messages was 0 to 90 while that for airtime was USD 0 to 23.5 per month. More of such promotional schemes could abet m-learning.

Still on m-learning subsidization, another learner wrote, "… m-learning could be subsidized through a cost sharing arrangement by the universities and the students".

[1] Phone calls tariff discounted based on an MTN subscriber's location and time
[2] Phone calls tariff discounted for WARID customers who chose to register their telephone numbers as a family

The fourth (12.9%) most important plan for sustaining m-learning as is shown in *Table 4.31* above was imploring m-learners to adopt cheaper communications strategies. "Learners should rationalize the use of the limited airtime by making only value for money calls during scheduled times of the day", wrote one of the learners. Relatedly, another learner suggested, "… learners should communicate mainly during off-peak and free call service times". Another learner indicated, "… let us invent a method of using 'beeps' or 'radio-call like language which can permit learners to communicate large amounts of information in few words". Another indicated, "… we should encourage the use of Internet to mobile communication and use of Internet telephony, for example, Skype or Voice over IP – VoIP". Another learner wrote, "… let us entrench the push strategy where students would mainly be on the receiving side for information". It was also suggested by another learner that, "… learners should subscribe to cheaper tariff plans of tariff offerings of their telecommunications service provider or they should be encouraged to participate in network syndication so as to enjoy within network benefits".

The fifth (12.0%) most important plan for sustaining m-learning as is shown in *Table 4.31* above was providing toll free m-learning services to registered students. One of the students said, "… the university should pay for m-learning services so that we get them toll free because the university has started charging us a technology fee". Owning up m-learning costs by the universities was also a view subscribed to by some content developers interviewed. One of them said;

> … introducing any new information system requires change management strategies that users can buy into when the system is meeting their needs. Change is not always a very easy thing. So it is nice to package change beautifully so as to avoid resistance to it. Universities should meet the costs of introducing m-learning and gradually pass them on to students after they have appreciated m-learning …

Another content developer said;

> I have a feeling that some of these things if started will never collapse. Though mobile phones have limitations, these will soon be history. Several years ago, when mobile phones were introduced in Uganda, they were only associated with 'sophisticated' people and some of us could not even think of having a mobile phone. You would think it is really very difficult to possess a mobile phone because it was extremely expensive to own and maintain one. Overtime, we have seen the emergence from China of high end mobile phones at affordable prices. Services on mobile phones are also becoming cheaper. Originally, telecoms used to charge a monthly service fee but at present they don't. Competition in the telecom sector is increasing and tariffs will soon drop. Costs of Internet access on mobile phones are also dropping. The number of persons accessing Internet on mobile phones is increasing. Because the costs are continuously declining, m-learning is likely to be sustainable. The only thing to think about is how to start. Universities must have seed money to kick start the innovation and it will go on. As they start the m-learning innovation, universities should not leave out the telecommunications companies, governments, sponsors, donors, parents and other stakeholders.

The above views suggest the need for universities to provide seed money to kick start m-learning and provide it free of charge (toll free) to students. Other stakeholders would then be drawn into supporting m-learning once its value is showcased. Also once started and everyone is onboard and comfortable with the innovation, costs can inadvertently be passed over to the beneficiaries.

Indeed, e-learning and distance education providers interviewed considered sustainability of m-learning as not being a 'big issue'. According to one of them, "… if m-learning is to be considered as a subset of e-learning then the infrastructure and mechanism for sustaining it are already in place in some universities. What is absent, are appropriate policies to address the use of m-learning and appropriate human resources to integrate m-learning within the e-learning systems". Another said,

> ... high costs are not a preserve of m-learning alone. M-learning follows the same cost trend that other information systems traverse. Systems are usually expensive to acquire or introduce after they have just been innovated but as they become common and readily available, their costs drop significantly. For example, the cost of Windows XP operating system at the time of its launch was higher than its cost today.

The above response supposes that m-learning costs would eventually decline. This is also the view of another respondent who said, "… due to increasing competition in the telecommunication sector and the ever declining costs of mobile devices, the cost m-learning will eventually decline significantly".

All the aforementioned m-learning sustainability plans relate to money. However, money is not the only input into system development and implementation. There is need for an appropriate and motivated human resource to design, develop, implement and use the information systems (Gasson, 1999). In light of this exposition, one of the e-learning providers suggested that, "... staff involved in promoting m-learning must be incentivized. The incentives could include: awarding points for promotion, giving certificates of recognition or providing monetary benefits". Another interviewees said, "… m-learning may alter the working hours of staff. Consequently, motivating staff is out of question if they are to work beyond official working hours". In other words, motivation will provide a catalyst for staff commitment to m-learning. Once staff are committed to using m-learning, students are likely to follow suit.

Staff aside, m-learning sustainability, also draws heavily from the students' side. How much is the student satisfied with the service? "… m-learning will not be sustained if learners do not accept it. For them to accept it, it must carry unique learning values", said one of the interviewees. "Having appropriate m-learning content, ICT skills and m-learning policies, strategies and guidelines are pre-requisites for students' acceptability of m-learning", said an e-learning provider. Another added, "…

having affordable access to m-learning devices, m-learning content and services and having readily available technical support services are important factors for students' acceptability of m-learning". Once students accept m-learning, then it can be sustained.

4.2.7 Perceptions and Opinions Towards M-Learning

This section presents results from all respondents on questions which required them to give their views or opinions towards m-learning. The purpose of these questions was to gauge the readiness of the environment for m-learning. In information systems, the environment in which a system operates is an important factor for such a system's successful deployment (Gasson, 1999). The components of an information system include: hardware, software, users and the environment in which the system is operating (Williams, 2002; Gasson, 1999). *Section 4.2.7 (i)* below presents findings on interviewees' views on delivering and utilizing learning objects onto learners' mobile phones. *Section 4.2.7 (ii)* presents findings on respondents' opinions towards the general concept of m-learning while *Section 4.2.7 (iii)* presents findings on the perceptions of the general public towards m-learning.

i Views on Delivering and Utilizing Learning Objects on Mobile Phones

Although mobile phones possess cost and technological limitations, they can be used to obtain access to and utilize learning objects. This conclusion was derived from responses to the question, 'What is your view on the issue of delivering learning objects onto learners' cell phones?' The question was put to all interviewees (N=26) in the study. Almost all interviewees (96.2% (n=25)) were agreeable to the idea of delivering and utilizing learning content onto learners' mobile phones and welcomed the innovation. Only one (1) interviewee (3.8%) was a little skeptical to the subject under caption. Here below, we present some of the positive views and suggestions espoused about the idea of delivering and utilising learning objects on mobile phones.

According to one of the software developers, "… through novel ways of managing the limited resources inherent in mobile phones and their associated infrastructure, mobile phones limitations can be mitigated". The software developer added, "… mitigation of the mobile phones limitations is aimed at enhancing learner comfort while utilising the learning objects". When asked how limitations of a mobile phone could be mitigated so as to permit deployment and utilization of learning objects on mobile phones, software developers suggested the following blended scenarios.

- Deploy a learning object together with an SMS containing a URL link to where it is warehoused and ensure that users of low end mobile phones only receive the SMS message with the URL link
- Utilize Internet cafes or high end mobile phones for accessing learning objects whose URL links are deployed through SMSs
- Download m-learning objects onto a mobile phone and then transfer them onto a standalone desktop computer using Bluetooth, infrared or USB cable.
- Introduce secondary storage devices such as flash disks, CDs and external hard disks for storage and transfer of information
- Add Micro SD (secure digital) memory in mobile phones to increase storage capacity
- Download a m-learning object onto a mobile phone and then use an external viewing device to increase the viewing comfort
- Deploy learning objects composed using universal media such as audio and text
- Deliver learning objects in a variety of media types (audio, video, images and text) depending on the learner's context
- Develop a special vocabulary for m-learning that can optimise the 160 characters of an SMS
- Using Bluetooth and infrared connectivity features to create adhoc networks for content distribution in a classroom
- Download m-learning objects onto the mobile phones and directly read them from there.
- Blend m-learning with e-learning

One of the aims in all the scenarios given above is to introduce and/or increase comfort in learning objects utilisation in an otherwise would be uncomfortable learning model. The other is to foster learning equity amongst learners with low and high end mobile devices. The scenarios assume a situation of lack of or limited desktop computer based Internet connectivity, a situation common in rural and semi-urban areas of Africa.

In another view that supported the idea of deploying and utilising learning objects on mobile phones, another interviewee said, "… delivering learning objects on mobile phones of learners in rural and semi-urban areas would bridge the learning objects divide that exists between them as a result of lack of access to desktop computer Internet".

Whereas the majority of interviewees (96.2%) were positive on the idea of deploying and utilising learning objects on mobile phones, caution was sounded by some of them on not relying entirely on mobile phones for learning objects delivery and utilisation. One of them said, "… yes, I support the idea, but, mobile phones can not be used as a sole platform for learning objects delivery. Mobile phones should just be supplementing desktop computers in e-learning". Another interviewee also advised on idea of using m-learning objects in a supplementary fashion. He said, "… the size of a m-learning object is likely to be smaller than an e-learning object, hence may not be able to provide all the learning experience needed by a given learner. M-learning objects should just supplement e-learning objects".

In this study it has been revealed that the size and media type of a learning object is dependant upon the memory capacity of the mobile phone in question, the networking technologies available

and the learning task at hand. A learning object may be expressed as text, graphics, audio, video, or as mixed media. Also in this study we have established that 32.0% of the learners had mobile phones with high end features (see *Table 4.27* above). Therefore learning objects to be deployed and utilised in this kind of context should be those that can benefit the majority of learners, that is, those that are portable within all mobile phone generation orders.

Still in support of learning objects delivery and utilisation on mobile phones, one of the telecommunications services providers said,

> Yes it is possible to deliver and utilize learning objects on mobile phones. 2.5G or 3G mobile phones (e.g. Nokia N95 8GB) and PDAs are capable of receiving GPRS/EDGE enabled Internet, reading PDF and Word files, transferring information via Bluetooth, connecting into a wireless LAN, storing large volumes of data and many more functions. Some of the 2.5G or 3G phones are more powerful than some desktop computers on the market in Africa. Moreover, the price for such powerful phones and PDAs is declining. A genuine Nokia N95 8GB phone from Korea is priced at about USD 882 while a 'duplicate' Nokia N95 8GB from China is priced between USD 153 and USD 265 on the Ugandan market. This means that high end mobile phones are no longer a preserve for the rich. Even the not so rich can own a 2.5G or 3G mobile phone or PDA but of a 'duplicate' nature. Purchasing second hand or 'duplicate' items is not a strange phenomenon to many people in developing countries. We in developing countries use second hand goods, such as clothes, cars, household items, mobile phones, computers, just to mention but a few. We have lived on like that and using a second hand powerful mobile phone for learning will not be strange to me. The important question I will ask myself will be, does it work?

In circumstances of poverty, it was the view of the above respondent that learners are encouraged to procure high end 'duplicate' mobile phones or PDAs that are cheap and function just as well as the genuine ones. This way, learners would have access to learning objects via their mobile phones.

Another respondents said, "… yes it is possible to deliver and utilize learning objects on resource constrained mobile phones provided there are standards for learning objects development and deployment. Standards enable all media types of learning objects to be delivered onto the resource constrained mobile phones". Other encouraging views about delivering and utilising learning objects on mobile phones as were espoused by some interviewees are cited below.

> Really I am impressed. I like the idea. It is a good move. It is a good way forward especially for distance learners in rural areas with no PC Internet access. Distance learners can access content anytime of the day/night with their mobile phones. They do not need to wait to go for residential sessions at the main campus and fetch content. They can work from anywhere for as long as they have a network connection. It is very possible and a great venture.
>
> ---
>
> That would be something very good because it will be supportive of learner mobility. Students would be able to learn wherever they are, even if they are traveling for as long as there is access to a mobile network. Indeed research done in Africa shows that there is a good response from students to m-learning. When learners are sent information via SMS they get a feeling that they are cared for. So I think delivering content to students on a mobile phone is a welcome innovation.
>
> ---

… I personally think it is the way to go since a good number of us have mobile phones

Source: Interviewee remarks

The sole respondent (3.8%) who was skeptical about learning objects delivery and deployment on mobile phones had this to say,

> There are things which facilitate learning and to me comfort is one of them. If I am struggling to see a word somewhere, there is no way you are going to expect me to pick whatever is being conveyed. So when content is intended for learning, it should be in a way that is easily viewed by a learner, easily accessible and readable. Now if you look at hand held devices they are becoming smaller and smaller …, though much more powerful. If we are to use them for learning then we really need to re-think the delivery of content. We might need to use voice or video as the media types for m-learning content because then one can be in a taxi or somewhere else and listen to or view the content. To me these are the two most important ways of delivering content, but via text, it pauses a bit of a problem.

The above response stemmed from limited resources of mobile phones which make it difficult to read text from their tiny screens. Therefore mitigation of mobile phones limitations is important.

ii Respondents' Opinions Towards the General Concept of M-Learning

As a new learning dispensation platform, it was important to establish learners' and interviewees' opinions towards the general concept of m-learning. We present, in *Table 4.32* below, the results of an open ended question paused to the learners regarding their personal opinions towards the general concept of m-learning and triangulate these findings with those obtained from other stakeholders interviewed on the same question. The results which are presented in *Table 4.32* below are ranked with 1 representing the most frequent view, 2 the next frequent and so on, for and against m-learning categories.

Table 4.32: Learners' Opinions Towards M-Learning

Opinion	Frequency	Rank Order
In Favor of M-learning	**65.5% (n=199)**	
M-learning is a good method of learning though it has limitations	43.4% (n=132)	1
M-learning is ubiquitous hence allows learning everywhere	13.8% (n=42)	2
M-learning is a good supplementary avenue to classroom learning	5.9% (n=18)	3
M-learning portrays technological development in the dot com age	2.3% (n=7)	4
Against M-learning	**34.5% (n=105)**	
M-learning should be discouraged	34.5% (n=105)	1

304 responses were received for this open ended question

From *Table 4.32* above, 65.5% (n=199) of the responses were in favor of m-learning while 34.5%

(n=105) were against it. In *Table 4.32* above, the number one (43.4%) most favorable opinion towards m-learning from learners in the survey was, 'm-learning is a good method of learning though it has limitations'. One of the responses in this theme was, "… m-learning is good but it comes with high costs of acquisition and maintenance. Moreover the devices enabling it are of a limited scope and have multiple restrictions imposed on them. Another learner pondered, "… I like the idea of m-learning but what shall we do with restrictions imposed on use of mobile phones such as: 'switch off your mobile phone while in the library', 'put your mobile phone in silent mode while in meetings', 'switch off your mobile phone while in class', 'mobile phones are not permitted in examinations rooms', and so on"? Another learner wrote, "… m-learning is a good learning paradigm because it taps into the digital lifestyle of the 'dot com' learners".

In *Table 4.32* above, the number two (13.8%) most favorable opinion towards m-learning from learners in the survey was that m-learning was ubiquitous and hence could allow learning to take place everywhere. "It is a platform for learning which is portable, ubiquitous, convenient and flexible", wrote one of the learners. Another learner wrote, "… it saves time, provides contextualized information on the spot, eases access to learning objects and information, and increases learner-learner and learner-lecturer interactions and collaboration". In another response, it was indicated that, "m-learning maximizes learning time by utilizing would be idle times hence maximizing the use of expensive mobile phone resources". Another learner indicated, "… m-learning is good because its enabling technologies were maturing by the day and permeating to almost all students".

In *Table 4.32* above, the number three (5.9%) most favorable opinion towards m-learning from learners in the survey was that m-learning was a good supplementary support avenue to classroom learning. One of the learners wrote, "… I have no problem with m-learning but the restrictions to mobile phones present serious threats to it and as such relegate it to a supplementary rather than a fully fledged mode of learning". Another learner indicated, "… I like the idea but I will only use m-learning in addition to other learning platforms".

In *Table 4.32* above, the number four (2.3%) most favorable opinion towards m-learning from learners in the survey was that m-learning portrayed technological development in the dot com age and as such is a good innovation. One of the learners in this category wrote, "… introduction of m-learning is a sign of technological development in the dot com age". Another said, "m-learning is welcome in this ICT era".

The positive views towards m-learning expressed by 65.5% of learners in *Table 4.32* above are

collaborated by similar views from key stakeholders interviewed. “I support whatever means of delivery that makes education available to the deserving students, after all, m-learning technologies are converging with e-learning technologies and hence blurring the line separating the two”, said one of the content developers. In another interviewee’s view, “… m-learning can support field research, non technical courses and administrative tasks”. This enhances learning. Another content developer said, “… I support m-learning because it can be made more readily available to students in Africa than e-learning. E-learning uses desktop computer Internet connectivity, which is quite minimal in Africa”. Therefore because of the widespread use of mobile phones in Africa, m-learning could be used to support great student numbers in Africa’s infrastructure constrained conditions. In the words of one of the content developers;

> M-learning presents an interesting opportunity to explore because it has real world application in Africa and particularly in Uganda. Our population is growing at about 1 million per year. The physical infrastructure is not growing at the same pace. So the best way of bridging the gap is to introduce systems that ensure that everybody has access to education or better still lifelong learning. E-learning and m-learning should be able to bridge the gap but the permeability of e-learning in Africa still leaves a lot to be desired. We should develop learning applications for the democratized mobile phone. We will however be faced with technological challenges, that is, making sure that content can be delivered using the available infrastructure.

The need to support great student numbers as a favorable condition for m-learning is reinforced by the increasing addition of functionalities onto the mobile phone. “Soon or later we are going to have an integrated mobile phone that will be used for opening ones house, switching on lights in the house, opening the car and remote controlling television and radio”, said a software developer. The software developer continued, “… mobile phones are personal technologies that have become part and parcel of our lives to the extent that when one forgets his/her mobile phone at home, he/she will feel something missing in his/her life and would incur costs to get back home and pick it”. According to him, “introducing m-learning would be equivalent to putting learning into the learners’ hands”.

In another response, a university academic based his/her positive stance for m-learning on the fact that mobile phones facilitate just-in-time communication. “In education, communication is vital”, said a university academic. Indeed, communication is one of the three imperatives of ICTs in education, the others being access and support (Brown, 2005). The potential of m-learning is enormous since it provides anytime anywhere communication. “M-learning has the potential of taking information into the hands of those who are up-skilling or lifelong learning,” said one of the distance education academic.

The potential of m-learning to make distance learning cheaper in the long run was provided as a factor inducing a positive opinion for m-learning. Whereas m-learning is costly in the short run, some sections of the interviewees opined that it could minimize costs for distance learners in the long run. This was expressed by one of the distance education academic in the following statement:

> It is more costly for a distance learner to travel to the main campus to read a message on the notice board than call or text an official concerned to get the same message. If we get m-learning to deliver content to learners, it would even be cheaper. M-learning would reduce the congestion at the main campuses. Pressure on the few administrative staff would be reduced. We could then have many rural based people who cannot afford to come to the main campuses get enrolled onto distance learning programmes. M-learning could also provide solution to the looming resource constraint scenarios that are about to unfold. The Government of Uganda for example, is implementing the Universal Primary Education (UPE) and Universal Secondary Education (USE) programmes with little planning for expanding physical facilities in higher institutions of learning. M-learning could help in supporting the expected great numbers that may take up distance learning programmes.

Accordingly, universities need to prepare for the high demand for education anticipated to emanate from governments' programmes such as UPE and USE. Universities need to put in place the necessary facilities to kick start m-learning and sensitize all those involved on its use as a learner support platform.

The positive opinions espoused in the foregoing presentation suggest that m-learning can be received with open hands on the African continent. This is because of the need for a versatile supplementary channel of content delivery and learner support in countries with poor e-learning infrastructure and high cost of education.

However, not all respondents in the survey were positive about m-learning. From *Table 4.32* above, 34.5% (n=105) of the survey participants were against the idea of introducing m-learning and they said it should be discouraged. They advanced many reasons for their refusal to accept m-learning. "I can not support m-learning because it comes with high costs and the technologies that enable it have multiple restrictions", said one of the learners. "I suspect mobile phones cause cancer. With m-learning, I will be forced to move around with a mobile phone all the time hence exposing my self to higher risks of cancer. I can not support m-learning", said another learner. "M-learning will cause a digital divide between the haves and have nots", wrote another learner. "There is a high loss rate of mobile phones and poor network connectivity in some areas and as such some learners will miss out", indicated another learner. One of the learners wrote extensively as to why he/she would not support m-learning. He/she wrote,

> … because mobile phones are not only meant for learning, they can be busied up by non-learning activities

which would constrain m-learning. Also there might be high cognitive overload on the part of a lecturer supporting great student numbers on his/her mobile phone and this will constrain m-learning. Further, mobile phones can store inadequate content due to limited storage capacity. Also, m-learning can not handle practical related subjects. As if that is not enough, in m-learning there is lack of precious face to face interactions, teacher gestures and expressions. Additionally, there will be fears for the security and privacy of information on mobile phones. Further, m-learning is inappropriate in areas that are highly affected by noise pollution and it is not possible to guarantee that a message sent out has reached its intended recipient. Also, m-learning has potential to disrupt classroom learning and students' concentration. It can also aid test and examination cheating. For these reasons I reject m-learning.

Direct stakeholders aside, the perceptions of the general public towards m-learning were also sought. These were however derived indirectly from the learners because we assumed that learners were part and parcel of the general public. The section that follows presents findings on this variable.

iii Perceptions of the General Public Towards M-Learning

Learners in the survey were asked the open ended question, 'what do you think could be the general public's opinion towards m-learning?' The views emanating from the learners were important for gauging the level of m-learning acceptance or rejection among the general public. Many views were elicited and summarized in three themes in *Table 4.33* below with the most frequent theme being ranked 1, the lesser frequent 2, and least frequent 3.

Table 4.33: Perceived Public Opinion Towards M-Learning

The learners think that…	Frequency	Rank order
The general public will accept m-learning	50.7% (n=145)	1
The general public will not accept m-learning	43.0% (n=123)	2
The general public will have mixed feelings about m-learning	6.3% (n=18)	3

Only 286 responses were received for this open ended question

In *Table 4.33* above, the learners were almost equally divided into two blocks with those thinking that m-learning would be accepted (50.7% (n=145)) being slightly more than those who felt it would be rejected (43.0% (n=123)). There was also a feeling among some learners (6.3% (n=18)) that the general public would receive m-learning with mixed feelings. These results indicate that there will be early and late adopters to m-learning.

In *Table 4.33* above, learners who felt that the general public would accept m-learning (50.7%) wrote variously. "We are currently faced by elitism among educated people and the need to embrace modernity in the dynamic 'dot com' age. This will precipitate m-learning acceptance", reasoned one of the learners. Another wrote, "…mobile phones have become a basic necessity to the majority and

putting an additional application to them would be considered a value addition by the general public". There was a feeling among some learners that since the public was increasingly embracing other mobile services, it could as well embrace m-learning. One of such learners wrote, "… m-learning is not the first mobile phone application but is coming to join a long list of other mobile phone applications such as *m-sente*, *m-money*, *m-banking* and others which have readily been accepted. Likewise, m-learning will also be accepted". Since m-learning personalizes learning, other learners felt it would be accepted for that reason. One of them indicated, "… the ubiquity, flexibility, freedom and convenience afforded by m-learning in lifelong learning could enhance its public acceptance". As a new service, a learner counseled, "… it would be accepted when the general public is sensitized about its applicability, practicability and affordability.

On the other hand, in *Table 4.33* above, learners who felt that the general public would not accept m-learning (43.0%) hinged their opinion on a number of reasons. According to one of them, "… m-learning will not be accepted by the general public because of the high costs associated with buying high end mobile phones and paying phone bills vis-à-vis the high poverty levels among the populace in Africa". Another reason for m-learning rejection, according to another learner was, "… some sections of the general public think mobile phones cause cancer and this will cause m-learning rejection". Further, another learner wrote,

> We have low literacy levels among the general public and many of them are ignorant about the learning potentials inherent in the mobile phones they own. The technologies that enable m-learning are not known to most people. Even computer literate persons own mobile phones with Bluetooth, GPS, WAP, GPRS and EDGE enabled features but they barely know what they are all about, hence never use them. Further, there is no policy to guide the implementation of m-learning, including sensitization of people about m-learning.

Some sections of the general public have long associated mobile phone ownership with moral degeneration amongst the youth. This, the learners said, would discourage parents from allowing their children to own mobile phones. One of the learners with this view wrote,

> … young girls may be tempted to acquire high end mobile phones and airtime through immoral ways. For young boys they may indulge in criminal activities to get funds to purchase mobile phones and airtime. This might be unacceptable to their parents.

Currently in Uganda, secondary schools have rules that bar their students from taking mobile phones into the school compound. This ban is indeed rooted in the moral and criminal angles associated with young unemployed boys and girls owning communication devices that require day to day

airtime funds. Schools and universities alike fear that mobile phones may encourage cheating in tests and examinations. While emphasizing this point, a learner wrote, "… at Makerere University, one of the rules on the examinations booklet is, mobile phones are not allowed in the examination room. This will discourage m-learning".

Another learner felt that the general public would reject m-learning because it is a mode of learning which requires a lot more financial resources than other learning modes. He wrote,

> … there are some people who perceive owning a mobile phone as a luxurious or extravagant undertaking. A mobile phone, according to them, can siphon the limited resources and deny its owner an opportunity to acquire urgent basics of life. People with such perceptions will not easily welcome m-learning ...

Many other reasons were advanced as is seen in this learner's exposition,

> … m-learning rejection by the general public will stem from the formal education culture because it is a common fact that the majority of people, with formal education, in Africa have had it through the traditional classroom method. Hence, it may be difficult to have them buy into m-learning. They may consider students employing m-learning as being 'half baked' because according to them, it may appear to be a strange method of learning. It is a new concept that would baffle teachers and school administrators alike. Further, some people live in areas with no or limited mobile network coverage hence will not be able to have access. Also, some may think that m-learning is a stimulant for laziness and disregard it.

Other reasons for the general public non acceptance of m-learning were, "… most mobile phones interfaces are in languages that are foreign to most people in Africa. Consequently, language barrier could lead to rejection of m-learning", wrote one of the survey participants. Another participant wrote, "… in developing countries, the public may perceive the introduction of m-learning as an avenue for universities to increase tuition fees which is already burdensome and expensive to most of them hence leading to its rejection".

However, as is seen in *Table 4.33* above, some learners (6.3%) felt that the general public would have mixed feelings about m-learning. One of such learners said,

> I believe m-learning will be received with mixed feelings. Those who have high end mobile phones with Internet access and large storage capacities will be in support of the motion while those without will not support it.

This trend is likely to mirror itself in urban and rural areas as one of the learners put it,

> The urban public is more likely to embrace m-learning as opposed to the rural ones because the former tend to have high capacity mobile phones than the latter. Further, urban dwellers are less conservative in as far as opening up to new technologies is concerned than their rural counterparts. However, as a new learning model, it might initially meet some resistance and later be accepted as people come to understand and appreciate its usefulness in providing learning opportunities for those who are dispersed - commonly outside cities.

4.3 Distance Learning Processes at Makerere University

In this section, we present the results from direct observation of the day to day learning and teaching activities at the Department of Distance Education, Makerere University. From the activities observed, we abductively draw different learning processes that distance learners go though in order to accomplish their studies. We chose to observe distance learning activities because according to Caudill (2007), m-learning mainly benefits distance learners. Distance learning, sometimes referred to as distance education, entails reaching out to learners wherever they are and providing them with the necessary tuition and information (Wang & Liu, 2003). This definition indicates that distance learners are separated by time and space from their institution of learning. The researcher spent four months (one semester) while observing distance learning and teaching activities at Makerere University, guided by the following eight key result areas

1 How distance learners were academically supported
2 How an administrator extended administrative support information to learners
3 How a learner acquired administrative support information/services
4 How learners requested for academic assistance/information
5 How learners supplemented lecture notes or course modules with additional reading materials
6 How lecturers secured content for teaching and research
7 How learners used high end mobile phones
8 How learners used low end mobile phones

The results of the observation guided by the above key result areas and challenges identified therein are presented below:

i Observation One: How Distance Learners Were Academically Supported

At Makerere University, distance learning was traditionally provided using print-based course modules written in distance education mode. The modules were supplemented by two (2) residential sessions each of two (2) weeks, in one semester of seventeen (17) weeks. Also, two (2) weeks were set aside for conducting examinations at the main campus. Dates for different learning events in a given year were communicated in the first residential session of semester one of each year using a paper based year planner.

In the first residential session in a semester, learners were given course outlines for the semester's courses, course study guides, course modules, additional reading materials, reading list and take home assignments having due dates. Because of large classes (for example, a Bachelor of Commerce External year one class had over 600 students), lecturers preferred giving group rather than individual take home assignments. Each student was implored to contribute as much as possible to the group assignment. Each assignment was supposed to be submitted before the second residential session. In the second residential session of a semester, learners took timed tests.

In the residential sessions, lecturers gave an overview of the content in their course module(s), paused rhetoric questions to the learners in order to stimulate discussions and reflection amongst them during and after residential sessions, provided clues to revision questions and encouraged learners to form discussion groups. Attending residential sessions was not compulsory for learners.

The two (2) residential sessions in a semester were separated by a period of eleven (11) weeks in which the learners studied independently. In these eleven weeks learners carried out independent learning from their homes, in study centers, in public libraries, in their offices or while traveling. They also received some support services from the department's administrators and lecturers.

After each residential session, each lecturer supported his/her learners by answering their queries and sending them useful reading materials whenever he/she found them. Some lecturers sent soft or hardcopy materials to the learners through their course leaders or the department. Occasionally, the administrator sent the lecturer to satellite centers to provide more tuition and academic support to the learners. The lecturer was free to use the mobile phone, e-mail and Internet to communicate with the learners. However because only 23.1% of the learners had access to hassles free Internet, most lecturers resorted to using the mobile phone because almost all learners owned mobile phones. The lecturer sometimes placed calls or text messages to learners to: provide summaries of what was discussed during residential sessions, answer questions paused by different learners, make appointments for face to face meetings, explain perceived difficult portions of the course modules, provide hints on how to approach given questions and send URLs of useful online materials created by him/her or other persons. Other information communicated included: additional reading materials, summaries of content, course reference list, hints on how to approach given questions, prerequisites for attending a given course, tips to various didactical aspects, and so on. Some learners responded to the lecturers' information by either thanking them or asking for more information.

The further reading materials suggested by the lecturer in the course reference list were at the

department headquarters, satellite centers or university library. Sometimes they were in: the university's LMS, learning objects repository or the Internet. When the materials were at the university's main or satellite libraries, the learners had to physically travel to that library to get them. From the above observation, we draw that learners created their own knowledge through independent learning. We also draw that learners shared knowledge amongst themselves through collaboration and interaction. In so doing, they worked together to create new knowledge. The rhetoric questions and summaries of learning events extended to learners abetted reflective learning, while the clues given to learners about different assignments questions introduced problem-based learning. Administrative and academic support was therefore rife in the student support system. There was also communication and exchange of information amongst learners.

ii Observation Two: How an Administrator Extended Administrative Support Information to Learners

When an administrator wanted to communicate some administrative information to all or a section of the distance learners, he/she wrote a circular and pinned it up on notice boards at the department of distance education headquarters and satellite centers. The administrator sometimes published the circular in newspapers or over the radio. The circular contained any of the following information: reminders to learning events, university almanac, announcements, deadlines for assignments, deadline for registration, information about lecture and examination venues, alerts about time table changes, alerts about due dates for library books, alerts about overdue library books, alerts about new reading materials in the library, requirements for attending a given class, motivational messages, general communication, counselling services, location of various services in the university, and so on. Learners sometimes physically went to the administrator's office at the main campus or satellite centre or placed a call or text message asking for particular information. Queries with answers on the administrator's fingertips were immediately responded to verbally or through writing while those with no readily available answers were deferred to a later time. For deferred questions, the administrator made consultations with records or other staff in the department to get the right answers before reverted to the student through a verbal face to face or written response.

This observation shows that there was administrative support services extended to learners.

iii Observation Three: How a Learner Acquired Administrative Support Information/Services

A learner received communications related to tuition fees, registration fees, registration deadlines, courseworks given in each course, coursework submission deadlines, examination dates, examination venues, available reading materials, residential session dates, timetables and information about satellite centers through several channels including: the admission letter, circulars pinned on notice boards, brochures, fliers, residential session briefings, year planner or radio announcements. When the learner did not visit the department or satellite center, he/she sometimes placed a call or text message to the required administrator or fellow learner seeking for the information. The learner ensured that they got the administrators', lecturers' and fellow learners' telephone contacts during residential sessions. The learner could still get the telephone contacts of staff and fellow learners from the department and satellite centers. The learners were told in briefing sessions that it was particularly important to get the administrators' telephone contacts because all "your queries to the department should be channeled through the different administrators". The administrators were in charge of student support, hence were responsible for providing feedback to all administrative queries from learners.

From this observation, we draw that there was academic and administrative support services received by learners. Learners also communicated /exchanged information amongst themselves. They thus shared knowledge and created new knowledge.

iv Observation Four: How Learners Requested for Academic Assistance/Information

It was observed that when learners were reading a course modules, text books or lecture notes and got to a given point in the module which they failed to understand yet this point was a pre-requisite for understanding the next section, they physically traveled to the lecturers' offices at the main campus and requested for an explanation about the not so clear point. The learners sometimes found when the lecturers were out of office. The learners sometimes physically consulted classmates in their neighborhood for an explanation. In many instances the learners did not know the other learners in their classes. Sometimes, the learners used their mobile phones to place calls or text messages to the lecturers or classmates for consultation. In other instances, the learners sought for an explanation from some other reading materials which were either paper based, online or offline. As it has been seen in this study, distance learners seldomly used e-mail because of its scarcity or lack

of e-mail use culture. Even if the learners accessed e-mail services from a nearby Internet café and sent e-mails to classmates or lecturers seeking for assistance, the response would come in an asynchronous way hence fail to meet the learners' immediate need for a just-in-time explanation that could enable quick advancement to the next section in the module.

Here learners sought for academic support services.

v Observation Five: How Learners Supplemented Lecture Notes or Course Modules with Additional Reading Materials

To increase their learning experiences, learners sometimes supplemented lecture notes or course modules with other reading materials. The learners supplemented lecturer notes or course modules with text books, journal articles, group discussions and learning objects stored in LMSs and learning objects repositories. The supplementary reading materials were either in hardcopy or softcopy form. The learners sometimes received softcopy materials on secondary storage devices such as flash disks, CDs and DVDs. The materials also sometimes came in the form of e-mail attachments. Once in a while, the learners accessed Internet from Internet cafés or the department's computer laboratories situated at the headquarters or satellite centers. Some learners owned mobile phones with GPRS capability and accessed Internet using their mobile phones. They could thus access Internet based additional reading materials. Other learners owned low end mobile phones which could only place and receive voice calls and text messages.

This observation depicts a case of academic support and reflective learning through supplementary learning content/objects

vi Observation Six: How Lecturers Secured Content for Teaching and Research

Just like the learners, the lecturers undertook research in order to get up-to-date and relevant content to support the learners and carry out research. The lecturers used paper based and electronic textbooks, journals and other materials. The lecturer generated lecture notes from previous lectures and learners' group discussions. He/she also generated content from face to face discussion with students and other experts. This means that learners co-created new knowledge. However, the most important sources of content for the lecturers' courses and research work were online learning content in learning objects repositories, Internet, LMSs and institutional databases. The lecturers had GPRS enabled mobile phones and Internet connected desktop computers in their offices.

vii Observation Seven: How Learners Used High End Mobile Phones

Only 32.0% of the learners had mobile phones with high end mobile phone features because of the high cost of acquiring such mobile phones. Learners with high end mobile phones could access the Internet and e-mail using the GPRS feature on their mobile phones. Sometimes the learners accessed online resources from the Internet and mobile web. The learners used their mobile phones for voice, text and multimedia communication. The learners sometimes networked their mobile phone using the Bluetooth feature in order to share music, video and other files. The learners sometimes connected their mobile phones in Makerere University's Wireless hotspots to access Intranet or Internet services. Using a USB port and cable, the learners sometimes connected their mobile phones to other devices such as laptop/desktop computers, televisions, external keyboards, external viewers, external storage devices, and so on. The learners also used their mobile phones to take still and moving pictures. The mobile phone had PDF readers hence could read PDF files for mobile phones. The mobile phones had applications such as Quick Office, Notepad and a converter. The mobile phones had large storage capacities and their screens were colored and relatively large in dimensions. They had tiny keyboards and a battery life of about 48 hours on average. When using the video camera feature, the battery life ran out much faster than when using the mobile phone for only voice and text communications. When in an area of limited network connectivity, the battery consumption rate was higher than when constantly in an area with full network connectivity. Using the GPS facility on the phone, the learners could be able to read their location coordinates. The high end mobile phones were almost miniature computers; known as 'smart phones'.

The high end mobile phones enabled learners to collaborate and interact with each other while accomplishing group assignments.

viii Observation Eight: How Learners used Low End Mobile Phones

In this study, it was revealed that the majority (68.0%) of the learners had low end mobile phones. These phones had no GPRS feature. The learners only placed and received calls and text messages on these phones. The learners could not access Internet, e-mails and file attachments on their phones. The learners could not access online resources from the Internet or mobile web. Low end phones has no Bluetooth capability hence could not share files with other devices within a radius of 10 meters. The phones were not capable of handling computer files. The learners could not connect the phone in a Wireless LAN and access Intranet or Internet services. The phones had no USB port hence could not be connected with other devices using a USB cable. The phones had no camera

feature hence could not take still or moving pictures. The phones had no PDF reader hence could not read PDF for mobile phone files. These phones' applications range was very limited. They had very limited phone memory and their screens were tiny and of mono color. They had a tiny keyboard and a battery life of about 48 hours. When in an area of limited network connectivity, the battery consumption rate was higher than when constantly in an area with full network connectivity. The phones had no GPS facility hence could not be able to read GPS coordinates.

The low end mobile phones permitted communication/information exchange amongst learners.

4.4 Preferred M-Learning Objects and Media Types

This section presents the findings related to the different m-learning objects and media types that are preferred for accomplishing different learning processes as identified in *Section 4.3* above. It provides answers to the research question, 'what kinds of learning objects can be used to service the identified learning processes amidst the cost and kind of constraints placed on mobile technologies?'

Before determining the preferred learning objects media types, the study first established the most common form of reading materials that learners employed. The learners were asked to indicate the form of their usual learning content/objects. The findings revealed that the majority (61.6%) of the learners used paper based content/learning objects. Those who relied on a combination of paper and electronic based learning objects were 35.4%. Only 2.9% relied solely on electronic learning objects. This implies that the majority of learners were heavily dependant on the traditional paper based textbooks and lecture notes for learning content. Whether this was what they preferred, constituted another variable of investigation.

The learners were asked to indicate the media type with which they learnt the most when a learning activity was expressed in such media type. They indicated mixed media (39.5%), as the most preferable media type. This was followed by text (28.1%), video (21.3%), audio (6.8%) and graphics (4.3%). The implication here is that learners were thirsty for mixed media learning objects, which are usually in electronic form, but the prevailing circumstances imposed mainly paper based learning objects that are usually in text form.

The need for mixed media learning objects was echoed by some interviewees as well. According to one of them, "… it is not pedagogical enough to stick to one learning object media type because there are variations in learning styles, cultures, preferences, contexts, device capabilities, networking technologies and costs involved". It is better to leverage different media types in ways that are appropriate to the prevailing circumstance so as to produce the best learning

experience. "It should be about how one can leverage text, video, graphics, voice or a combination of these to get the best learning experience", said a distance education academic. In deciding which learning object media type to use, one of the content developers said,

> … the strengths and weaknesses of each media type in the different learning arenas should be evaluated. As for text, it is the most obvious and best media that cuts across the continuum of low to high end mobile phones. Administrative and academic support messages and content can be sent via text messages or simply delivered in PDF or word files to learners' mobile phones. Multiple choice quizzes could be set in text form and delivered to learners' mobile phones. Text can be 'audio-lized' using text to speech conversion tools.

While commenting on text an m-learning object media type, another responded said, "… text is light in terms of memory consumption but text messages are limited to only 160 characters which constrain communication". As such SMS communication has caused a strange vocabulary in a bid to maximize communication in the 160 character limitation. In a preliminary study to this research, we found the following text communication,

> … I will be waiting 4 the instructions as u promised. I was ur rsch student and I am requestg u 2 B my referee. Mai RESEARCH was gven 2 da RECEPTIONIST. *THAXS FR DE MSG AM SORRY I HV BN AWAY. I'M CONFIRMING THAT I WILL HAND IN MY DRAFT REPORT AT DE END OF FEB 2007 YR STUDENT. Am realy very sorry sir! I got an accident dt almost put me 2 death but now i've just dropped mi report in ur off, kindly act as a parent & tel me wn 2 mt.* I'm finalizing with the last bit of the research a hope to travel any time this week to present it. I still have adv.a/c to retake next sem.my resch work wil be handed over to yu soon for oct gradtn. Thks so much….

The text in this extract is a combination of text messages that were sent to a research supervisor's mobile phone by undergraduate students undertaking field research. The vocabulary minds less about spellings and English language syntax. It however cares to ensure that a message is communicated. In the same vain, as a way of solving the 160 character limitation in an SMS, universities could develop a vocabulary of learner support terms, abbreviations and acronyms that could be communicated to learners upfront.

Video learning objects were preferred by 21.3% of the learners. However, a telecommunications services provider cautioned, "… the telecommunications infrastructure and type of mobile phones available to the learners must be able to support video calls and multimedia messaging". The mobile phone should be able to play video. Armed with video phones, learners could call and chat with each other as they view their surroundings. The only trade off under this arrangement would be the high costs involved. However, in an example given by a distance education administrator at Makerere University, the so called high costs can be traded off with the convenience and benefits accruing

from the video call. He exemplified thus,

> For distance learners, the cost of engaging in a video call is lower than the cost of arranging a face to face meeting with their supervisors at the main campus. For a 10 minutes video call, a student could pay about USD 2.94, which may sound expensive on the face of it. However, if it was in research supervision, for instance, this is a cost a student could comfortably meet. Consider a Makerere University distance learner in a far off upcountry town of Gulu, using about USD 29.41 in transport, food and accommodation when he/she travels to Kampala to physically meet his/her supervisor for about 10 minutes. In this case, it would be economical to pay USD 2.94 for a video call of 10 minutes than pay USD 29.41 to travel to Kampala to meet the supervisor for the same duration. Besides, there are risks associated with use of the road. The student would call the supervisor, turn on the camera on his/her mobile phone and film what he/she is doing as he/she charts away with the supervisor.

The above example is obviously made with assumption that the supervisor's mobile phone and the mobile network subscribed to, support video calls. This reinforces an earlier finding in this study which indicated that staff's mobile phones must be part and parcel of the m-learning infrastructure that universities should plan for.

"Mobile networks in many African countries do not support video calls but video files can be transferred from one mobile phone to another using bluetooth", said a mobile telecommunications services provider.

Just like text, audio/voice is also a default media types that even low end mobile phones are capable of sending and receiving. Audio learning objects were preferred by 6.8% of the learners. Audio learning objects may be in the form of audio podcasts that can be played back on an iPod or mobile phone. Also audio learning objects can be used to augment paper based study materials. This view is supported by one of the telecommunications services providers who said, "… an application can be created where a student dials a certain number and listens in to a brief lecture snippet stored on a telecom service provider's server". Additionally, a software developer said,

> … an ambitious and costly mobile application could be where voice commands are acceptable. This would be helpful to the visually impaired or blind. In this application a student could be presented with audio multiple choice questions where he/she is simply required to speak out the correct option and the system marks him/her. Such an application would require embedment of a voice recognition tool usually associated with an interactive voice recognition (IVR) systems.

Voice/audio learning content /objects can abet reflective learning.

About 4.3% of the learners preferred graphic learning objects. One of them said, "… a picture is worthy a thousand words and therefore I prefer my learning materials to be presented as pictures". There are relatively less costly mobile phones on the market today with cameras that can take static

pictures**.** One of the advocates of graphical learning objects gave an example where graphical learning objects could be used.

> Using MMS, pictures can be transmitted amongst learners' phones. For example, an agriculture student in the field could take a picture of a disease infested crop and send it to his/her course mate's or lecturer's mobile phones for discussion. The limited size of the picture on the phone may however constrain its interpretation but if we integrate m-learning with other learning technologies, the picture could be copied onto a desktop computer using Bluetooth technology or USB cable for a wider view analysis. Graphical m-learning objects are presently exchanged as MMSs and are possible in most mobile networks in Africa.

Therefore different media types are preferred by different learners in different learning contexts. It would be better to have content represented as per learners' preference, which calls for learner profiling.

4.5 Conclusion

From the results of this chapter, it can be concluded that learning objects can be deployed and utilised on mobile phones if considerations for addressing m-learning context, m-learning policies, m-learning costs, m-learning resources, learning processes, m-learning devices and their limitations, m-learning objects, m-learning connectivity, m-learning interfaces, m-learning objects users, m-learning etiquettes/ethics and m-learning evaluation are put in place. The results have showed that learners, whether internal or distance based, were faced with more or less the same learning contexts and availability of learning technology resources. No wonder the majority (94.0%) of these learners were ignorant about the term 'm-learning'. The limited epistemology for m-learning amongst respondents calls for m-learning user education and institutionalisation. Institutionalisation can be achieved by putting in place appropriate m-learning policies. Once appropriate policies are in place, the high m-learning costs can be mitigated and resources for m-learning secured through an m-learning cost sustainability plan. Institutions should identify appropriate learning processes to be executed through m-learning. As per this study, co-creation of new knowledge, knowledge sharing, reflective learning, collaborative and interactive learning, problem-based learning, academic and administrative learning and teaching support and communication/information exchange have been identified as candidate processes that can benefit from m-learning. As to whether learning can occur through the use of a mobile phone to execute the aforementioned learning processes, requires m-learning evaluation mechanisms. The learning processes require single or multiple media (text, audio, graphics and video) learning objects because different m-learning objects users have different media type preferences. Consequently, there is need to mitigate the mobile phones and connectivity

limitations if we are to advance beyond deploying and utilising only text/SMS based learning objects in a push and asynchronous nature. The other implication is the need to profile the m-learning interfaces through which m-learning objects are to be deployed and utilised. As was found in this study, the interface could be of a mobile phone or a personal computer, something which calls for learning objects interoperability. The other implication emanating from mobile phones limitations is the amount of information that can be communicated in an SMS. As this study found out, this has caused the emergence of a strange vocabulary that need to be understood by m-learning object users. It has also, in some instances, caused a cognitive overload on the part of the lecturer/administrator supporting great student numbers on their mobile phones. Security and privacy concerns have also been expressed. These three aforementioned discourses call for the development of m-learning etiquettes/ ethics among m-learning objects users. They also call for a vocabulary of learner support terms that can be used to maximize the use of the character constrained SMS.

CHAPTER FIVE

5. DISCUSSION

5.0 Introduction

This Chapter discusses the results of the study with the view of abducting/deducing dimensions and sub-dimensions for developing the mobile learning objects deployment and utilisation framework (*MoLODUF*). Indeed, it fulfills the third objective of this study which is aimed at developing the *MoLODUF*. The Chapter is underpinned by the *Suggestion* and *Development* process steps of the Design Research methodology and *Phase 2* of the research strategy. The detailed description of the *Suggestion* and *Development* process steps are in *Section 3.2.2* above.

The results are discussed based on the six research questions of this study. The Chapter is therefore arranged as follows. In *Section 5.1,* a discussion of the current practices and prospects for the development and growth of m-learning in Africa is given (*Research Question One*). In *Section 5.2, the* different learning processes that can be accomplished through m-learning are discussed (*Research Question Two*). *Section 5.3* discusses the kinds of learning objects that can be used to service the identified learning processes amidst the cost and kind of constraints placed on mobile technologies (*Research Question Three*). In *Section 5.4,* the issues and factors to obtain access to and use learning objects in m-learning are discussed (*Research Question Four*). *Section 5.5* presents the mobile learning objects deployment and utilisation framework *(MoLODUF)* (*Research Question Five*). *Section 5.6* compares and contrasts the *MoLODUF* with existing learning frameworks with the aim of teasing out this research's contribution (*Research Question Six*).

5.1 Research Question One: What are the Current Learner Contexts, Practices and Prospects for the Development and Growth of M-Learning in Africa?

5.1.1 Current Learner Contexts

The study has falsified the current common belief that internal learners were endowed with more learning resources and better learning contexts than their counterparts, the distance learners as an association between mode of study and the majority of context variables considered in the study returned non-significant p-values. Learners faced similar contextual challenges and opportunities in as far as ICTs for learning were concerned. Mobile connectivity was available to all distance and internal learners (p=0.062). Urban areas were not a preserve for internal learner alone but they

hosted distance learners as well (p=0.532). All the learners faced similar availability or intermittence in power supply (p=0.199) and internet connectivity (p=0.329). This confirms Farrell and Isaacs (2007) conclusion that developing countries of Africa are faced with a multitude of contextual constraints that undermine the development and growth of conventional e-learning. The light at the end of the tunnel is in m-learning which has the potential to defy the odds that inhibit conventional e-learning. This calls for an *M-Learning Context* dimension in the *MoLODUF*. There was no significant association between power supply and mobile network connectivity (p=0.301), yet conventional Internet connectivity which powers conventional e-learning was highly significantly associated (p=0.000) with availability of power supply. The implication in these findings is that there is need for equal planning for educational technologies aimed at enhancing learning amongst distance and internal learners. The findings agree with those in Aguti and Fraser (2006) which advocate integration of ICTs in all modes of learning..

5.1.2 Current M-Learning Practices

This section discusses the results on the current practices of m-learning in Africa. It discusses the epistemology of m-learning (*Section 5.1.2 (i*)), most prevalent m-learning objects in use (*Section 5.1.2 (ii*)), the purpose for which the most prevalent m-learning objects were used (*Section 5.1.2 (iii))*, the location where and time when m-learning occurred (*Section 5.1.2 (iv*)) and the resources that were being used for m-learning (*Section 5.1.2 (v*)).

i Epistemology of M-Learning

Table 4.18 above indicated that there were a few instances of m-learning taking place in a few universities, albeit inadvertently. In the majority of these instances, it was established that both learners and staff could not be able to tell whether placing a call or text message for the purposes of learning or education constituted m-learning. These findings are not surprising because in Traxler (2007) the infancy of m-learning is reiterated. M-learning just like any other infant field of study is likely to face limited epistemology. Consequently, the limited epistemology of m-learning has resulted into its limited practice.

ii Most Prevalent M-Learning Objects

This study has showed that where m-learning existed, it was mainly practiced through text and audio learning objects in trial and pilot projects for collaborative and interactive learning. M-learning

mainly occurred in a push nature with limited bi-directional synchronous and asynchronous collaboration and interaction through text messaging. The use of text messaging in a push fashion was brought about by the prevalence of low end mobile phones which were owned by the majority (68.0%) of learners. The one way use of text messages was mainly due to the limitations imposed by low end mobile phones. Low end mobile phones limitations curtail push and pull synchronous text messaging (Grant *et al*., 2007).

Through voice calls, the study has shown that pull and push synchronous and asynchronous audio communication was practiced and preferred on low end mobile phones because voice calls imposed no character length limitations inherent in text messages. In Butgereit & Botha (2009) and Ford & Botha (2009), the use of audio m-learning objects on low end mobile phones is reported. In Butgereit & Botha's (2009) m-learning project, learners learn how to pronounce and spell English words by listening in to a word from the Hadeda system before being required to type it out. If a learner correctly typed the word, the system congratulated him/her; otherwise it gave him/her the correct spelling. In Ford & Botha's (2009) m-learning project, a mobile audio-wikipedia system is reported. In this system, learners use their mobile phones to dial into it and listen to a definition of a given word. If the definition does not exist, the learner is given a chance to dictate a definition to the system.

Whereas audio learning objects for low end mobile phones were in use, earlier studies (Barker *et al*., 2005, Brown, 2005, Masters, nd) on the practice of m-learning in Africa showed that text messaging was the most prevalent way of deploying and utilising learning objects in m-learning. SAIDE (2008), in a report for the Commonwealth of Learning on the use of mobile phones for open schooling, enumerated a number of innovative m-learning projects in which text messaging was the key technology for learning objects deployment and utilisation. One of such projects is the mobile research supervision initiative in Uganda in which lecturers and distance learning students interact with each other for the purpose of accomplishing field research activities. Another project is Dr. Math on Mxit, for collaborative learning in mathematics using instant text messaging (SAIDE, 2008). Though all these projects were not underpinned by any development framework, they factored in the quality of the learner's mobile device which calls for an *M-Learning Devices* dimension in the *MoLODUF*.

In contexts where high end mobile phones are prevalent, m-learning can be practiced in both push and pull synchronous and asynchronous fashion (Motiwalla, 2007; Zhang, 2003). Since the study has established that learners own a myriad of mobile phones from low through to high end,

the contribution in the *MoLODUF* should be the ability to facilitate m-learning by deploying and utilising multi-media learning objects on the continuum of low through to high end mobile phones. In so doing, the framework bridges the digital divide between those with low and high end mobile phones. This further entrenches the need for an *M-Learning Devices* dimension in the *MoLODUF*.

iii Purpose for Which Most Prevalent M-Learning Objects Were Used

Results in *Table 4.19* above, show that learning activities that were being undertaken by learners on their mobile phones were mainly for extending and acquiring academic and administrative support services. Learner support is one of the three imperatives of ICTs in education (Brown, 2005; Naismith *et al*., 2006). The other two being access to content and communication (ibid). When learners are adequately supported, a lot of their time is freed to participate in other learning activities. They also feel cared for and are motivated to learn.

In *Table 4.19* above, learners being in touch with their classmates, was established as the number one (77.7%) learning activity that was being practiced by learners on their mobile phones. Through this constant communication and interaction, learners were able to work collaboratively by employing text and audio based m-learning objects for purposes of learning/education as is shown *Table 4.18* above. Also in *Section 4.3, Observation One*, distance learners were given group assignments to accomplish. It is thus possible that the text and audio communication and interaction reported in *Table 4.18* above was meant to aid collaborative execution of the assignments. This affirms the notion that mobile devices enhance collaboration and interaction amongst learners and tutors (Ayala & Castillo, 2008; Low & O'Connell, 2006; Uden, 2007). It also puts collaborative and interactive learning as one of the learning processes possible in m-learning. For distance learners who are separated by time and space (Aguti & Fraser, 2006; Caudill, 2007; Traxler, 2007; Wang & Liu, 2003), collaborative and interactive learning can be an avenue for reducing the loneliness usually associated with distance learning. In so doing the 'distance' amongst the distance learners themselves and between the distance learners and their university can be bridged. This then calls for a dimension for an *M-Learning Objects User.*

Whereas m-learning was mainly used for academic and administrative support services, it is the intention of this study to extend it to all the three imperatives (support, access and communication) of ICTs in education. Indeed, access to and utilisation of learning objects and learner-learner and learner-staff communication is entrenched in the *MoLODUF*.

iv Locations Where and Time When M-Learning Occurred

Learners enjoyed administrative and academic support services on their mobile phones from several locations and at anytime as is seen in *Tables 4.20* and *4.21* above. These results cement the notion that m-learning provides flexible, ubiquitous and personalized learning (Luis de Marcos *et al*., 2006; Traxler, 2007). They also cement the fact that m-learning occurs in learners authentic contexts (Ayala & Castillo, 2007; Uden, 2007). Thus m-learning integrates learning into the learners' daily lives. This entrenches the need for the *M-Learning Context* and *M-Learning Objects User* dimensions in the *MoLODUF*.

v Current M-Learning Resources

M-learning requires infrastructural, human and financial resources and an enabling policy to develop and grow which calls for an *M-Learning Resources* dimension in an m-learning framework. We discuss the availability of each of the above resources.

a. Available M-Learning Infrastructural Resources

In the results, 96.2% of the learners owned a mobile phone but even those who did not personally own a mobile phone were able to access mobile phone services from borrowed mobile phones or payphones. These statistics indicate a high level of mobile phone permeation and acceptance in Uganda. The statistics compare well with those in Kajumbula (2006) who indicated that 97.0% of distance learners in Uganda owned mobile phones. The results also support ITU's (2007a) statistics which indicate that Africa had the highest CAGR of 49.4% in the World between 2002 and 2007. These statistics augur well for the development and growth of m-learning.

The results have further indicated that learners owned a myriad of mobile phones ranging from low end through to high end generation order. On average, only 32.0% of the learners had mobile phones with high end features. About 50.0% of the learners owned mobile phones with low end features while about 18.0% where not sure whether their mobile phones had high end features. In effect 68.0% of learners had low end mobile phones. The 18.0% of the learners who were not sure of the existence of high end mobile phone features on their mobile phone suggest the need for a *Mobile Phone User Education* sub-dimension, under the *M-Learning Objects User* dimension.

The ability of mobile devices to deploy voice, audio, graphics and text depend on their technical capabilities (Caudill, 2007). The capabilities and capacities of the mobile phones in possession by the learners surveyed were found to be low. Such capacities presented several limitations, including

but not limited to: tiny screens and keyboards, and limited memory, processing power and bandwidth. Similar mobile phones limitations have been reported in Caudill (2007), Grant *et al*. (2007), Motiwalla (2007), Quinn (2002), Uden (2007), Woukeu *et al*. (2005), Zhang (2003) and many others. In the *MoLODUF*, a *Mobile Devices Limitations* sub-dimension should be included in the *M-Learning Devices* dimension to enable the deployment and utilisation of mixed media learning objects on current mobile phones. Mixed media learning objects were preferred by the majority (39.5%) of the learners surveyed.

In as far as infrastructural resources were concerned; about 12.5% of the interviewees reported the existence of limited infrastructural resources set aside for m-learning. However, if m-learning was to benefit from the infrastructural resources for conventional e-learning, 83.3% of the learners indicated it could benefit from conventional e-learning infrastructure such as LANs, servers, fiber optic backbones and Wi-Fi hotspots that existed in some universities. This collaborates with Farrell & Isaacs (2007) report in which several e-learning initiatives in different universities in Africa are enumerated. One of the e-learning initiatives enumerated is the AVOIR initiative in which eight universities in Africa are using the open source KEWL.Nextgen LMS to develop their own customized LMSs. The existence of e-learning infrastructure is also evidenced in Tusubira's (2006) e-learning project progress report presented at the Carnegie Steering Committee meeting at Makerere University.

To further prove that conventional e-learning infrastructure can abet m-learning, results in this study have shown that members of staff were using the free Internet to mobile phone text messaging services on their office Internet ready desktop computers to support distance learners. This cements the fact that existing e-learning infrastructure was being used to support m-learning, which confirms Brown's (2005) submission that m-learning is a subset of e-learning. This suggests the need for an *Infrastructure Resources* sub-dimension in the *M-Learning Resources* dimension.

The other m-learning infrastructure that was found to cover a substantial part of Uganda was mobile network connectivity. According to this study, 71.1% of the learners surveyed had constant mobile network connectivity. It implies that 28.9% of the learners did not have or sometimes found themselves in locations with no mobile network connectivity. Such learners therefore experienced offline states on their mobile phones whenever they got into areas with no mobile network connectivity. For digital divide reduction and learning equity fulfillment, mechanisms have to be put in place to enable the continuity of m-learning in areas with no network connectivity. For such mechanisms to work there must be a mobile network connectivity profiler. In Goh and Kinshuk

(2006) a connectivity profiler is provided for as one of the dimensions in a framework for adapting content for mobile devices. In Trifonova & Ronchetti (2006), a model is developed for hoarding m-learning objects for use during offline states. This then suggests the need for a m-learning connectivity dimension in the *MoLODUF*. It further suggests the need for *Mobile Connectivity State* and *Mobile Network Service Providers* sub-dimensions in the *M-Learning Connectivity* dimension. It also suggests the need for *Learning Equity* and *M-Learning Objects Deployment Feedback* sub-dimensions under the *M-Learning Evaluation* dimension

b. Available M-Learning Human Resources

As was the case with m-learning infrastructural resources, there were also limited human resources for m-learning. Only 12.5% of the interviewees reported the existence of human resources with a bias in m-learning. As this study has shown, some universities had staff with a bias in e-learning. Since m-learning is a subset of e-learning (Brown, 2005), e-learning staff can be trained and re-trained to support the development and growth of m-learning. However the ultimate goal should be to have staff that is specialized in m-learning development and support. Under the *M-Learning Resources* dimension therefore, there is need for a *Human Resources* sub-dimension in the *MoLODUF*.

c. Financial Resources

The total cost of m-learning emanates from the cost of acquiring and maintaining m-learning equipment, infrastructure, content, personnel and communication costs. This study established that 88.5% of the learners met their own mobile communication costs. It also revealed that the majority (88.0%) of learners spent between USD 0 and 24.9 per month in airtime, amounts which were insufficient for m-learning since mobile communications costs for an m-learner were composed of two cost components, namely: m-learning and non m-learning cost components. If learners were left to meet the cost of communication in m-learning, as this study has established, the whole m-learning paradigm would not be sustainable. Lack of m-learning financial resources led to the switching off of the mobile broadcast system at Makerere University (Kajumbula, 2006).

We therefore posit that m-learning cost is a central aspect which requires special consideration during the development and growth of m-learning. Thus *M-Learning Costs* dimension is essentials in a framework for m-learning. This dimension is absent in Khan's (2001) and Mescan (nd) e-learning frameworks, Goh and Kinshuk's (2006) multi-dimensional framework for content

adaptation and Zhang's (2003) framework for delivery of personalized adaptive content to mobile devices. Since cost is an impediment to m-learning, then the *MoLODUF* should address, in the *M-Learning Costs* dimension, the *M-Learning Cost Sustainability Plan* and *M-Learning Unit Cost* sub-dimensions. The m-learning unit cost sub-dimension should aid in pinpointing the exact m-learning costs. There is also need for *Financial Resources* sub-dimension under the *M-Learning Resources* dimension.

According to results in this study, an m-learning cost sustainability plan requires the full commitment to m-learning by telecommunications companies, governments, universities, learners, parents, employers and donors. The plan implores the aforementioned stakeholders to provide user friendly billing and payment mechanisms (30.3%), empower individual learners to meet their own m-learning bills (24.5%), subsidize m-learning services (20.3%), adopt cheaper communications strategies (12.9%) and provide toll free m-learning services to registered students (12.0%). The sustainability plan also suggests the need to have: staff incentivized, unique added learning values in m-learning and appropriate policies for m-learning.

d. M-Learning Policy

The results in this study have indicated the presence of general policies for e-learning that have no specific tenets for m-learning. In Tusubira (2006), evidence is given of an e-learning policy at Makerere University whose implementation was in a balance. The existing e-learning policies give little or no attention to the special need of m-learning. For instance, this study has unearthed numerous restrictions that are imposed on the use of mobile phones, for example, 'switch off your mobile phone while in the library', 'put your mobile phone in silent mode while in meetings', 'switch off your mobile phone while in class', 'mobile phones are not permitted in examinations rooms', and so on. For m-learning to succeed an m-learning policy must address itself to these and many other restrictions. An m-learning policy is an important aspect for the success of m-learning (Keough, 2005). Therefore, it is not only developments in m-learning technology and human resources per se which propel m-learning but equal developments must be made in regulatory policies for m-learning. An enabling *M-Learning Policy* is therefore a vital dimension in an m-learning framework. In Khan's (2001) e-learning framework, the policy issues are addressed in the *Institutional* dimension. The need for favourable institutional and government policies for m-learning calls for *Institutional Policy* and *Government Policy* sub-dimensions under the *M-Learning Policy* dimension

5.1.3 Prospects for the Development and Growth of M-Learning in Africa

This section discusses results from this study that were considered to have a positive or negative impact on the development and growth of m-learning. These include results on: candidate m-learning activities (*Section 5.1.3 (i)*), existing favorable conditions for m-learning (*Section 5.1.3 (ii)*) and m-learning inhibitors (*Section 5.1.3 (iii*)).

i Candidate M-Learning Activities

There exists a host of possible m-learning activities that can be ported onto m-learning. We disclaim that the discussion in this section does not exhaust all the possible m-learning activities but only provides those that the study has unearthed. Indeed, the scope of possible m-learning activities is dependant upon the creativity and ingenuity of m-learning systems analyst. That said however, according to findings in this study, the number one candidate m-learning activities were those that learners accomplished while they were outside the classroom. These activities were either direct learning activities or activities meant to plan and support direct learning activities.

While outside the classroom, some learners participated in collaborative and interactive learning (41.0%), co-curricular/extra-curricula activities (20.0%) and independent research (16.0%). Other learners completed theoretical, practical and field courseworks and assignments (8.0%) and watched/listening to educative and entertaining music, news and movies (6.0%). Some learners engaged in work related activities (4%), consulted their lecturers (7.0%), acquainted themselves with the university environment (1.0%) and took computer lessons (1.0%). All these activities can be variously supported through m-learning. However, let us focus on the number one (41.0%) out-of-classroom learning activity – participating in collaborative and interactive learning. When learners collaborate and interact with each other, they create new knowledge (Does *et al*., 2005; Fisher & Baird, 2007; Uden, 2007; Vygotsky, 1978). In Doos *et al*. (2005), workers collaboratively engaged each other to co-create new knowledge for new product development. Likewise, in this study, it was established that learners collaboratively accomplished group assignments, which indicated that there was collaborative and interactive learning. Thus through collaborative and interactive learning, the social constructivistic theory of learning (Vygotsky, 1978) was fulfilled.

Other candidate learning activities suggested in this study for possible porting in m-learning were: provision of summaries of classroom discussions, reminders/alerts to various learning events and requirements, information about lectures and examinations venues, motivational messages, reference lists and hints on approach to questions, requirements for attending a given lecture, self evaluation

via sequenced multiple choice quizzes and reflective learning using simulated classroom/laboratory activities recorded as MP3 files or video clips. These are learning support activities that are underpinned by the learning and teaching support theory (Naismith *et al*., 2006).

Other than m-learning outside the classroom, the study also revealed areas in the classroom where m-learning could be employed. These include: sharing of files using Bluetooth, anonymous voting and playing short demonstrations of experiments. The above learning activities represent different learning processes that were possible on learners' mobile phones. This reinforces the need for a *Learning Processes* dimension in the *MoLODUF***.** It also suggests the need for an *M-Learning Evaluation* dimension with an *MCQ Quizzes* sub-dimension.

ii Favorable Conditions for M-Learning

M-learning development and growth can be scaffolded by a favorable environment/context. In information systems, the environment in which a system operates is an important factor for such a system's successful deployment (Gasson, 1999). This study has established that distance and internal learners were more or less faced with similar learning contexts and conditions, something which calls for equal planning for both categories of learners in as far as m-learning is concerned. It also calls for profiling of learner's context before implementing m-learning hence the *M-Learning Context* dimension in the *MoLODUF*. Other context issues were to be found in favourable and unfavorable factors for m-learning.

This study has established a number of factors that can favor/propel the development and growth of m-learning. The conditions include: increasing permeation of mobile phones amongst the populace (67.7%), increasing coverage of mobile telecommunication networks (64.6%), favorable government policies for telecommunication investments (57.4%), and existing e-learning infrastructure (44.8%). Other favorable conditions include: the surfacing of distance learning units in conventional universities (21.3%) and the harsh economic and political situation in Africa (4.5%). Other studies have also identified prospects for m-learning. In Mitchell and Doherty (2003), the increasing processing power and declining cost of mobile devices are favorable conditions for the development and growth of m-learning.

> As the PDA and the cell phone merge, small high resolution, daylight viewable, tactile screens become rapidly affordable, with economies of scale impacting on costs. The hybrid PDA's and the new smart phones have more bandwidth and speed to transfer data and are capable of dealing with the Web, receiving and sending e-mail, as well as storing MP3 files and other data. High screen resolution allows viewing of documents and web pages at full page width without the necessity of horizontal scrolling. All this, together with significantly more processing power, undeniably affords interesting prospects for m-learning developers.
>
> (Mitchell & Doherty, 2003, p.5)

Favorable conditions for m-learning need to be exploited. For instance the positive perception received from 100% of the interviewees on deploying and utilising learning objects on mobile phones should be exploited by introducing and/or increasing learning comfort on mobile phones. In this study such comfort can be attained through blended learning. This suggest the need to regularly evaluate m-learning for learning comfort, hence the need for the *Learning Comfort* sub-dimension in the *M-Learning Evaluation* dimension of *MoLODUF*.

The above m-learning favorable conditions aside, the study also revealed numerous reasons why m-learning can develop and grow. The reasons included: the portability, ubiquity, convenience and flexibility afforded by the mobile phone, the need to democratize education by using this already pervasive and increasingly powerful technology and the need to support great student numbers in light of the anticipated high demand for higher education. Other reasons were: the ability for m-learning to facilitate just-in-time communication, interaction and support to distance learners in cheaper ways, the need to embrace modernity in the 'dot com' age and the elitism among the educated. These reasons compare well with those provided in Brown (2005), Caudill (2007), Luis de Marcos *et al.* (2006), Motiwalla (2007), Pettit and Kukulska-Hulme (2007), Traxler (2007), and many others, on the possibilities and benefits of m-learning. The reasons advanced in favor of m-learning also provide "… growing expectations on the part of educationalists and the media that mobile technologies do have a significant contribution to make in education" (Mitchell & Doherty, 2003, p.3). Such expectations provide fertile ground or prospects for m-learning development and growth, hence within the *M-Learning Context* dimension; there is need for an *M-Learning Propellers* sub-dimension which establishes the possible m-learning favourable factors in a given context.

iii M-Learning Inhibitors

The inhibitors of m-learning should be overcome if we are to develop and grow m-learning. This then requires prior knowledge about all possible inhibitors before any attempt at implementing m-learning. In this study, the inhibitors of m-learning were: the high cost of m-learning (96.9%), technological limitations of mobile phones (89.7%), lack of policies and guidelines for m-learning (85.2%), negative mindsets to m-learning (70.2%), limited knowledge of use of all features of a mobile phone (54.9%), limited or lack of mobile network connectivity in some areas (45.7%), resistance from environmentalists (7.6%) and political instability (4.5%). The findings suggest the need for the *M-Learning Inhibitors* sub-dimension within the *M-Learning Context* dimension. E-

learning frameworks in Khan (2001) and Mescan (nd) do not address this sub-dimension. *MoLODUF* takes care of m-learning inhibitors.

5.2 Research Question Two: What Learning Processes Can be Accomplished Through M-Learning?

In *Section 5.1.3 (i)* above, we have identified the need for a *Learning Processes* dimension in the *MoLODUF*. This dimension is non-existent in Khan' (2001) e-learning framework. Learning processes are value addition learning activities (Doos *et al.*, 2005). This study has confirmed Traxler's (2007) and other authors' view that m-learning is mainly suited for distance learners, that is, learners on-the-go with limited access to web-based computers. Already, candidate learning processes that can benefit from m-learning have been suggested from the learning and teaching activities observed in a traditional distance learning setting in *Section 4.3* above and activities learners engaged in while outside the classroom in *Section 4.2.3* above. These learning processes include: co-creation of new knowledge learning process (discussed in *Section 5.2.1* below), knowledge sharing learning process (discussed in *Section 5.2.2* below), collaborative and interactive learning process (discussed in *Section 5.2.3* below), reflective learning process (discussed in *Section 5.2.4* below), problem-based learning process (discussed in *Section 5.2.5* below), academic and administrative support learning process (discussed in *Section 5.2.6* below) and communication/information exchange learning process (discussed in *Section 5.2.7* below). Note that the identified learning processes are not mutually exclusive. A given learning process can accentuate other learning processes.

5.2.1 Co-Creation of New Knowledge Learning Process

In *Observation One* of *Section 4.3* above, we deduce the existence of a *co-creation of new knowledge* (Doos *et al.* 2005) learning process. It was observed that in the residential sessions, lecturers asked rhetoric questions to the learners in order to stimulate discussion amongst learners during and after residential sessions and encouraged them to form discussion groups. It was also observed that group courseworks were administered as a measure for handling great student numbers and encouraging knowledge sharing. Being distance learners, we observed a lot of independent learning as learners sometimes supplemented lecture notes or course modules with other reading materials such as text books, journal articles, group discussions and learning objects stored in LMSs and learning objects repositories.

Being distance learners, learners were located in different learning contexts. This fact contributed to a rich learning experience especially in the group discussion where learners co-created new knowledge (Doos *et al.*, 2005) for solving the group assignments. The co-created new knowledge emanated from different authentic learning contexts. Learning occurs in situated contexts and is socially mediated (Brown, 2005; Engeström, 1987; Lave & Wenger, 1991, Uden, 2007). Under the social constructivist theory (Vygotsky, 1978), learning is seen as an interactive and collaborative process in which peers help each other to learn. Social constructivism accepts plurality of meanings and promotes situated learning and the collaborative construction of knowledge. Vygotsky (1978) depicts learning as an interaction with more capable peers, helping the learner through the zone of proximal development (ZPD). The ZPD is gap between what the learner knows and can do and what the learner needs to know. Through interaction with other learners and the teacher, mediated by mobile technologies (m-learning), the ZPD emerges. The ZPD can be addressed through the interaction and collaboration afforded by mobile devices (ibid).

5.2.2 Knowledge Sharing Learning Process

In *Observation Four* of *Section 4.3* above, we deduce the existence of a *knowledge sharing* (Doos *et al.* 2005). learning process It was observed that when a learner was reading a course module, text book or lecture notes and got to a given point in whatever they were reading and failed to understand a point therein, yet that point was a pre-requisite for understanding the next section, he/she sought help from his/her lecturers or classmates who were more knowledgeable. This represented a knowledge sharing learning process as is espoused in Vygotsky's (1978) zone of proximal development. Knowledge sharing accentuates the process of co-creating new knowledge. Through the interaction and collaboration afforded by mobile devices, knowledge sharing can be enhanced. In this study, it has been revealed that learners sometimes placed a call to their lecturers or fellow learners to get an explanation of the difficult portion in course modules or other reading materials. Therefore this learning process was underpinned by the social constructivist theory of learning (Vygotsky, 1978).

5.2.3 Collaborative and Interactive Learning Process

In *Observations One* and *Six* of *Section 4.3* above, we deduce the existence of a *collaborative and interactive* (Vygotsky, 1978) learning process. It was observed that lecturers encouraged their learners to form discussion groups for knowledge sharing as well as for accomplishing group

assignments. Further in *Table 4.22* above, 41.0% of the learners participated in collaborative learning while outside the classroom to accomplish group learning activities. Group activities undertaken by distance learners fostered collaborative (Vygotsky, 1978) and conversational (Pask, 1975) learning as learners had to engage each other in finding common solutions. Collaborative and interactive learning activities are key tenets of social constructivist learning (Prawat & Floden, 1994; Vygotsky, 1978). Collaborative learning activities ensure two way information sharing (Mitchell & Doherty, 2003; Naismith *et al*., 2006). Mobile devices have all the necessary potential to foster the collaborative and interactive learning process.

5.2.4 Reflective Learning Process

In *Observations One* and *Five* of *Section 4.3* above, we deduce the existence of a reflective learning (Lin *et al*., 1999) process. It was observed that after residential sessions, lecturers provided learners with summaries of what transpired during residential sessions. Lecturers also provided answers to different questions paused by different learners, summaries of content, hints on how to approach given questions and URLs of useful online resources. Other information communicated included additional course reference lists and tips to various didactical aspects. Also in *Section 4.3, Observation Five* above, it was observed that learners sometimes supplemented lecture notes or course modules with other reading materials which were either of hardcopy or softcopy forms. The softcopy materials were sometimes online or offline based. Offline materials were on secondary storage devices such as flash disks, CDs and DVDs. For learners with high end mobile phones (see *Section 4.3, Observation Seven* above) some materials were kept as files on their mobile phones and could access Internet from those phones. These activities helped learners to reflectively think about what they had covered in prior residential sessions and other readings. In the words of Lin *et al*. (1999, p.43),

> Reflective thinking involves actively monitoring, evaluating, and modifying one's thinking and comparing it to both expert models and peers. This requires a combination of both individual and collaborative reflection

Thus reflective learning was one of the learning processes practiced by distance learners.

5.2.5 Problem-Based Learning Process

In *Observation One* of *Section 4.3* above, we deduce the existence of a *problem-based* (Lave & Wenger, 1991) learning process. Being distance learners, we observed in *Section 4.3, Observation*

One, that there was a lot of independent learning in different authentic contexts. This means that learning was situated and hence underpinned by the situated learning theory (Lave & Wenger, 1991). The situated learning theory presupposes that learning occurs in specific social contexts (ibid). Again in *Section 4.3, Observation One*, we have seen that lecturers asked rhetoric questions during residential sessions to stimulate group discussions. We also observed that lecturers provided hints to different questions or problems. This means that learners took away half defined problems. Half defined problems are best handled through problem based learning (Koschmann *et al.,* 1996). The aim of problem-based learning is to develop the learner's higher order cognitive skills by providing them with a half defined problem which is synonymous with a real problem they will find in the field as a practicing professional (ibid). Problem-based learning is not geared towards testing the learner's skills but at developing their practical skills (Naismith *et al.,* 2006). Hence problem based learning was one of the learning processes practiced by the distance learners.

5.2.6 Academic and Administrative Support Learning Process

In *Observations One, Two, Three, Four* and *Five* of *Section 4.3* above, we deduce the existence of a learning process involving academic and administrative learner support. Provision of education is not just about providing content and learning activities to learners alone. Learning also involves a great deal of coordination of learners and resources (Naismith *et al*., 2006). In *Section 4.3*, *Observation One*, we observed that learners received support from administrative and academic staff and learners themselves. This means that the distance learning on offer at Makerere University could fit into the nomenclature of 'supported distance learning'. Supported distance learning is underpinned by the learning and teaching support theory (Naismith *et al*., 2006; Goh & Kinshuk, 2007).

According to the learning and teaching support theory (Naismith *et al.,* 2006), learning is not only about providing learners with content but is coupled with a great deal of learner and learning resources coordination. The theory emphasizes the need for support systems in learning and teaching. ICTs play three roles in education, namely, access, information and support (Brown, 2005). Most of the support functions given in *Section 4.3* can be extended via a mobile phone. For instance, by using SMSs and voice calls, a lecturer can be able to coordinate activities of his/her class and organize resources for the class. He/she can be able to support learners through reminders of learning events and provide URLs of reading materials. Similarly, administrators can extend administrative support to learners via text messaging and voice calls. Learners too can support each

other using the same media. A student support system employing SMSs is reported in Kajumbula (2006). The system broadcasts/multicasts academic and administrative text messages to distance learners.

5.2.7 Communication/Information Exchange Learning Process

In *Observations One* and *Three* of *Section 4.3* above, we deduce the existence of a communication/information exchange learning process. It this observation, it was seen that learners, lecturers and administrative staff communicated with each other and exchanged information. In so doing, they were able to collaborate and interact with each other. Collaboration and interaction can enable learners to share information in form of data, files and messages (Ayala & Castillo, 2008; Caudill, 2007; Uden, 2007). Collaboration and interaction was made possible through communication and conversations, which means that it was underpinned by the conversational learning theory (Pask, 1975).

Collaborative learning theory (Vygotsky, 1978) is in all aspects accentuated by the conversational learning theory (Pask, 1975). The conversational learning theory requires a continuous two-way conversation and interaction between the lecturer and learner and amongst the learners themselves, if learning is to take place. Learning will take place if the two parties participating in the collaboration can understand each other. As Naismith *et al*. (2006, p.15) observed, learning will take place if "Person A [makes] sense of B's explanations of what B knows, and person B can make sense of A's explanation of what A knows". Conversational learning theories emphasize the need for continuous collaboration/conversation with peers and the teacher or a device which subsumes the role of a teacher. In all the conversations however, successful learning will take place when the learner is in controls of the learning environment/activity (Naismith *et al*., 2006).

In some cases, a shared conversational learning space could be provided by the technology for a single user or a group of users (Naismith *et al.,* 2006). Mobile devices can support mobile computer supported collaborative learning (MCSCL). In MCSCL, learners virtually collaborate with each other in a seamless human to human interaction as opposed to online communication where the human to human interaction is seemingly lost.

5.3 Research Question Three: What Kinds of Learning Objects Can be Used to Service the Identified Learning Processes Amidst the Cost and Kind of Constraints Placed on Mobile Technologies?

In this section, we establish the different m-learning objects and discuss their ability to service the learning processes identified in *Section 5.2* above. From literature (Ayala & Castillo, 2008, Brown, 2005; Ketterl *et al*., 2007; Toledano, 2006), m-learning objects can take the form of SMSs, voice calls, MMSs, audio and video podcasts, Wapsites, software modules/components or games. The results in this study have shown that the ability to deploy and utilize any of the aforementioned m-learning objects depends on cost, constraints placed on mobile technologies, the learning processes in question, management/institutional rubrics and ethical considerations. With these conditionalities in mind we discuss the kinds of m-learning objects that can service co-creation of new knowledge learning process (S*ection 5.3.1*), knowledge sharing learning process (S*ection 5.3.2*), collaborative and interactive learning process (*Section 5.3.3*), reflective learning process (*Section 5.3.4*), problem based learning process (*Section 5.3.5*), academic and administrative support learning process (*Section 5.3.6*), and communication/information exchange learning process (*Section 5.3.7*).

5.3.1 M-Learning Objects for the Co-creation of New Knowledge Learning Process

Co-creation of new knowledge involves learners "talking with each other, particularly as part of a problem solving and task execution process (Doos *et al*., 2005, p.485). It thus involves communication, information exchange, interaction and collaboration. Co-creation of new knowledge is underpinned by the social constructivistic theory of learning (Prawat & Floden, 1994; Vygotsky, 1978). The social constructivist theory posits that knowledge creation is shared rather than an individual experience. Knowledge is constructed through interaction of a number of minds and not just one (Goodman, 1986). Hence knowledge is a social product (Prawat & Floden, 1994).

Tools and raw materials for creating this social product can arise from technologies that encourage interaction and collaboration. The mobile phone is a good example of such technologies. With a mobile phone, learners can co-create new knowledge and share it freely with peers at anytime in anyplace using SMSs, MMSs and audio calls. They can share data files in adhoc short ranged networks using Bluetooth. With the constraint placed on mobile phones owned by learners, SMSs and voice calls remain the appropriate learning objects for the learning process in question.

This view is also shared by Brown (2005).

5.3.2 M-Learning Objects for the Knowledge Sharing Learning Process

In the social constructivist learning theory, learners interplay their minds to create new knowledge. Lecturers and administrators also share knowledge with their learners by providing them with lecture notes, reading materials and administrative information. In addition to sharing knowledge using SMSs, MMSs and voice calls, lectures can be recorded as audio or video podcast and distributed to learners on iPods or mobile phones. "Video or audio podcasts based on recorded lectures offer a very interesting approach to support ubiquitous [knowledge sharing]" (Ketterl, *et al*., 2007, p.61). Lecturers can create websites for mobile phones (Wapsites) to enable learners with no access to PCs to share knowledge. However, it is only GPRS enabled mobile phones that would be able to partake of these. In this study, 56.0% of the learners had GPRS enabled mobile phones.

5.3.3 M-Learning Objects for the Collaborative and Interactive Learning Process

Collaboration and interaction are key tenets of social constructivist learning. Collaboration and interaction enable learners to share information in form of files, data and messages (Ayala and Castillo, 2008; Uden, 2007). Using Bluetooth, it is possible to share files and data. In SMSs, voice calls and MMSs, learners can share data and files and exchange messages. With the constraint placed on mobile phones owned by learners, SMSs and voice calls remain the most appropriate learning objects for the collaborative and interactive learning process. This is in line with Brown's (2005) framework for m-learning in Africa.

5.3.4 M-Learning Objects for the Reflective Learning Process

Reflective learning involves developing a mentor model in a given learning activity. It thus involves reflective thinking. "Reflective thinking involves actively monitoring, evaluating, and modifying one's thinking and comparing it to both expert models and peers. This requires a combination of both individual and collaborative reflection" (Lin *et al*., 1999, p.43). Game based m-learning objects can help foster reflective learning (Mitchell & Doherty, 2003). Game based m-learning objects can be written using java midlets to run on java enabled mobile phones. A mobile game can be used to challenge the mind of a learner on an activity they have learnt in class. For distance learners, a text message can be written to provide a reflection on what transpired during a given residential session.

Further, multiple choice text quizzes can be set to evaluate the learner's understanding of a given topic. In other words, m-learning objects that provide regular updates and feedback to learners come in handy to enforce the reflective learning process. This further suggests the need for an *M-Learning Evaluation* dimension with an *MCQ Quizzes* sub-dimension. Such a dimension is present in Khan's (2001) e-learning framework.

5.3.5 M-Learning Objects for the Problem-Based Learning Process

The aim of problem-based learning (Koschmann, *et al*., 1996) is to develop the learner's higher order cognitive skills by providing him/her with a half defined problem which is synonymous with a real problem he/she will find in the field as a practicing professional. In this research, we observed that distance learners were, during residential sessions, given rhetoric questions with hints to answering them. These questions presented a perfect example of half defined problems.

On a mobile phone, a distance learner could be provided with reference guides to enable him/her solve the rhetoric questions given during residential sessions. The reference guide could be made as an audio or video podcast and distributed to learners' mobile phones or iPods. The guide could also be posted in a Wapsite for access by GPRS enabled mobile phones. Also, an SMS containing a URL to the reference guide could be sent to the target learners for them to access during problem-based learning. Further, an MMS m-learning object could be sent out to learners in the field to aid them solve different problems. "Camera phones have real potential for annotating learning" (Mitchell & Doherty, 2003, p.11). Hence pictures can be taken and distributed as MMSs. Also using voice calls, learners in problem-based learning can interact with each other and with their teachers in order to arrive at a solution to the problem at stake.

5.3.6 M-Learning Objects for Academic and Administrative Support Learning Process

Distance learners were supported variously by administrative and academic staff. The support involved coordination of the entire learning process and resources for learning and provision of content and useful support information. This means that all possible m-learning objects can be used to service the academic and administrative support learning process. These include SMS, voice call, MMS, Podcast, game and, Wapsite based m-learning objects. Institutional affairs, academic affairs and student services constitute sub-dimensions in the institutional dimension of Khan's (2001) e-learning framework that are used for supporting students.

By using SMSs and voice calls, a lecturer can be able to coordinate learning processes and resources for his/her learners. He/she can be able to support learners through reminders of learning events and provide URLs to reading materials. Learners can also support each other. In Kajumbula (2006), SMS based learner support is reported. Through voice calls learners can interact with their peers and lecturers. Through MMS, an agriculture lecturer, for example, can take a picture of a disease infested crop and send it to his/her students in the field to diagnose and vise versa. Through mobile games, learners can be induced to participate in reflective learning. Using video or audio podcasts, lectures can be recorded and distributed to learners' mobile phones and iPods. Also content can be posited on Wapsites and accessed by learners having GPRS enabled mobile phones. However, when the number of learners to support at ago, grows big, a lecturer or administrator may experience a cognitive overload. This suggests the need for a *Cognitive Overload* sub-dimension in the *M-Learning Ethics* dimension in the *MoLODUF*.

5.3.7 M-Learning Objects for Communication/Information Exchange Learning Process

In order to establish the feasibility of carrying out a PhD research in m-learning, we undertook a preliminary m-learning study in which we supported field research students using SMS and voice based learning objects. The initiative was called the mobile research supervision initiative. This initiative was mainly hinged on the communication/information exchange learning process. An evaluation of this initiative established that m-learning was a very important platform for communication and information exchange. Now in the present study, almost all the observations in *Section 4.3* above indicate that learners communicated and exchanged information with each other, and their lecturers and administrators. The most common m-learning objects used were voice calls and SMS messages. SMS messages are being widely used for a variety of communication needs. As Mitchell & Doherty (2003, p.11) put it,

> SMS is more than just a passing fad; it is a communication medium integral to young people's lives… The asynchronous nature of SMS is key to its phenomenal success [as a communication/information exchange learning object].

This means that the communications/information exchange learning process can be serviced by SMS based m-learning objects. At the University of Pretoria, the distance learning unit uses text messages to communicate with their distance learners (Brown, 2005). In Mxit, children in South

Africa chart with each other using text messages, as they solve mathematics problems (SAIDE, 2008).

Just like text messaging, voice calls, can offer enormous service to the communication/information exchange learning process because they are universal media learning objects that can be deployed and utilised across the continuum of mobile phones.

The discussion in this section (*Section 5.3*) has shown that different m-learning objects can be used to service different learning processes. However, due to costs and constraints placed by mobile technologies in our context, SMS/text and audio based learning objects are more feasible than any other learning objects. It is therefore necessary to have an *M-Learning Objects* dimension in the *MoLODUF*.

5.4 Research Question Four: What are the Issues and Factors to Obtain Access to and Use Learning Objects in M-Learning?

5.4.1 Factors for Obtaining Access to Learning Objects in M-Learning

Smith (2005) has identified three design issues that can enable easy access to learning objects. These include: designing for device independence (*Section 5.4.1 (i)*), designing for multiple media content (*Section 5.4.1 (ii)* and allowing learners to control moving content *(Section 5.4.1 (iii))*. However in this research, we have established that network connectivity/networking technology *(Section 5.4.1 (iv))* and intellectual property rights issues *(Section 5.4.1 (v))* are also important factors to consider while obtaining access to learning objects in m-learning. This calls for an *M-Learning Objects Accessibility* sub-dimension in the *M-Learning Objects* dimension.

i Designing for Device Independence

According to findings in this study, a myriad of mobile phones exist with multiple limitations. This is also true in Grant *et al*. (2007). A learning object should therefore be designed in various forms to enable it to be accessed by a variety of mobile phones (Smith, 2005) and on PCs. Low end mobile phones are only capable of accessing text and voice while high end mobile phones can access all media types due to differences in their interface resolutions. This calls for an *M-Learning Interface* dimension having *Mobile Device* and *PC Interface* sub-dimensions. It also calls for the *Generation Order*, *Mobile Device Property*, *Mobile Device Capability* and *Limitations* sub-dimensions in the *M-Learning Devices* dimension

ii Designing for Multiple Media Content

We have established in this study that there existed digital native and digital migrant learners. There were also different contexts related to power, Internet and mobile connectivity, and noise level of the learners' usual learning environment. Also, learners preferred different media types for learning objects content, including: text, audio, graphic, video and mixed media. This implies that learners were faced with different learning contexts and had different learning styles and preferences. These issues present different challenges and opportunities for audio and visual learning. Therefore as learning objects are being designed, one should provide for,

> … alternative formats for visual and auditory content. …We should thus include a text description or transcript of pertinent images, diagrams, sounds, video clips, and so on for learners who don't have the ability to access those types of media directly
>
> (Smith, 2005, p.13)

This calls for the *M-Learning Object Media Type* sub-dimension in the *M-Learning Objects* dimension

iii Allowing Learners to Control Moving Content

This research has shown that mobile learning is flexible, ubiquitous and personal (Luis de Marcos *et al*., 2006; Traxler, 2007). This implies that access to learning objects in m-learning must take advantage of these three attributes. Learners should be able to start, stop, pause, and control the pace of scrolling text, animated images, video clips, and other moving content (Smith, 2005). Avoid content that moves too fast or is too distracting for learners with cognitive disabilities to follow (ibid). This calls for *M-Learning Objects Organization, Granulation, Usability*, and *Pedagogy* sub-dimensions in the *M-Learning Objects* dimension.

iv Mobile Network Connectivity/ Networking Technology

In this research, we established that mobile network connectivity was always available to 71.1% of the learners. This implies that 28.9% of the learners sometimes did not have mobile network connectivity because they were in areas with no network connectivity. In the later case, access to learning objects on the mobile phone can not be accomplished. Likewise, the research has established that the ability of a mobile device to obtain access to audio, video, graphical, text and mixed media learning object depends on the mobile networking technology at hand. Bluetooth, Wi-

Fi, GSM, GPRS, WiMax (cellular broadband) and EDGE are some of the mobile networking technologies (Caudill, 2007; Woukeo, *et al.*, 2005). Access to learning objects in short ranged distances of a radius of 10m can be obtained using Bluetooth networking technology on Bluetooth enabled devices. GSM supports access to text and voice call learning objects in a wide area network while GPRS permits access to Internet based learning objects in addition to text and audio learning objects (Woukeo, *et al.*, 2005). Wi-Fi enables access to learning objects in the Intranet or Internet. The learner must however have access to Wi-Fi hotspots. WiMAX connectivity offers WAN mobile connectivity (ibid). This suggests the need for *Mobile Connectivity State, Mobile Networking Technology, Mobile Service Providers* and *Bandwidth* sub-dimensions in the *M-Learning Connectivity* dimension.

v Intellectual Property Rights

This research has shown that learning objects exist in learning objects repositories, institutional databases and learning management systems, the mobile web and over the Internet. The content in these learning objects is either of free access or closed access type. To obtain access to closed access content, intellectual property rights (IPR) issues must be cleared by paying a fee. This suggests the need for *M-Learning Objects Brokering* and *Repository* sub-dimensions in the *M-Learning Objects* dimension. It also calls for the *Security* and *Privacy* sub-dimension in the *M-Learning Ethics* dimension.

5.4.2 Factors for Utilising Learning Objects in M-Learning

Nash (2005) has identified seven factors for determining usability of learning objects. These include: relevancy, usability, cultural appropriateness, infrastructural support, redundancy of access, size of object and relation to the infrastructure/delivery. These however are not the only factors. From findings of this study, the list should be extended to include factors such as cost of accessing and utilisation a learning object and contexts of the learner.

i Relevancy of the Learning Object

Distance learners go through different learning processes as has been deduced in *Section 5.2.* Each learning process requires different m-learning objects to service it as was discussed in *Section 5.3.* This implies that usability of an m-learning object is dependent upon its relevancy to the learning process in question and m-learning objects user at stake. This is in line with Nash (2005, p.222) who

states that, "… for a digital object to be effective in an online course, it must be relevant to its intended users and must materially contribute to the achievement of outcomes". This suggests the need for *M-Learning Object User Role* and *M-Learning Objects User Profile* sub-dimensions in the *M-Learning Objects User* dimension.

ii Usability of the Learning Object

This research has established that learners had a myriad of mobile phones. A learning object in m-learning should be usable on all families of mobile phones/devices and accessible to all users (Nash, 2005). By so doing the digital divide that would have otherwise been created between the have and have nots is bridged. Utilisation of a learning object can also be enhanced at learning objects design. In Smith (2004), learning objects can effectively be utilised if there was consistence in use of design elements, language and appearance functionality (Smith, 2004). Further usability of learning object can be enhanced if learners are given chance to control their own interaction. Using learning objects standards and conventions that are familiar to learners and simplifying learning objects design where possible, greatly improves learning objects usability (ibid). This suggests the need for an *M-Learning Interface* dimension in the *MoLODUF*. In Khan (2001), interface design is one of the major dimensions.

iii Cultural Appropriateness of Learning Objects

We have established in this study that a new form of vocabulary was emerging with increasing use of SMS for communication. For instance the abbreviation 'cu' was used to connote the phrase 'see you'. In the USA and most of the Western World, putting emphasis on something by writing it in upper case is considered to be impolite. A "digital object should be appropriate culturally, and the meanings that it communicates within a cultural context should reinforce learning objectives" Nash (2005, p.222). Nash's cultural appropriateness factor is limited to the norm of a given community while the factor of context that we consider being an important dimension in learning objects utilisation is broader. This suggests the need for an *M-Learning Ethics* dimension with a *Cultural Appropriateness* sub-dimension. The ethical dimension is also present in Khan's (2001) e-learning framework.

iv Infrastructure Support for Learning Objects

This study has established that the ability to obtain access to and utilize a m-learning objects

depends on the capability of the mobile device and networking technology at play. This concurs with Nash's (2005) factor on infrastructural support for learning objects utilisation. According to Nash (2005, p.222), "objects, whether large or small, simple or complex, should be housed and delivered on a system that is sufficiently robust to handle surges in traffic, bandwidth usage, and storage of large files". This implies that limitations in infrastructure and technologies for learning objects utilisation must be mitigated. This confirms the need for Khan's (2001) technological dimension in an e-learning framework. It suggests the need for the *M-Learning Connectivity* and *M-Learning Devices* dimensions. It further suggests the need for the *Bandwidth* sub-dimension under the *M-Learning Connectivity* dimension.

v Redundancy of Access to Learning Objects

Results in this study concluded that it is not pedagogical enough to compose a learning object using a single media type. They further led to a conclusion that different media types must be leveraged to support different learning styles, conditions, preferences and contexts. Consequently, usability of a learning object would greatly be enhanced if the learning object is designed with more than one media types and delivered via multiple delivery channels. This creates redundancy of access. For instance, "… an mp3 audio object could be delivered via Podcast, RSS, or direct download via link" (Nash, 2005, p.222). This suggests the need for the *M-Learning Objects Pedagogy* sub-dimension under the *M-Learning Objects* dimension.

vi Size of the Learning Object

In this study we have established that there is no standard definition and size for an m-learning object. We have also established that m-learning objects could be SMSs, MMSs, video or audio podcasts, games, java midlets, Wapsites or files. The size of an m-learning object can be small, medium or large. According to Nash (2005, p.222),

> Large objects are sometimes unusable if the users are distributed in remote location where access is poor and/or slow. Optimizing the size of the object, particularly images and audio files is important. For example, using mp3 files instead of wav files can help save space and lead to a more cost-effective solution.

This further suggests the need for an *M-Learning Objects* dimension. It also suggests the need for the *M-Learning Objects Organization* and *M-Learning Objects Granulation* sub-dimensions in the *M-Learning Objects* dimension.

vii Relation to the Infrastructure/Delivery

The study has recommended the use of m-learning as a supplementary mode of delivery to conventional e-learning mode. This implies that usability of an m-learning object will be enhanced if it is interoperable within mobile and conventional e-learning environments such as institutional learning management systems. "If the object is easily integrated into the learning management system, it is treated differently than a large, complex object (a game, for example), that might be run in conjunction with the learning management system. It may be necessary to modify the delivery system …" (Nash, 2005, p.222). This suggests the need for learning objects interoperability in mobile device and PC environments, which in turn suggests the need for an *M-Learning Interface* dimension with *Mobile Device* and *PC Interface* sub-dimensions.

viii Cost of Accessing and Utilising a Learning Object

The usability of a learning object in m-learning will depend on its cost. The cost is two fold, namely; the cost of accessing and acquiring learning objects. Access costs include costs of communication while acquisition costs involve costs of resolving IPR issues for closed access learning objects. If one chooses to use content created by someone else in their learning object, they must obtain permission and provide correct attribution (Smith, 2005). This further suggests the need for an *M-Learning Costs* dimension. It also further suggests the need for a *Financial Resources* sub-dimension under the *M-Learning Resources* dimension.

ix Contexts of the Learner

In this study we have found out that there were noisy, sometimes noisy and quiet learning environments. Audio learning objects are not suitable for noisy contexts. In such a context, text based learning objects would be suitable. We have also established that mobile network connectivity was not uniformly available in all parts of the country, implying that some on-the-go learners could find themselves in no network areas. For learning continuity, the m-learning system should be able to hoard m-learning objects for use in offline states. Further, power connectivity was found to be intermittent. In this context, text based learning objects can not be utilized at night when power is off but audio learning objects can be utilised. The study also established that learners could be characterized as digital natives or immigrants. The digital natives were more proficient in use of ICTs especially, e-mail for learning than the digital immigrants. The study further established the existence of contextual factors that could propel or inhibit m-learning. These results suggest the

need for an *M-Learning Context* dimension in *MoLODUF*. They also suggest the need for *M-Learning Propellers*, *M-Learning Inhibitors* and *M-Learning Environment* sub-dimensions in the *M-Learning Context* dimensions.

5.5 Research Question Five: What are the Major Dimensions and Sub-Dimensions of a Mobile Learning Objects Deployment and Utilisation Framework and How are they Related?

This section is underpinned by the *Development* process step of Design Research methodology because it is in this section where the artifact, the mobile learning objects deployment and utilisation framework (*MoLODUF*), is developed. *MoLODUF* is aimed at aiding m-learning application developers to develop/instantiate applications for effectively deploying and utilisation learning objects on mobile phones. The section is organized as follows. In *Section 5.5.1* we assemble and collate the major dimensions and sub-dimensions of the *MoLODUF* as have been discussed from *Section 5.1* through to *Section 5.4* above. In *Section 5.5.2*, we provide generic guidelines for developing m-learning objects deployment and utilisation applications underpinned by the *MoLODUF*. In *Section 5.5.3* we provide a grid showing the relationship between the major dimensions of the *MoLODUF*. In *Section 5.5.4*, we suggest a loose sequence of process steps that may be followed while utilising the *MoLODUF* to develop m-learning object deployment and utilisation applications/ environments.

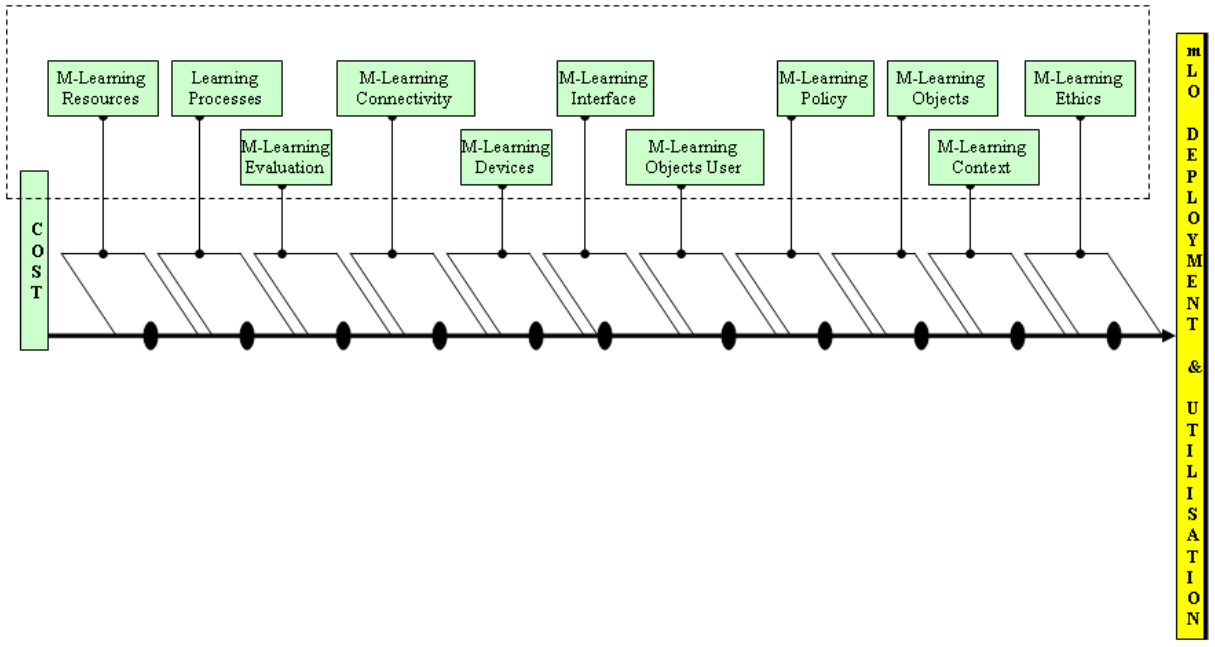
5.5.1 Major Dimensions for Mobile Learning Objects Deployment and Utilisation Framework

The discussion in this chapter has generated a dozen (12) major dimensions for effective deployment and utilisation of mobile learning objects on mobile phones. These are: M-Learning Context (*see pg 156*), M-Learning Devices (*see pg 157*), M-Learning Objects User (*see pg 159*), M-Learning Resources (see *pg 159*), M-Learning Connectivity (*see pg 161*), M-Learning Costs (*see pg 161*), M-Learning Policy (*see pg 162*), M-Learning Evaluation (*see pg 164*), Learning Processes (*see pg 164*), M-Learning Objects (*see pg 175*), M-Learning Ethics (*see pg 178*) and M-Learning Interface (*see pg 175*) dimensions. The above dimensions and their respective sub-dimensions are assembled/collated in *Table 5.1* and *Figure 5.1* below to form the Mobile Learning Objects Deployment and Utilisation Framework (MoLODUF).

Table 5.1: Mobile Learning Objects Deployment and Utilisation Framework (MoLODUF)

1. M-Learning Costs	**5. M-Learning Resources**	**9. M-Learning Evaluation**
▪ M-Learning Unit Cost ▪ M-Learning Cost Sustainability Plan	▪ Infrastructural resources ▪ Human Resources ▪ Financial Resources	▪ MCQ Quizzes ▪ Learning Comfort ▪ Learning Equity ▪ MLO Deployment Feedback
2. Learning Processes	**6. M-Learning Connectivity**	**10. M-Learning Ethics**
▪ Co-creation of New Knowledge ▪ Knowledge Sharing ▪ Collaboration and Interaction ▪ Reflective Learning ▪ Problem-Based Learning ▪ Academic & Administrative Support ▪ Communication/Information Exchange	▪ Mobile Connectivity State ▪ Mobile Networking Technology ▪ Mobile Network Service Providers ▪ Bandwidth	▪ Cognitive Overload ▪ Cultural Appropriateness ▪ Privacy and Security
3. M-Learning Objects	**7. M-Learning Objects User**	**11. M-Learning Policy**
▪ M-Learning Objects Organization ▪ M-Learning Objects Granulation ▪ M-Learning Objects Media Types ▪ M-Learning Objects Accessibility ▪ M-Learning Objects Usability ▪ M-Learning Objects Pedagogy ▪ M-Learning Objects Repository ▪ M-Learning Objects Brokering	▪ M-Learning Objects User Role ▪ M-Learning Objects User Profile ▪ M-Learning Object User Education	▪ Institutional policies ▪ Government policies
4. M-Learning Devices	**8. M-Learning Interface**	**12. M-Learning Context**
▪ Generation Order ▪ Mobile Device Property ▪ Capability ▪ Limitations	▪ Mobile Device Interface ▪ PC Interface	▪ M-Learning Propellers ▪ M-Learning Inhibitors ▪ Learning Environment

Figure 5.1: Mobile Learning Objects Deployment and Utilisation Framework (*MoLODUF*)



The guidelines for building m-learning objects deployment and utilisation applications, as offered by the *MoLODUF* dimensions and sub-dimensions shown *Table 5.1* and *Figure 5.1* above are provided in *Section 5.5.2* below.

5.5.2 Generic Guidelines for Developing Applications for Deploying and Utilising M-Learning Objects

The purpose of this sections is two fold - i) providing a description of the different *MoLODUF* dimensions and sub-dimensions, and ii) offering generic guidelines for developing m-learning objects deployment and utilisation applications that are underpinned by the *MoLODUF* dimensions and sub-dimensions.

i M-Learning Costs Dimension

In this study, results showed that the cost of m-learning was high. These results collaborate with SAIDE (2008) who established that several m-learning projects in Africa were donor funded due to inability of the institutions where they existed to fund them. The study also found that m-learning would be untenable if learners were left on their own, to foot its associated communications costs. This implies that the success of m-learning hinges on an institution's ability to mitigate the high cost of m-learning for the m-learner and the institution itself. The *M-Learning Costs* dimension is the 'midrib' or 'backbone' in the *MoLODUF*. For effective deployment and utilisation of learning objects in m-learning, there must be mechanisms to mitigate the usually high cost of m-learning. This study has suggested two solutions in two sub-dimensions, namely: determining the *Unit Cost of M-Learning* and implementing an *M-Learning Cost Sustainability Plan*.

a. Unit cost of m-learning

Results in this study showed that the total cost of mobile phone communication (*TCMPC*) for an m-learner was composed of two components, namely: the m-learning and non m-learning cost components. This was expressed in an equation as follows:

$$TCMPC = Call(L, O)T_{call} + SMS(L, O)T_{sms} + Data(L_{du}, O_{du})T_{data}$$

Where

$Call(L, O)T_{call}$ = Total cost for calls made for learning and other purposes in a given period

$SMS(L, O)T_{sms}$ = Total cost for SMS made for learning and other purposes in a given period and

$Data(L_{du}, O_{du})T_{data}$ = Total cost for data downed/uploaded for learning and other purposes

Institutions wishing to deploy and utilize learning objects on mobile phones should disaggregate mobile phone communications costs from other communication costs so as to pinpoint and be able to mitigate only m-learning costs. This disaggregation can be made possible by the formula we have developed in the above equation. Once the actual m-learning cost is ascertained, then an *M-Learning Cost Sustainability Plan* should be implemented.

b. M-Learning Cost Sustainability Plan

There must be a plan to mitigate the high cost of m-learning. The findings in this study suggested a plan for sustaining m-learning costs. The m-learning cost sustainability plan (*MLCSP*) is based on the full commitment to m-learning from telecommunications companies, governments, universities, learners, parents, employers and donors. The plan implores these aforementioned stakeholders to: provide user friendly billing and payment mechanisms, empower individual learners to meet their own m-learning bills through provision of part-time jobs, subsidize m-learning services, adopt cheaper communications strategies, provide toll free m-learning services to registered students, incentivize staff involved in m-learning, showcase unique added learning values in m-learning and have appropriate m-learning policies. When the commitment to this plan is secured from all the above stakeholders, then learning objects will be deployed and utilised in m-learning with limited or no financial constraints.

ii Learning Processes Dimension

This research has abducted several learning processes that can be fulfilled by m-learning. Mobile learning processes are overarching issues in m-learning because they provide all the learning and teaching models commensurate with m-learning (Traxler, 2007). This research has identified seven (7) learning process where m-learning can be employed, namely: *Co-Creation of New Knowledge, Knowledge Sharing, Collaboration* and *Interaction, Reflective Learning, Problem-Based Learning, Academic and Administrative Support and Communication/Information Exchange*. Consequently, learning processes specify appropriate m-learning activities; determine whether blended learning is needed and whether human intervention (seeded serendipity) is needed in a given learning activity. In Fisher and Baird (2007), seeded serendipity is recommended as a mechanism for supporting learners in learner-centered learning approaches.

This discussion therefore makes it a requirement for institutions wishing to effectively deploy and utilize learning objects in m-learning to first profile existing learning processes with the aim of

determining those which are appropriate for m-learning. As the results in this study have shown, learning processes should be abducted from the different learning activities partaken of by the learners especially when they are on-the-move or outside classroom learning environments.

iii M-Learning Objects Dimension

This dimension is responsible for modelling the learning objects for deploying and utilising on mobile devices. It should therefore have sub-dimensions for *M-Learning Objects Organization, M-Learning Objects Granulation, M-Learning Objects Media Types, M-Learning Objects Accessibility, M-Learning Objects Utilisation, M-Learning Objects Pedagogy, M-Learning Objects Repository* and *M-Learning Objects Brokering*. The first three sub-dimensions are also available in Goh and Kinshuk's (2007) framework for content adaptation for mobile and PC environments.

a. M-Learning Objects Organization Sub-Dimension

M-learning objects can be organized as course modules having attributes related to content parts, chapters and sections (Goh and Kinshuk, 2007).

b. M-Learning Objects Granulation Sub-Dimension

The *M-Learning Objects Granulation* sub-dimension should indicate the level of difficulty of the content presented to the learner (Goh and Kinshuk, 2007).

c. M-Learning Objects Media Types Sub-Dimension

M-Learning Objects Media Types sub-dimension specifies the media type a given learning objects should be formatted in. This could be text, audio, video, graphics or combination of these. In this research we have established that it is not pedagogical enough to stick to one media type but rather, it is important to leverage the different media types in order to achieve the best learning experience.

d. M-Learning Objects Accessibility Sub-Dimension

One should determine the accessibility restriction imposed on a given m-learning object. Accessibility is enhanced right from the stage of learning objects design. Learning objects should be designed for device independence using multiple media. They should also be designed in a way that allows learners to control movements within them (Nash, 2005; Smith, 2004). Other than these factors, there is also need to establish the mobile connectivity profile of the area in question and

determine the IPR restriction on the learning object (s). IPR issues obviously include cost of accessing learning objects.

e. M-Learning Objects Utilisation Sub-Dimension

The *M-Learning Objects Utilisation* sub-dimensions demands for consistence in use of design elements, language and appearance functionality (Smith, 2004). Further usability of learning object can be enhanced if learners are given chance to control their own interaction. Also using learning objects standards and conventions that are familiar to learners and simplifying learning objects design where possible, greatly improves learning objects usability (ibid). The other factor for consideration is the cost of utilising the learning object (s) and the context in which a learning object is to be utilised.

f. M-Learning Objects Pedagogy Sub-Dimension

M-Learning Object Pedagogy sub-dimension represents the teaching models and domain expert that the system adopts (Goh & Kinshuk, 2007). There is need to determine the teaching models to adopt and the domain expert to mimic in any m-learning system. Smith (2004) has also advocated for the incorporation of an effective pedagogy in a learning object.

g. M-Learning Objects Repository Sub-Dimension

Learning objects are stored and warehoused in learning objects databases called learning object repositories (Luis de Marcos *et al.* 2005). In an m-learning system, the *M-Learning Object Repository* sub-dimension in the *M-Learning Objects* dimension should be responsible for storing and warehousing learning objects. Whereas an m-learning system can have its in-house learning objects repository/database, it is a good idea to allow the system to access external repositories/databases as well. This sub-dimension should 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.

h. M-Learning Objects Brokering Sub-Dimension

There should be a central sub-dimension in the *M-Learning Objects* dimension for coordinating the access, deployment and utilisation of m-learning objects. In Goh and Kinshuk (2006), this sub-dimension is represented as a full dimension and called the *Coordination* dimension. This sub-

dimension should determine the different sources of learning objects, their access types, IPR issues on them and the cost of acquiring those learning objects. It should be a central processing sub-dimension for m-learning objects. It should provide software and algorithms to enable other components in an m-learning system get access to m-learning objects. It should coordinate the presentation, interactions and navigation of the learning object content. 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 device. This sub-dimension should contain the metadata necessary for searching and retrieving a learning object from learning object repositories. It should also provide an audit trail for deployment and utilisation of a given learning object.

iv M-Learning Devices Dimension

This dimension dictates the need to profile the mobile devices for use in m-learning objects deployment and utilisation. By profiling the mobile devices in use, their *Generation Order, Properties, Capabilities* and *Limitations* can be determined. Mobile devices limitations constrain learning (Grant *et al*. 2007). It is for this reason that the study has suggested mobile devices limitations mitigation measures. These measures are underpinned by the blended learning philosophy (Caudill, 2007; Luis de Marcos *et al.*, 2006). They include:

- Deploying a learning object together with an SMS containing a URL link to where it is warehoused and ensuring that users of low end mobile phones only receive the SMS message with the URL link.
- Utilizing Internet cafes or high end mobile phones for accessing learning objects whose URL links are deployed through SMSs.
- Downloading m-learning objects onto a mobile phone and then transferring them onto a standalone desktop computer using Bluetooth, infrared or USB cable.
- Introducing secondary storage devices such as flash disks, CDs and external hard disks for storage and transfer of information.
- Adding Micro SD (secure digital) memory in mobile phones to increase their storage capacities.
- Downloading a m-learning object onto a mobile phone and then using an external viewing device to increase the viewing comfort.
- Deploying learning objects composed using universal media such as audio and text.

- Delivering learning objects in a variety of media types (audio, video, images, text or multiple media) depending on the learner's context.
- Developing a special vocabulary for m-learning that can optimise the 160 characters of an SMS.
- Using Bluetooth and infrared connectivity features to create adhoc networks for content distribution in a classroom or group.
- Downloading m-learning objects onto higher end mobile phones and directly utilising them from there.

There are two main reasons for blending m-learning with e-learning in the mobile devices limitation mitigation measures above. One of them is to introduce and/or increase comfort in learning objects utilisation in an otherwise would be uncomfortable learning model. The other is to inculcate equity in learning experiences of learners with and without high end mobile phones. This consequently reduces the digital divide. M-learning application developers should therefore select from the range of mitigation measures provided above to foster comfortable m-learning.

v M-Learning Resources Dimension

From findings in this study, the *M-Learning Resources* dimension has three sub-dimensions which are necessary for the successful implementation of m-learning, namely: *Infrastructural, Human* and *Financial Resources* sub-dimensions.

a. Infrastructural Resources Sub-Dimension

The infrastructural resources needed for m-learning are: servers, fiber optic backbones, computers, fast Internet connectivity, e-mail, high end mobile phones, mobile network connectivity, learning management systems, local area networks (wired and wireless) and mobile applications development software.

b. Human Resources Sub-Dimension

The human resources needed for m-learning are: flexible managers, administrators, lecturers and students willing to experiment with innovations in core educational practices. Other vital m-learning human resources are: m-learning researchers and systems analysts, mobile applications programmers, technicians, instructional and graphic designers, and content developers.

c. Financial Resources Sub-Dimension

The availability of financial resources is central for the acquisition, installation and maintenance of all the other m-learning resources. Financial resources are also necessary for sustaining m-learning costs as is espoused in *Section 5.5.1 (i)* above. Therefore a budget vote for m-learning is a must for institutions wishing to deploy and utilize learning objects on mobile phones.

vi M-Learning Connectivity Dimension

In this study we found out that, Internet and mobile network connectivity were not always available to all the learners. We also found out that the ability to deploy and utilize a given media type of a learning object depends not only on the capability of the mobile phone but also on the mobile networking technology at hand. Further the study established over five mobile telecommunications service providers in Uganda each having different promotional schemes. Following from these findings, it is important to have *Mobile Connectivity State*, *Mobile Networking Technology, Mobile Service Providers* and *Bandwidth* sub-dimensions in the *M-Learning Connectivity* dimension.

a. Mobile Connectivity State Sub-Dimension

The study showed that there were times when some learners' mobile phones were offline due to being in areas with no mobile network connectivity. Sometimes learners could not be 'connected' due to insufficient or no airtime credit on their mobile phones. This implies that learners found themselves in either online or offline mobile connectivity states. The *Mobile Connectivity State* sub-dimension in the *M-Learning Connectivity* dimension should profile the offline and online states of the learners' mobile phone with the aim of mitigating offline states. In Trifonova and Ronchetti (2006), mobile content is pre-fetched and hoarded into the mobile phone's memory for use during offline states. This however presupposes the existence of mobile phones with sizeable storage capacities.

b. Mobile Networking Technology Sub-Dimension

Long (GPS, GPRS, Wi-Fi, WiMax and EDGE) and short (Bluetooth) ranged mobile networking technologies were found to exist in the midst of learners. However for distance learners, GPRS was found to be the most appropriate because it could enable them to access Internet. As mobile

devices' properties are profiled, one of the aspects that should be established is whether they support the above mentioned technologies. Also the existing mobile networks should be profiled to establish the kind of mobile networking protocols supported. The above two steps (profiling mobile devices properties and mobile networking technologies) should be undertaken so as to determine the kind of m-learning objects that can be deployed and utilised within the prevalent networking technologies.

c. Mobile Telecommunications Service Providers Sub-Dimensions

The m-learning cost sustainability plan suggested in this study (see *Section 4.2.6 (v)* above) hinges a lot on the commitment to m-learning from mobile telecommunications service providers. It is these that offer connectivity and user-friendly billing mechanisms. It is them who subsidize communications cost, offer promotional communications schemes, permit third party application to be installed on their network backbones and undertake research into innovative mobile applications. Therefore mobile telecommunications service providers play a very vital role in the successful deployment and utilisation of learning objects on mobile phones. A close working relationship should be established between institution wishing to implement m-learning and mobile network service providers.

d. Bandwidth

This sub-dimension is responsible for profiling the available versus the required bandwidth for mobile learning objects deployment and utilisation.

vii M-Learning Objects User Dimension

The *M-Learning Objects User* dimension should profile the users of m-learning objects. To be able to do so, it should have three sub-dimensions, namely: *M-Learning Objects User Role*, *M-Learning Objects User Profile* and *M-Learning Objects User Education*.

a. M-Learning Objects User Role Sub-Dimension

This study established three main actors in traditional distance learning and teaching. These are learners, lecturers and administrators. Each of these actors performs different roles in m-learning. We refer to these actors as m-learning objects users in the *MoLODUF*. An *M-Learning Object User Role* dimension has the responsibility of profiling the roles of the different m-learning object users. By so doing, the right learning object will be deployed to the right user.

b. M-Learning Objects User Profile Sub-Dimension

An m-learning system must be able to profile learner's learning history, preferences, style and motivation for learning. This will aid in brokering the appropriate learning objects for each individual learner.

c. M-Learning Objects User Education

The study established that there was limited epistemology for the term 'm-learning'. The study also established that mobile phone users do not know all the functions of the features on their mobile phones. By putting in place m-learning objects user education, the acceptance and use of m-learning among m-learning objects users could be orchestrated. This sub-dimension should also aim at providing the technical skills needed for using mobile applications and mobile phones to learn.

viii M-Learning Interface Dimension

We chose a blended approach for mitigating the mobile phones limitations (see *Section 5.5.1.4*). One of the aims of doing this was to introduce and/or increase learning comfort in m-learning. This implies that interfaces for m-learning are not strictly tied to *Mobile Devices Interfaces* alone. A blended approach means that m-learning objects could as well be deployed and utilised on *PC Interfaces*. This has learning objects design implication in the sense that a learning object should be designed with interoperability between mobile devices (*Mobile Device Interface* sub-dimension) and PCs (*PC Interface* sub-dimension).

a. Mobile Device Interface Sub-Dimension

Most *Mobile Devices Interfaces* are tiny and of a low resolution (Caudill, 2007; Grant *et. al*., 2008). Hence content has to be transformed to fit these interface. The *Mobile Interface* sub-dimension of the *M-Learning Interface* dimension requires that characteristics of target mobile devices interfaces be determined in advance before m-learning objects can be deployed and utilised onto them. This will enable learning objects to be appropriately rendered for a given *Mobile Device Interface*.

b. PC Interface Sub-Dimension

The study established that lecturers and administrators supported learners using Internet connected desktop computers found in their offices. It also established that there were instances when learners accessed Internet from their university computer laboratories, public Internet cafes and other

Internet sources. This implies that lecturers and administrators, and on some occasions, learners, used desktop computers to deploy and utilize learning objects via a resource rich *PC Interface*. M-learning objects can be deployed on PCs as well (Goh & Kinshuk, 2006; Zaharieva & Klaus, 2005; Quinn, 2002). The *PC Interface* sub-dimension in the *M-Learning Interface* dimension should aid in the rendering of m-learning objects in PC interfaces. This sub-dimension permits learning objects to interoperate between PCs and mobile phones.

ix M-Learning Evaluation Dimension

"Evaluation is a reflective learning process" (Lin *et al*., 1999, p.43). Therefore there must be mechanisms in an m-learning system for self evaluation. The framework has an *M-Learning Evaluation* dimension whose functions are to establish whether an m-learning objects user has understood the content in the m-learning object (*MCQ Quizzes* sub-dimension), to establish whether there is learning comfort in m-learning (*Learning Comfort* sub-dimension), to establish whether there is learning equity (*Learning Equity* sub-dimension) and to establish whether a deployed learning object actually reached its intended recipients (*M-Learning Object Deployment Feedback* sub-dimension)

a. MCQ Quizzes Sub-Dimension

When learning objects are deployed and utilised on a mobile phone, it is important to establish whether learning has taken place. According to Mescan (nd), learning is accomplished if materials are cognitively retained and applied in solving problems. The *MCQ Quizzes* sub-dimension should be put in place for m-learners to evaluate themselves as they use m-learning objects.

b. Learning Comfort

Since mobile phones have several limitations, a mechanism should be put in place to establish from m-learners, the level of comfort they experience when deploying and utilising learning objects on their mobile phones.

c. Learning Equity

Similarly, there should be a mechanism to establish the learning equity between m-learners and those who learn mainly through traditional learning models.

d. M-Learning Objects Deployment Feedback

This sub-dimension is responsible for providing feedback about the deployment status of a mobile learning object which was deployed for use. If a mobile learning object does not get to the intended recipient, it should be the role the *M-Learning Objects Deployment Feedback* sub-dimension to provide feedback to the user who deployed the object. Likewise a feedback should be provided for objects that are successfully deployed.

x M-Learning Ethics Dimension

The *M-Learning Ethics* dimension has three (3) sub-dimensions, namely: *Cognitive Overload, Cultural Appropriateness* and *Privacy and Security*.

a. Cognitive Overload

In this study, it was reported that learners sometimes placed text messages and voice calls to their lecturers, administrators and fellow learners seeking for academic or administrative assistance. Assuming many learners placed text messages at the same time to a single lecturer, the lecturer would experience a cognitive overload. Besides, the lecturer's mobile phone memory would run out. An m-learning system should be able to mitigate cognitive overload by allowing a mobile phone user to press a single button that can re-route all messages to an e-mail address with the mobile number as the e-mail account at a mobile services provider's domain, e.g. 077240619@mtn.co.ug. The concerned user can then get to their e-mail at an appropriate time and respond accordingly. This obviously will be detrimental to synchronous or real-time interaction and collaboration but would reduce cognitive overload.

b. Cultural Appropriateness

This dimension should spell out the m-learning etiquettes. For instance, what time should learners communicate with their lecturers and administrators? What language should be used while communicating? Should learners 'beep' lecturers/administrators or should lecturers/administrators 'beep' learners? The communications norm of a given learning community should be established so as to determine culturally appropriate m-learning.

c. Privacy and Security

As an information system, any m-learning application must ensure its users' privacy and security of

information therein. This sub-dimension should therefore be responsible for ensuring these two facets of information systems.

xi M-Learning Policy Dimension

This dimension consists of two sub-dimensions, namely: *Institutional Policies* and *Government Policies*. *Institutional Policies* can curtail or propel the development and growth of m-learning. A favourable m-learning policy is therefore necessary. Likewise, if a government has an e-learning policy which takes cognizance of all learning platforms including m-learning, then m-learning will get support. The policies should be able to give guidelines and strategies for using m-learning in universities and other institutions of learning. The *M-Learning Policy* dimension ensures that favorable m-learning policies, strategies, regulations and guidelines are put in place. Policies will inform the m-learning processes and therefore guide all m-learning activities in an institution. They will even provide regulations on the mobile devices to be used for m-learning and set aside resources for sustaining m-learning.

xii M-Learning Context Dimension

In this study learners lived and operated in different contexts. According to Uden (2007) learning context is an important factor in m-learning. Therefore a mobile learning objects deployment and utilisation framework should have an *M-Learning Context* dimension. The m-learning context in this study has been found to have three (3) sub-dimensions, namely: *M-Learning Propellers, M-Learning Inhibitors* and *Learning Environment* sub-dimensions.

a. M-Learning Propellers Sub-Dimension

M-learning propellers are factors that favor the development and growth of m-learning. Any institution wishing to deploy and utilize learning objects in m-learning must establish and take advantage of these factors. In this research we have established factors like the increasing permeation of mobile phones, liberalization of the telecommunication sector, increasing porting of different applications on mobile phones and many others, as being favourable factors for m-learning. These m-learning positive factors should be identified and efforts made to fully exploit them.

b. M-Learning Inhibitors Sub-Dimension

M-learning inhibitors are the barriers to the development and growth of m-learning. In this research

we have established barriers such as the mobile phones limitations, the high cost of m-learning, the conventional learning stereotyped mindsets and many others, as being inhibitors of m-learning. These negative factors to m-learning must be fully identified and mitigated before introducing m-learning.

c. Learning Environment.

We have established that it is mostly out of classroom learning activities that benefit the most from m-learning. One should ask themselves a number of questions relating to the context of the learner. Is m-learning suitable in the usual learning environment of the learner? Is there mobile connectivity in the area? Is the area noisy or quiet? Do learners have resource rich desktop computers or not? Do they have GPRS enabled mobile phones? Is there power connectivity? The answers to these questions should indicate that the environment is ready for m-learning before we deploy and utilize learning objects on mobile phones.

5.5.3 Relationships in MoLODUF Dimensions

Each dimension in the MoLODUF is related with each other (in the cell providing an intersection of a row and a column). The relationships are depicted in *Table 5.2* with different color schemes.

Table 5.2: Relationships in MoLODUF Dimensions

Dimension	M-Learning Cost	M-Learning Object	M-Learning Object User	M-Learning Device	M-Learning Connectivity	M-Learning Policy	Learning Process	M-Learning Interface	M-Learning Resources	M-Learning Evaluation	M-Learning Context	M-Learning Ethics
M-Learning Cost		Closed access MLOs costs money	MLOs users have to meet a cost for accessing MLOs	M-Learning Devises Cost Money to be acquired	M-Learning Connectivity is made possible after paying for it	An M-Learning Policy is Formulated at a cost	Different learning Processes are accomplished in m-learning at a cost	High end mobile phones with best interfaces are costly to acquire	M-Learning Costs can be sustaining by providing adequate M-Learning Resources	M-Learning Evaluation costs money	The M-Learning Costs varies from one M-Learning Context to another	M-Learning Ethics are developed at Cost
M-Learning Object	Closed access MLOs costs money		MLOs are structurally associated with MLO User	The kind of MLO to be rendered depends on the capability of the M-Learning Device in question	Access to MLOs depends on the M-Learning Connectivity in an area	MLOs are accessed and used as per the existing M-Learning Policy of an institution	MLOs to be used depend on the Learning Processes in question	MLOs rendering is dependant upon the capability of the M-Learning Interface	MLOs need resources to be created, accessed and utilised	M-Learning Objects need to be Evaluated to determine whether they meet learning objectives	Different kinds of MLOs are suited for different kinds of contexts	When many MLOs are deployed at the same time they can cause cognitive over load
M-Learning Object User	MLOs users have to meet a cost for accessing MLOs	A MLO User is structurally associated with the MLO		A MLO User uses a M-Learning Device to obtain to and utilize MLOs	A MLO User uses the M-Learning Connectivity condition in place to obtain access to MLOs	A MLO User is associated with his/her institution's M-Learning Policy	A MLO User uses MLOs to accomplish different Learning Processes	A MLO User uses a M-Learning Interface to deploy and utilize MLOs	A MLO user requires resources to deploy and utilize MLOs	There is need for M-Learning Objects Users to Evaluate themselves on the extent of learning through MLOs	MLOs users find themselves in different contexts as the learn on-the-go	M-learning Objects users need to abide by M-Learning Ethics
M-Learning Device	M-Learning Devises Cost Money to be acquired	The Mobile Device capability determines the kind of MLO to be rendered	A M-Learning Device is used by a MLO User to obtain access to and utilize MLOs		A Mobile Device uses the M-Learning Connectivity conditions and technology to obtain access to MLOs	M-Learning Devices in use depend on the M-Learning Policy of an institution	M-Learning Devices in use depends on the Learning Processes to be fulfilled	A M-Learning Device provides the M-Learning Interface to be used in deploying and utilising MLOs	M-Learning Devises require M-Learning Resources to be acquired	There is need to evaluate the learning comfort on different M-Learning Device	Different M-Learning Devices are required in different M-Learning contexts	M-Learning Devices should be used within the M-Learning Ethics
M-Learning Connectivity	M-Learning Connectivity is made possible after paying for it	M-Learning Connectivity in area provides a channel for obtaining access to MLOs	M-Learning Connectivity condition in place influences how a MLO User obtains access to MLOs and the kinds of MLOs he/she accesses	A Mobile Device uses the M-Learning Connectivity conditions and technology to obtain access to MLOs		The M-Learning Connectivity adopted by an institution depends on its M-Learning Policy	The M-Learning Connectivity conditions dictate the kinds of Learning Processes that can be accomplished through m-learning	The M-learning Connectivity conditions dictate the kind of M-Learning Interface to use for deploying & utilizing MLOs	M-Learning Connectivity requires M-Learning Resources to be acquired	There need for an evaluation of the M-Learning Connectivity available to the learner to see if it is suitable for m-learning	M-learning Connectivity varies from one M-Learning Context to another	M-Learning Connectivity should abide by the M-Learning Ethics

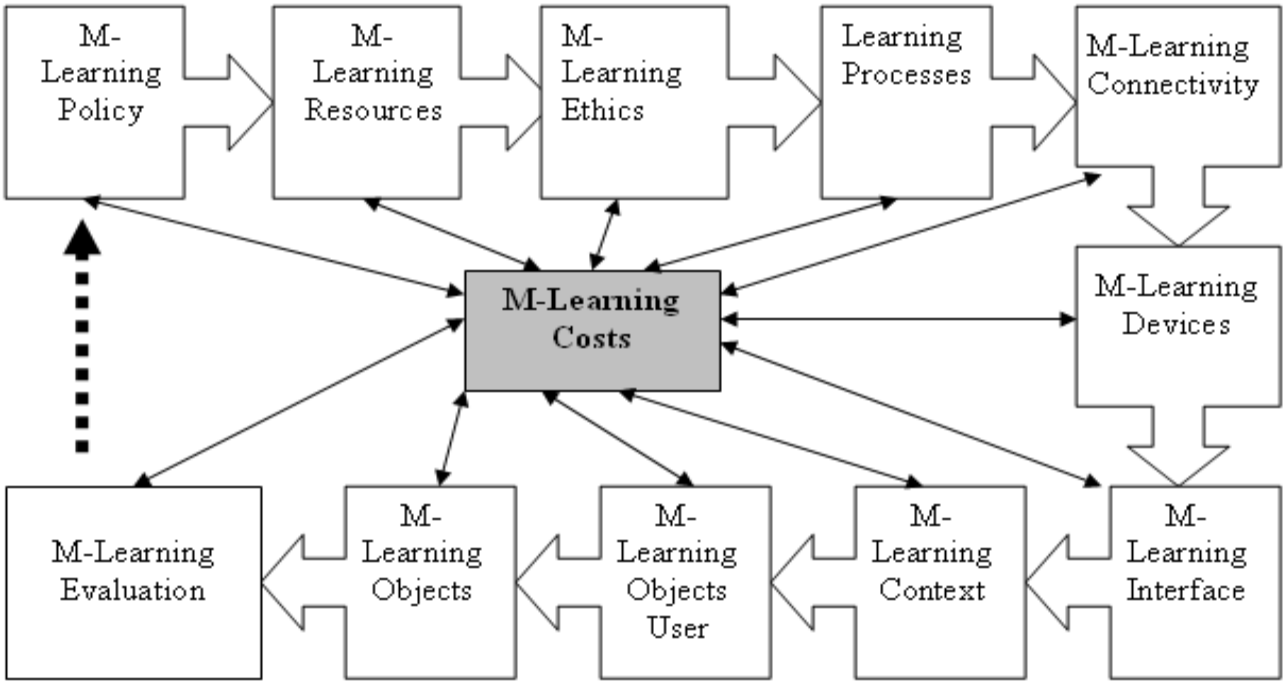
Dimension	M-Learning Cost	M-Learning Object	M-Learning Object User	M-Learning Device	M-Learning Connectivity	M-Learning Policy	Learning Process	M-Learning Interface	M-Learning Resources	M-Learning Evaluation	M-Learning Context	M-Learning Ethics
M-Learning Policy	An M-Learning Policy is Formulated at a cost	MLOs are accessed and used as per the existing M-Learning Policy of an institution	A MLO User is associated with his/her institution's M-Learning Policy	M-Learning Devices in use depend on the M-Learning Policy of an institution	The M-Learning Connectivity adopted by an institution depends on its M-Learning Policy		The M-Learning Policy of an institution determines the kinds of Learning Processes that can be implemented in m-learning	The M-Learning Policy determines the M-Learning Devices to be used and hence M-Learning Interface	M-Learning Policy requires M-Learning Resources to be formulated and implemented	There need to evaluate current e-learning policies to see if they are suitable for m-learning	M-Learning Policy should be formulated as per prevailing M-Learning Context	M-Learning Policy should be formulated as per M-Learning Ethics
Learning Processes	Different learning Processes are accomplished in m-learning at a cost	MLOs to be used depend on the Learning Processes in question	A MLO User uses MLOs to accomplish different Learning Processes	M-Learning Devices in use depends on the Learning Processes to be fulfilled	The M-Learning Connectivity conditions dictate the kinds of Learning Processes that can be accomplished through m-learning	The M-Learning Policy of an institution determines the kinds of Learning Processes that can be implemented in m-learning		The Learning Processes to be accomplished in m-learning depend on the capability of the M-Learning Interface at hand	Different Learning Processes require M-Learning Resources to be accomplished	There is need to evaluate the use of m-learning in different Learning Processes	Learning Processes to benefit from m-learning are determined by the M-Learning Context of a given area	Learning Processes in m-learning should be carried out within the M-Learning Ethics
M-Learning Interface	High end mobile phones with best interfaces are costly to acquire	MLOs rendering is dependant upon the capability of the M-Learning Interface	A MLO User uses a M-Learning Interface to deploy and utilize MLOs	A M-Learning Device provides the M-Learning Interface to be used in deploying and utilising MLOs	The M-learning Connectivity conditions dictate the kind of M-Learning Interface to use for deploying & utilizing MLOs	The M-Learning Policy determines the M-Learning Devices to be used and hence M-Learning Interface	The Learning Processes to be accomplished in m-learning depend on the capability of the M-Learning Interface at hand		Best M-Learning interfaces require M-Learning resources to acquire	There is need to evaluate the suitability for m-learning of different M-Learning Interfaces	The M-Learning Interface is dependant on the M-Learning Context of a given area	M-Learning Interface in use has an influence on M-Learning Ethics
M-Learning Resources	M-Learning Costs can be sustaining by providing adequate M-Learning Resources	MLOs need resources to be created, accessed and utilised	A MLO user requires resources to deploy and utilize MLOs	M-Learning Devises require M-Learning Resources to be acquired	M-Learning Connectivity requires M-Learning Resources to be acquired	M-Learning Policy requires M-Learning Resources to be formulated and implemented	Different Learning Processes require M-Learning Resources to be accomplished	Best M-Learning interfaces require M-Learning resources to acquire		There is need to evaluate the adequacy of existing M-Learning Resources	M-Learning Resources determine the M-learning Context	Available M-Learning Resources affect the M-learning Ethics

Dimension	M-Learning Cost	M-Learning Object	M-Learning Object User	M-Learning Device	M-Learning Connectivity	M-Learning Policy	Learning Process	M-Learning Interface	M-Learning Resources	M-Learning Evaluation	M-Learning Context	M-Learning Ethics
M-Learning Evaluation	M-Learning Evaluation costs money	M-Learning Objects need to be Evaluated to determine whether they meet learning objectives	There is need for M-Learning Objects Users to Evaluate themselves on the extent of learning through MLOs	There is need to evaluate the learning comfort on different M-Learning Device	There need for an evaluation of the M-Learning Connectivity available to the learner to see if it is suitable for m-learning	There need to evaluate current e-learning policies to see if they are suitable for m-learning	There is need to evaluate the use of m-learning in different Learning Processes	There is need to evaluate the suitability for m-learning of different M-Learning Interfaces	There is need to evaluate the adequacy of existing M-Learning Resources		There is need to Evaluate the M-Learning Context for proper deployment and utilisation of MLOs	M-learning evaluation should be carried out within the M-Learning Ethics in place
M-Learning Context	The M-Learning Costs varies from one M-Learning Context to another	Different kinds of MLOs are suited for different kinds of contexts	MLOs users find themselves in different contexts as the learn on-the-go	Different M-Learning Devices are required in different M-Learning contexts	M-learning Connectivity varies from one M-Learning Context to another	M-Learning Policy should be formulated as per prevailing M-Learning Context	Learning Processes to benefit from m-learning are determined by the M-Learning Context of a given area	The M-Learning Interface is dependant on the M-Learning Context of a given area	M-Learning Resources determine the M-learning Context	There is need to Evaluate the M-Learning Context for proper deployment and utilisation of MLOs		Different M-Learning contexts demand for different M-Learning Ethics
M-Learning Ethics	M-Learning Ethics are developed at a Cost	When many MLOs are deployed at the same time they can cause cognitive over load	M-learning Objects users need to abide by M-Learning Ethics	M-Learning Devices should be used within the M-Learning Ethics	M-Learning Connectivity should abide by the M-Learning Ethics	M-Learning Policy should be formulated as per M-Learning Ethics	Learning Processes in m-learning should be carried out within the M-Learning Ethics	M-Learning Interface in use has an influence on M-Learning Ethics	Available M-Learning Resources affect the M-learning Ethics	M-learning evaluation should be carried out within the M-Learning Ethics in place	Different M-Learning contexts demand for different M-Learning Ethics	

5.5.4 Process Steps for Utilising the MoLODUF in Creating M-Learning Objects Deployment and Utilisation Applications

Whereas the *MoLODUF* process steps are not necessarily sequential in nature, we suggest that implementation of the *MoLODUF* guidelines be based on the loose sequence provided the process steps suggested in *Figure 5.2* below.

Figure 5.2: Process Steps for Utilising the *MoLODUF* in Creating M-Learning Objects Deployment and Utilisation Applications



Loosely speaking, organizations wishing to create applications for deploying and utilising learning objects on mobile phones should implement the guidelines given in the *MoLODUF* dimensions following the sequence provided in *Figure 5.2* above. However, as can be seen in this Figure, m-learning costs present a central challenge that must be dealt with at all process steps. Further, sustainable deployment and utilisation of m-learning objects will only be achieved if there is an appropriate m-learning policy. This is the reason why an m-learning policy must be put in place first before implementing any other dimension. Though formative m-learning evaluation is important to evaluate the m-learning applications development process, *Figure 5.2* above suggests the need for summative evaluation to measure the learning outcomes, learning comfort and learning equity emanating from the learning object deployed and utilised by any m-learning application. *Figure 5.2* further shows that as a result of an m-learning summative evaluation recommendation can be made

to revise the m-learning policy. The relationships between the different dimensions shown in Figure 5.2 above are provided in *Table 5.5* above and the detailed guidelines for deploying and utilising learning objects in each of the dimensions is given in *Section 5.5.2* above. The actual use of the *MoLODUF* to create an actual m-learning objects deployment and utilisation application has not been done in this present work but has been earmarked as an area for future work, that is to say, doctoral research project.

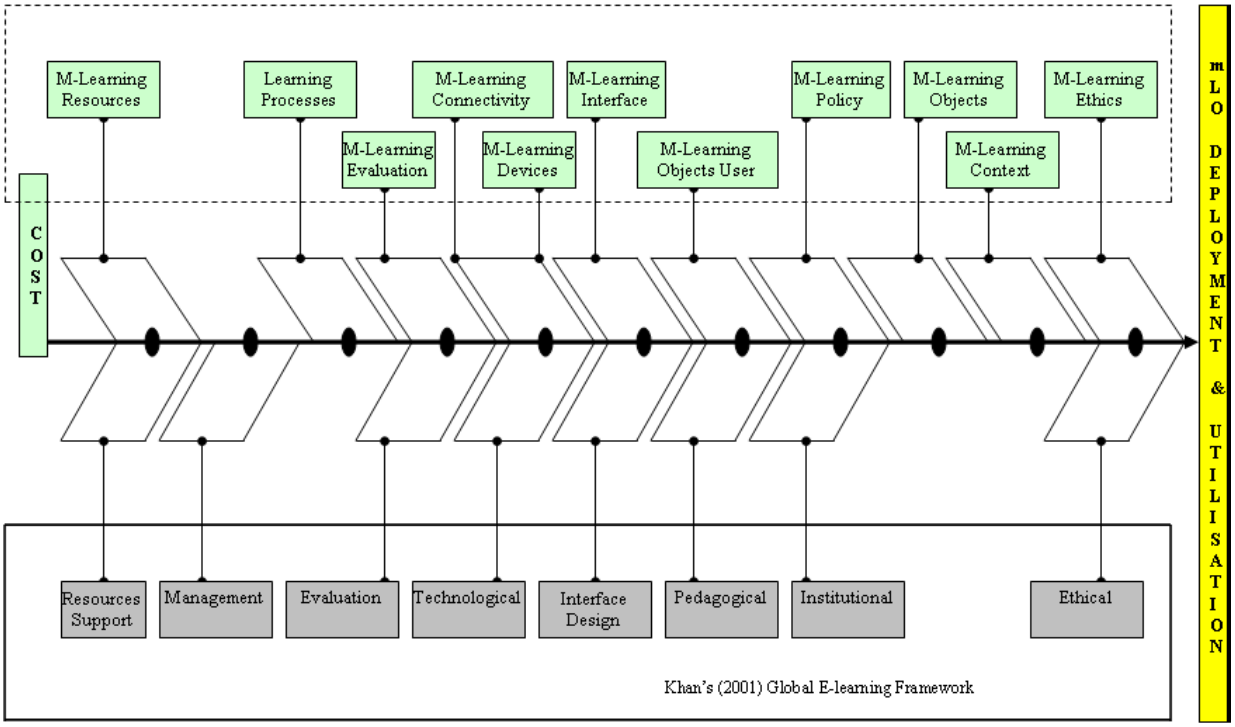
5.6 Research Question Six: Where are the Similarities and Differences With Other Similar Learning Frameworks?

This section adduces the research contribution in the *MoLODUF*. The contribution is brought out by comparing the *MoLODUF* with Khan's (2001) global e-learning framework, Goh and Kinshuk's (2006) multidimensional framework for content adaptation in PC and mobile learning environments and other similar frameworks.

5.6.1 Comparing MOLODUF With Khan's (2001) Global E-Learning Framework

M-learning is a subset of e-learning (Brown, 2005). Therefore it is important to compare *MoLODUF* with Khan's (2001) global e-learning framework. A pictorial representation is preferred where we juxtapose in *Figure 5.3* below, the *MoLODUF* dimensions onto the eight dimensions in Khan's e-learning framework. As reviewed in *Section 2.1.2 above,* the eight dimensions in the global e-learning framework are*: Resources Support, Management, Evaluation, Technological, Interface Design, Pedagogical, Institutional* and *Ethical* dimensions (Khan, 2001). The aforementioned juxtaposition is shown in *Figure 5.3* below.

Figure 5.3: Comparison of *MoLODUF* with Khan's (2001) Global E-Learning Framework



Khan's (2001) global e-learning dimensions are shaded in grey in the lower part of *Figure 5.3* above. The *MoLODUF* dimensions, which are described in *Section 5.5* above are shown on the upper side of *Figure 5.3* above and shaded in light green. From the juxtaposition, a number of differences and similarities are unearthed.

i Differences between MoLODUF and Khan's E-Learning Framework

The differences arise from four major dimensions namely: *M-Learning Cost*, *Learning Processes, M-Learning Objects* and *M-Learning Context*. The aforementioned dimensions are non-existent in Khan's (2001) global e-learning framework. However in Khan's framework there is major dimension called *Management* which the *MoLODUF* does not have as major dimension. The *Management* dimension has two sub-dimensions, namely: *Content Development* and *Maintenance*. In *Content Development* sub-dimension, a requirement for a project support site for e-learning production team is placed. In the *Maintenance* sub-dimension, a requirement for constant and timely updates within the e-learning program is placed. The updates to the learners could be made through e-mail, announcement page, alert boxes, running footer added to a page or phone call. The functionalities of Khan's *Management* dimension are subsumed in the *M-Learning Objects* and *M-Learning Resources* dimensions in the *MoLODUF*.

The contribution here therefore lies in extending Khan's (2001) e-learning framework with the *M-Learning Costs, Learning Processes, M-Learning Objects* and *M-Learning Context* dimensions.

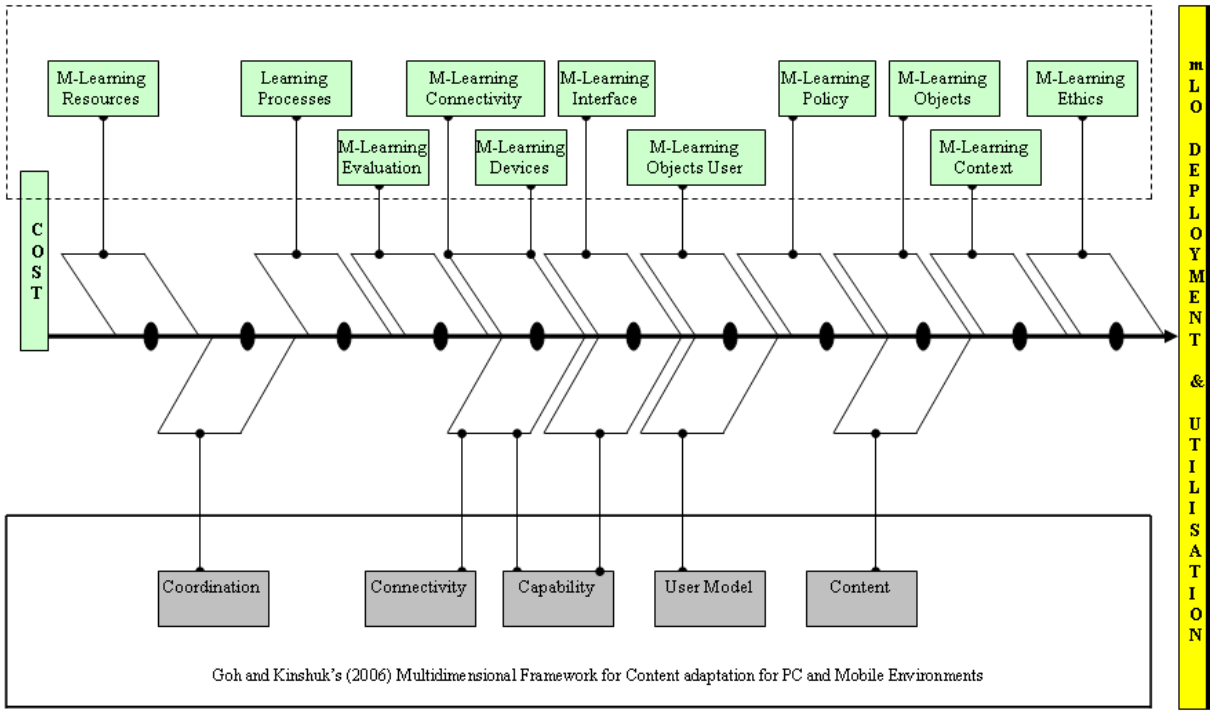
ii Similarities between MoLODUF and Khan's E-Learning Framework

Figure 5.1 above shows several similarities between the *MoLODUF* and Khan's (2001) global e-learning framework. *M-Learning Resources* dimension in *MoLODUF* is similar to *Resources Support* dimension in Khan's framework. *M-Learning Evaluation* dimension in *MoLODUF* is similar to the *Evaluation* dimension in Khan's framework. As is shown in *Figure 5.1* above, dimensions having an upper and lower flap connected by the *M-Learning Cost* line are similar.

5.6.2 Comparing MoLODUF and Goh and Kinshuk's Multidimensional Framework

Goh and Kinshuk's (2006) multidimensional framework for content adaptation for PC and mobile learning environments consists of only five dimensions each of which has sub-dimensions. The major dimensions are *Coordination, Connectivity, Capability, User Model* and *Content* dimensions. When a juxtaposition of the *MoLODUF* and Goh and Kinshuk's (2006) framework is made in *Figure 5.4* below, a number of differences and similarities are unearthed.

Figure 5.4: Comparison of *MoLODUF* with Goh and Kinshuk's (2006) Framework



i Differences between MoLODUF and Goh and Kinshuk's Framework

The juxtaposition in *Figure 5.4* above indicates that *MoLODUF* is more global than Goh and Kinshuk's framework. Goh and Kinshuk's (2006) framework pays less attention to exogenous dimensions that impact m-learning. *MoLODUF* pays attention to endogenous and exogenous dimensions that impact m-learning objects deployment and utilisation. *MoLODUF* considers dimensions such as *M-Learning Cost, M-Learning Resources, Learning Processes, M-Learning Evaluation, M-Learning Policy, M-Learning Context* and *M-Learning Ethics* which are non existent in Goh and Kinshuk's (2006) framework. However in Goh and Kinshuk's framework, the *Coordination* dimension is brought out as a major dimension. The roles of the *Coordination* dimension in Goh and Kinshuk's (2006) framework are fulfilled by the *M-Learning Brokering* sub-dimension in the *M-Learning Objects* dimension in the *MoLODUF*.

The contribution here therefore lies in extending Goh and Kinshuk's m-learning framework with the *M-Learning Cost, M-Learning Resources, Learning Processes, M-Learning Evaluation, M-Learning Policy, M-Learning Context* and *M-Learning Ethics* dimensions.

ii Similarities between MoLODUF and Goh and Kinshuk's Framework

Clearly, from *Figure 5.4* above, down and upper flaps connecting *Connectivity, Capability, User Model* and *Content* show similarities in dimensions of the *MoLODUF* and Goh and Kinshuk's framework.

5.6.3 Summary Comparison of the MoLODUF with E- and M-Learning Frameworks

Using the juxtapositioning technique adopted in *Section 5.6.4* above, we present in *Table 5.3* below, a summary comparison of the *MoLODUF* with e- and m-learning frameworks reviewed in the *Chapter Two* above.

Table 5.3: Summary Comparison of *MoLODUF* With E- and M-Learning Frameworks

M-Learning Framework	Dimensions												
	ML- Cost	ML-Resources	L-Processes	ML-Evaluation	ML-Connectivity	ML-Devices	ML-Interface	MLO User	ML-Policy	ML-Object	ML-Context	ML-Ethics	Coordination
MoLODUF	■	■	■	■	■	■	■	■	■	■	■	■	■
Khan' (2001) E-learning Framework		■		■	■	■	■	■	■			■	■
Mescan's (nd) E-learning Framework		■		■				■		■	■		■
Goh & Kinshuk's (2006) Framework					■	■	■	■		■	■		■
Quinn's (2002) Framework					■	■	■	■		■	■		■
Zhang's (2003) Framework		■			■	■	■	■		■	■		■
Trifonova & Ronchetti's (2006) Framework		■			■	■	■	■		■	■		■
Yang's (2007) Framework		■			■	■	■	■		■	■		■
Motiwalla's (2007) Framework		■			■	■	■	■		■	■		■
Nakabayashi's (2007) Framework		■			■	■	■	■		■	■		■
Ayala & Castillo's (2008) Framework		■			■	■	■	■		■	■		■

In *Table 5.3* above, a shaded box in the dimensions column indicates the existence of the corresponding dimension in the respective framework. From *Table 5.3* above, it can be seen that existing m-learning frameworks (shaded in light yellow) do not have dimensions for *M-Learning Costs, Learning Processes, M-Learning Evaluation, M-Learning Policy* and *M-Learning Ethics*. However, all the aforementioned dimensions are present in the *MoLODUF*. When *MoLODUF* is compared with Khan's (2001) global e-learning framework, it can be seen that the global e-learning framework is deficient of the M-Learning Cost, Learning Processes, M-Learning Objects and M-Learning Context dimensions. The *Coordination* and *M-Learning Objects User* dimensions are present in all frameworks. Mescan's (nd) e-learning framework is the one which is most deficient in m-learning dimensions.

In the m-learning arena, *MoLODUF* has contributed the *M-Learning Costs, Learning Processes, M-Learning Evaluation, M-Learning Policy* and *M-Learning Ethics* dimensions. In the conventional e-learning arena, *MoLODUF* has contributed towards integrating m-learning with e-learning by suggesting the addition of *M-Learning Cost, M-Learning Processes, M-Learning Objects* and *M-Learning Context* into Khan's (2001) global e-learning framework.

5.7 Conclusion

By providing a global m-learning objects deployment and utilization framework in this Chapter we

have fulfilled the goal, and objectives of this study. The *MoLODUF* provides all the answers needed for answering the research questions set in the study. The *MoLODUF* has extended existing m-learning frameworks with the *M-Learning Costs, Learning Processes, M-Learning Evaluation, M-Learning Policy* and *M-Learning Ethic dimensions*. It has also contributed towards the quest for integrating m-learning with e-learning by introducing the *M-Learning Cost, M-Learning Processes, M-Learning Objects* and *M-Learning Context dimensions* in exiting e-learning frameworks. *MoLODUF* does not only provide competence sets for developing m-learning objects deployment and utilisation applications but can also be used as a method for evaluating existing m-learning environments.

CHAPTER SIX

6. *MoLODUF* VALIDATION

6.0 Introduction

This Chapter is underpinned by the *Evaluation* process steps of the Design Research methodology. It fulfills the objective for validating the framework and accomplishes *Phase 3* of the research approach (See *Chapter Three*). Validation is an evaluation based on the functional specifications implicit or explicit in the suggestion (AIS, 2007). Several validation techniques exist including prototyping (Homrighausen *et al*., 2002, p.35) and domain expert evaluation (Hillstone, 2003; Nielsen & Mack, 1994). This research adopted the domain expert method to validate the *MoLODUF* because expert evaluation is a descriptive design evaluation method that can be used "…. to build a convincing argument for the artifact's utility" (Hevner *et al*. 2004, p.18). The experts (N=5) were asked in an in-depth interview (*see Appendix F*) to provide their levels of agreement to the suitability of the different dimensions and sub-dimensions of the *MoLODUF* (see *Section 5.5.1, Table 5.1 above).* The detailed *MoLODUF* validity/evaluation methodology is provided in *Section 3.3.3* above and the results of the expert evaluation (validation) are presented in *Section 6.1* below.

6.1 Reliability and Validity of the Main Dimensions of *MoLODUF*

As can be seen in *Section 5.5.1, Table 5.1* above, *MoLODUF* is made up of twelve (12) main dimensions, namely: *M-Learning Costs, Learning Processes, M-Learning Devices, M-Learning Objects, M-Learning Resources, M-Learning Evaluation, M-Learning Connectivity, M-Learning Interface, M-Learning Objects User, M-Learning Policy, M-Learning Context* and *M-Learning Ethics.*

Five (5) experts were asked to give their levels of agreement to the inclusion of each of the twelve dimensions in a framework for deploying and utilising learning objects on mobile phones. The levels of agreement were measured on a nominal four point likert scale of strongly disagree (1), disagree (2), agree (3) and strongly agree (4). In order to establish whether the twelve (12) dimensions (items) were reliable for inclusion in the framework, we analyzed the experts' intuitions about the twelve (12) dimensions by performing a reliability test run on them. In the test run, we generated Cronbach's alpha and ANOVA statistics.

A Cronbach's alpha of 0.8908 and a standardized item Cronbach's alpha of 0.9227 were generated. This indicates that the twelve (12) *MoLODUF* dimensions were highly reliable and

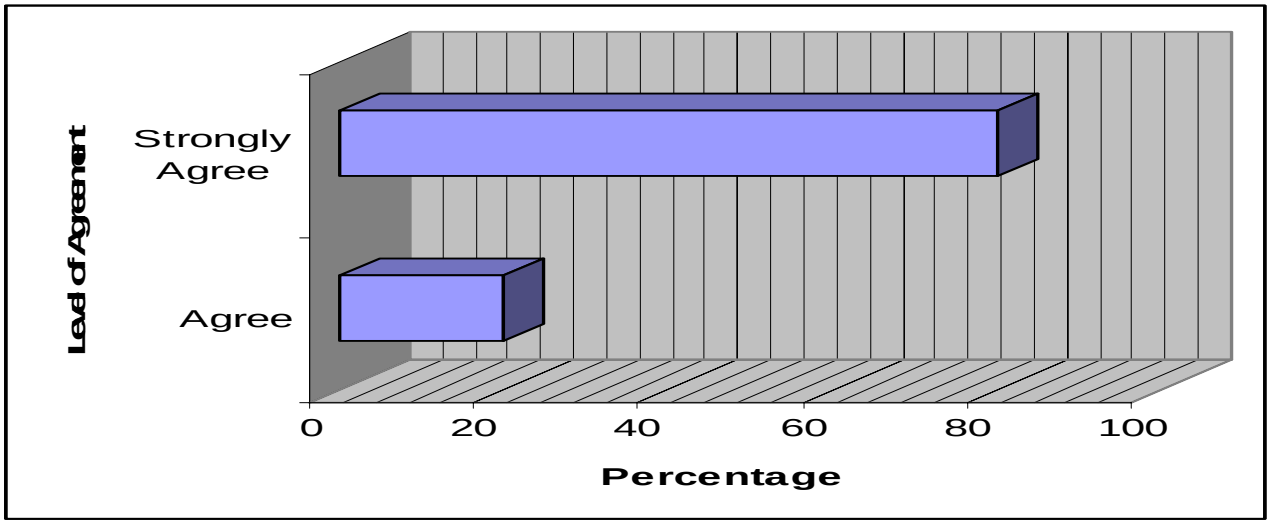
internally consistent. This means that the *MoLODUF* is "rigorously defined, formally represented, coherent, and internally consistent." (Hevner *et al*., 2004, p.11). The Cronbach's alpha was also collaborated by the ANOVA results generated on the 12 dimensions. The ANOVA results are shown in *Table 6.1* below.

Table 6.1: ANOVA Statistics for the Twelve Main Dimensions of the MoLODUF

Source of Variation	Sum of Sq.	DF	Mean Square	F	Prob.
Between People	9.2667	4	2.3167		
Within People	12.9167	55	0.2348		
Between Measures	1.7833	11	0.1621	0.6407	0.7841
Residual	11.1333	44	0.2530		
Total	22.1833	59	0.3760		
Grand Mean	3.6167				

N = 5

Figure 6.1: Level of Agreement as to Whether the Twelve Dimensions Constitute the MoLODUF



From *Table 6.1* above, the grand mean of the nominal four point likert scales of strongly disagree (1), disagree (2), agree (3) and strongly agree (4) is 3.6167 with F = 0.6407. Considering the likert scale chosen, a grand mean of 3.6167 with F = 0.6407 and probability of 0.7841, indicates a very high level of acceptance by the experts, of the need for the twelve dimensions in the *MoLODUF*. These findings therefore confirm that *M-Learning Cost, Learning Processes, M-Learning Devices, M-Learning Objects, M-Learning Resources, M-Learning Evaluation, M-Learning Connectivity, M-Learning Interface, M-Learning Objects User, M-Learning Policy, M-Learning Context* and *M-*

Learning Ethics are valid dimensions in the *MoLODUF*.

Yes, the twelve (12) dimensions are reliable and valid, but do they constitute a mobile learning objects deployment and utilisation framework (*MoLODUF*)? The experts' levels of agreement to this question are presented in *Figure 6.1* above.

Figure 6.1 above, shows that no single expert strongly disagreed (1) or disagreed (2) to the statement that the twelve (12) dimensions shown in *Section 5.5.1, Table 5.1* above constituted a mobile learning objects deployment and utilisation framework (*MoLODUF*). There was total (100%) agreement to this statement as is seen in *Figure 6.1* above. This provides further validation proof for the entire *MoLODUF*.

Now that the major dimensions of the *MoLODUF* were validated, it was important to validate the sub-dimensions of each dimension in the *MoLODUF*. This was aimed at weeding out the sub-dimensions which were not valid. Again the experts were asked to provide their level of agreement for the inclusion of different sub-dimensions in the different major dimensions. *Table 6.2* below summarizes the experts' views on the different sub-dimensions. *Section 6.1.1* through to *Section 6.1.12* discusses the experts' views on the sub-dimensions validation.

6.1.1 Validity of the Sub-Dimensions of the M-Learning Costs Dimension

From *Table 6.2* below, there was 80.0% agreement among the experts interviewed to the inclusion of *M-Learning Unit Cost* and *M-Learning Cost Sustainability Plan* sub-dimensions in the *M-Learning Cost* dimension. While emphasizing the need to mitigate the high cost of m-learning, one of the experts said,

> Downloading information from mobile phone internet is financially not cost effective especially if compared to the free access available through the university. Students who use the Internet on their phones mostly use the free interface of facebook and not necessarily educational materials.

Another said,

> Cost, quality and time are the major pillars on project management. If you are to implement mobile learning, you must consider the cost implications otherwise the implementation might fail before seeing results

Therefore, the *M-Learning Cost Sustainability Plan* and *M-Learning Unit Cost* are valid sub-dimensions of the *M-Learning Costs* dimension.

Table 6.2: Validity of the *MoLODUF* Sub-Dimensions

Dimensions	Sub-Dimensions	Level of Agreement For Inclusion of the Sub-Dimension			
		Strongly Disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)
M-Learning Costs	M-Learning Unit Cost	20	0	20	60
	M-Learning Cost Sustainability Plan	20	0	20	60
Learning Processes	Co-creation of New Knowledge	0	0	40	60
	Knowledge Sharing	0	0	40	60
	Collaboration and Interaction	0	0	40	60
	Reflective Learning	0	0	60	40
	Problem-Based Learning	0	0	40	60
	Academic & Administrative Support	0	0	40	60
	Communication/Information Exchange	0	0	40	60
M-Learning Objects	M-Learning Objects Organization	0	0	40	60
	M-Learning Objects Granulation	0	0	40	60
	M-Learning Objects Media Types	0	0	40	60
	M-Learning Objects Accessibility	0	0	40	60
	M-Learning Objects Usability	0	0	40	60
	M-Learning Objects Pedagogy	0	0	40	60
	M-Learning Objects Repository	0	0	40	60
	M-Learning Objects Brokering	0	0	40	60
M-Learning Devices	Generation Order	0	0	20	80
	Mobile Device Property	0	0	20	80
	Capability	0	0	20	80
	Limitations	0	0	20	80
M-Learning Resources	Infrastructural Resources	0	0	0	100
	Human Resources	0	0	0	100
	Financial Resources	0	0	0	100
M-Learning Connectivity	Mobile Connectivity State	0	0	20	80
	Mobile Networking Technology	0	0	20	80
	Mobile Network Services Providers	0	0	20	80
	Bandwidth	0	0	20	80
M-Learning Objects User	M-Learning Objects User Role	0	0	40	60
	M-Learning Objects User Profile	0	0	40	60
	M-Learning Objects User Education	0	0	40	60
M-Learning Interfaces	Mobile Device Interface	0	0	0	100
	PC Interface	0	0	0	100
M-Learning Evaluation	MCQ Quizzes	0	0	0	100
	Learning Comfort	0	0	0	100
	Learning Equity	0	0	0	100
	MLO Deployment Feedback	0	0	0	100
M-Learning Ethics	Cognitive Overload	0	0	0	100
	Cultural Appropriateness	0	0	0	100
	Privacy and Security	0	0	0	100
M-Learning Policies	Institutional Policies	0	20	20	60
	Government Policies	0	20	20	60
M-Learning Context	M-Learning Propellers	0	0	40	60
	M-Learning Inhibitors	0	0	40	60
	Learning Environment	0	0	40	60

6.1.2 Validity of the Sub-Dimensions of the Learning Processes Dimension

All (100%) the experts interviewed agreed to the inclusion of the seven (7) sub-dimensions as shown in *Table 6.2* above, in the *Learning Processes* dimension. They however associated the achievement of the above learning processes to the capability of the mobile phone in question and encouragement from their instructors to use m-learning. One of the experts said, "… it is possible as long as the students have been encouraged by their instructors to [accomplish the learning processes] even before they start using e-learning". Another said, "… this will be possible provided the mobile phone used has the capacity to enable the student to fulfill the [the learning processes] and provided the phone is affordable to all". The implication here is that the seven (7) sub-dimensions of the *Learning Processes* dimension are valid for as long as learners are motivated to participate in m-learning and have high capacity mobile phones.

6.1.3 Validity of the Sub-Dimensions of the M-Learning Objects Dimension

All (100%) the experts interviewed agreed to the inclusion of the eight (8) sub-dimensions as shown in *Table 6.2* above, in the *M-Learning Objects* dimension. The need for clarity in an m-learning object was expressed by one of the experts interviewed as follows:

> … the simpler and clearer content is, the better the utilization of that [content]. It requires a move away from the yellow notes approach to better synthesized information that undoubtedly captures the imagination of the students.

This implies that the eight (8) sub-dimensions in the *M-Learning Objects* dimension are valid.

6.1.4 Validity of the Sub-Dimensions of the M-Learning Devices Dimension

All (100%) the experts interviewed agreed to the inclusion of the four (4) sub-dimensions as shown in *Table 6.2* above, in the *M-Learning Devices* dimension. Some of the support received from experts for these sub-dimensions is as follows:

> Most phones have a rather not so friendly interface and this limits the capability of the features available for the user and one might opt not to trouble [him/herself] if they feel the process of unraveling the mobile phone features is tedious.

> Of course the kind of mobile phone you have determines what you can do with it. For example, if the learning object is a video simulation, it must run on a phone that has that capability. If the learning object is say programming a game in Python on your mobile phone, then you may need say Nokia N95 that comes with the Python interpreter as part of software.

All the above findings imply that the four (4) sub-dimensions of the *M-Learning Devices* dimension are valid.

6.1.5 Validity of the Sub-Dimensions of the M-Learning Resources Dimension

All (100%) the experts interviewed strongly agreed to the inclusion of the three (3) sub-dimensions as shown in *Table 6.2* above, in the *M-Learning Resources* dimension. While stressing the validity of the three sub-dimensions, one of the experts said, "… this is so true because you must have enough expertise to deploy content on any system including mobile phones and you need finances to run the system on top of working hand in hand with the mobile phone companies which have the infrastructure for such deployment or other service providers." This implies that the three (3) sub-dimensions of the *M-Learning Resources* dimension are valid.

6.1.6 Validity of the Sub-Dimensions of the M-Learning Connectivity Dimension

All (100%) the experts interviewed agreed to the inclusion of the four (4) sub-dimensions as shown in *Table 6.2* above, in the *M-Learning Connectivity* dimension. While supporting the need for the sub-dimensions mentioned in *Table 6.7* above, one of the experts said, "… these provide the ease with which content and objects can be shared especially the free sharing technologies like Bluetooth." Another expert said,

> … of course without the above, the mobile phone has very little role in the mobile learning environment. Only the services available on the mobile phone when it is offline, like calendar and calculator can play a role in learning. Alternatively, if the phone is offline, we can upload a learning object on it directly and the student learns on the move.

The implication here is that the four (4) sub-dimensions of the *M-Learning Connectivity* dimension are valid.

6.1.7 Validity of the Sub-Dimensions of the M-Learning Objects User Dimension

From *Table 6.2* above, 40.0% and 60.0% agreed and strongly agreed that the three (3) sub-dimension of the *M-Learning Objects User* dimension are necessary. While supporting the *M-Learning Objects User* sub-dimensions in *Table 6.2* above, one of the experts said, "… you can only communicate to someone whose needs you have clearly profiled so that the content is relevant and easily understood as it would communicate to the user. Another said, "… of course getting to know the kind of learner you have will help you to know what and how content should be presented to

him/her." All these are clear testimonies and statistics that validate the three (3) sub-dimensions of the *M-Learning Objects User* dimension.

6.1.8 Validity of the Sub-Dimensions of the M-Learning Interface Dimension

All (100%) the experts interviewed strongly agreed to the inclusion of the two (2) sub-dimensions as shown in *Table 6.2* above, in the *M-Learning Interface* dimension. The need for both *Mobile Device* and *PC Interfaces* could be seen in the experts' expositions. One of them said, "… in all instructions, blended learning is the best way of transferring knowledge because it augments the strong learning points of learners as well as exploit the strengths of the instructor". Another said,

> Having versions for both the mobile phone and PCs will benefit the learner who has both. But for the purposes of costs and speaking in the realm of m-learning, I would say that it is not that necessary to have both. I think what matters here is the interoperability of the learning objects in mobile phone and PC interface.

The implication here is that the two (2) sub-dimensions of the *M-Learning Interface* dimension are highly valid for the purpose of m-learning objects interoperability.

6.1.9 Validity of the Sub-Dimensions of the M-Learning Evaluation Dimension

All (100%) the experts interviewed strongly agreed to the inclusion of the four (4) sub-dimensions as shown in *Table 6.2 above*, in the *M-Learning Evaluation* dimension. One of the experts supported the sub-dimensions this way,

> This helps the instructor know the effectiveness of their preferred model of instruction and the impact it has had on the students whether they have learnt better and whether they are enjoying the experience of increasing interfacing through technology. This would help guard against complacency and the attendant negative impacts of technological instruction

Another said, "… the results of the evaluation will help to improve on m-learning service delivery".

These results imply that the four (4) sub-dimensions of the *M-Learning Evaluation* dimension are highly valid.

6.1.10 Validity of the Sub-Dimensions of the M-Learning Ethics Dimension

All (100%) the experts interviewed strongly agreed to the inclusion of the three (3) sub-dimensions as shown in *Table 6.2 above*, in the *M-Learning Ethics* dimension. This implies that the three (3) sub-dimensions are highly valid.

6.1.11 Validity of the Sub-Dimensions of the M-Learning Policy Dimension

Even if 20.0% of the experts interviewed disagreed with the view of including *Institutional* and *Government* policies as sub-dimensions of the *M-Learning Policy* dimension, the majority (80.0%) of the experts interviewed, as is shown in *Table 6.2* above, agreed to inclusion of these sub-dimensions. An 80.0% acceptance level from experts indicates that the two sub-dimensions shown in *Table 6.2* above are valid sub-dimensions of the *M-Learning Policy* dimension.

6.1.12 Validity of the Sub-Dimensions of the M-Learning Context Dimension

All (100%) the experts interviewed agreed to the inclusion of the three (3) sub-dimensions as shown in *Table 6.2 above*, in the *M-Learning Context* dimension. One of them said, "… it is always good to understand the environment in which a certain technology is deployed in order for the users to maximize access and utilization and for the one deploying the technology to maximize diffusion." Another expert said, "… yes the sub-dimensions are good because they provide a checklist of what support and what does not support m-learning." This implies that the three (3) sub-dimensions of the *M-Learning Context* dimension are valid.

6.2 Conclusion

From the statistical evidence presented in *Section 6.1* above, the *MoLODUF* as is shown in *Section 5.5.1*, *Table 5.1* above, is all valid. The statistics validate the twelve (12) major dimensions and their respective sub-dimensions as being the ones that can indeed guide applications developers to create/instantiate applications for deploying and utilizing learning objects on mobile phones. Therefore in order to successfully deploy and utilize learning objects on mobile phones, an m-learning application developer must take care of the m-learning costs and determine the kind of learning processes to be fulfilled by the m-learning application. The developers must decide on the kind of learning objects and m-learning device to be used to fulfill the identified learning process. He/she must ensure the existence of infrastructural, human and financial resources to support the development and growth of m-learning. He/she should profile the kind of mobile network connectivity available to the m-learner. The m-learning objects users must also be profiled to determine their roles, learning styles, history and preferences and digital characteristics. The interface in which the m-learning objects will be deployed and utilised should be profiled so as to determine the kind of m-learning objects to be deployed and utilised in them. Further, as an m-learning object is deployed and utilised, there is need for a mechanism to establish whether learning

is taking place, whether there is learning comfort and equity and whether indeed, the m-learning objects deployed reach their intended recipient(s). More still, the m-learning application developer must ensure that as people learn through m-learning, they have to abide by m-learning ethics put in place by their respective institutions. The ethics will be guided by a given institution's m-learning policy, which should be put in place if it doesn't exist. Above all, the application developer should profile the context in which m-learning is to take place so as to enable the deployment of the right m-learning objects to the right users.

CHAPTER SEVEN

7. CONCLUSION

7.0 Introduction

We have finally come to the last Chapter of this dissertation. The Chapter is underpinned by the *Conclusion* process step of the Design Research methodology. It accomplishes *Phase 4* of the research approach (See *Chapter Three*). The Chapter is organized as follows. In *Section 7.1*, a summary of the key contributions from the study is given. In *Section 7.2*, we provide the implications of the research to theory and practice. In *Section 7.3,* we highlight the limitations that manifested during the study. In *Section 7.4,* we recommend areas of future research and finally in *Section 7.5*, we provide a list of awards worn and publication derived from this PhD research.

7.1 Summary of Key Contributions

The aim of this research was to develop a framework for instantiating/creating pedagogic applications that can enable learners in developing countries obtain access to and use learning objects, delivered over the Internet/other networking technologies, regardless of their proximity to higher education institutions through the use of mobile phones. The main output of this research is the *Mobile Learning Objects Deployment and Utilisation Framework* (*MoLODUF*). The *MoLODUF* is composed of twelve (12) main dimensions each of which has sub-dimensions. The main dimensions of the *MoLODUF* are: *M-Learning Costs, Learning Processes, M-Learning Objects, M-Learning Devices, M-Learning Resources, M-Learning Connectivity, M-Learning Objects Users, M-Learning Interfaces, M-Learning Evaluation, M-Learning Ethics, M-Learning Policies and M-Learning Context.*

We therefore conclude that successful deployment and utilization of learning objects on mobile phones will rest on an m-learning application developer's ability to determine and mitigate the m-learning costs. It will also rest on the developer's ability to establish the learning processes that can be fulfilled through m-learning. The developer will also need to decide on the kind of m-learning objects and m-learning device to be used to fulfill the identified learning process. Candidate learning processes may be: *Co-Creation of New Knowledge, Knowledge Sharing, Collaboration and Interaction, Reflective Learning, Problem-Based Learning, Academic and Administrative Support* and *Communication/Information Exchange*. The developer also needs to ensure the availability of infrastructural, human and financial resources to support the development and growth of m-learning.

The developer will need to profile the kind of mobile network connectivity available to the m-learning objects user. The m-learning objects users will also need to be profiled to determine their roles, learning styles, history and preferences and digital characteristics. The interface in which the m-learning objects will be deployed and utilised will as well need to be profiled so as to determine the kind of m-learning objects to be deployed and utilised in them. Further, as an m-learning object is deployed and utilised, there will be need for evaluations mechanisms to establish whether learning is taking place, whether there is learning comfort and equity and whether indeed, the m-learning objects being deployed are reaching their intended recipient(s). More still, the m-learning application developer will have to ensure that as people learn through m-learning, they abide by the m-learning ethics which must be put in place by their respective institutions. The m-learning ethics will be guided by a given institution's m-learning policy, which should be put in place if it does not exist. Above all, the application developer will need to profile the context in which m-learning is to take place so to mitigate m-learning inhibitors and exploit available m-learning propellers. Profiling of m-learning context will also be done to enable the deployment of the right m-learning objects onto the right user and device in the right context.

The foregoing conclusion provides a competence set of dimensions and sub-dimensions (guidelines) for successfully and meaningfully obtaining access to and utilising learning objects on mobile phones. This competence set of dimensions and sub-dimensions can also be used to evaluate existing m-learning environments. Consequently, this study has fulfilled the research gaps indentified in *Section 2.5* above as indicated in *Table 7.1* below.

Table 7.1: Summary of Key Contributions

Identified Research Gap	Research Contribution
The need for research to enhance existing e-learning framework for m-learning	The *MoLODUF* extends Khan's (2001) global e-learning frameworks with m-learning dimensions such as *M-Learning Cost, Learning Processes, M-Learning Objects, M-Learning Policy and M-Learning Context.* These creatively developed and appropriately validated dimensions extend and improve on the existing e-learning frameworks for m-learning integration.
The need for research to enhance the development and growth of m-learning in different contexts	Key issues for m-learning development and growth such as the existing candidate m-learning activities and favourable conditions for m-learning have been identified. Further, *MoLODUF* has extended existing m-learning frameworks with *M-Learning Costs, Learning Processes, M-Learning Evaluation, M-Learning Policy* and *M-Learning Ethics* dimensions.
The need for research on how to integrate m-learning into e-learning	*MoLODUF* has suggested the addition of *M-Learning Cost, M-Learning Processes, M-Learning Objects* and *M-Learning Context* dimension in existing e-learning frameworks. Also a blended technology use approach has been recommended especially in as far as mobile devices limitations mitigation is concerned.

Identified Research Gap	Research Contribution
The need for research into the pedagogic use of mobile phones and development of m-learning pedagogies	The research has revealed seven learning processes that are suitable for m-learning. These are: *Co-Creation of New Knowledge, Knowledge Sharing, Collaboration and Interaction, Reflective Learning, Problem-Based Learning, Academic and Administrative Support* and *Communication/Information Exchange*. These are all learning processes whose learning pedagogies are underpinned by the social constructivist learning theory, conversational theory, problem-based learning theory, reflective learning theory and teaching and learning support theory.
The need for research on how to adopt and implement m-learning	The dimensions and sub-dimensions in the *MoLODUF* provide a competence set of issues to be followed when adopting and implementing m-learning.
The need for research on learning processes that can be accomplished through m-learning	Seven learning processes including: *Co-Creation of New Knowledge, Knowledge Sharing, Collaboration and Interaction, Reflective Learning, Problem-Based Learning, Academic and Administrative Support* and *Communication/Information Exchange* have been revealed as being suitable for m-learning.
The need for research on the kinds of learning objects that can be used to accomplish the possible m-learning processes	The study has counseled that it is not pedagogical enough to stick to one learning object media type because there are variations in learning styles, cultures, preferences, contexts, device capabilities, networking technologies and costs involved. According to this study, it is better to leverage different media types in ways that are appropriate to the prevailing circumstance so as to produce the best learning experience. Hence for each learning process identified the research has identified its suitable m-learning objects. This research revealed that SMSs, text messaging, voice calls, MMSs, audio and video podcasts, Wapsites, software modules/components or games were the m-learning objects that could be used to fulfill different learning process. However, within the cost and constraints placed by mobile technologies in our context, SMS/text and audio based m-learning objects were more feasible.
The need to develop guidelines for developing applications for deploying and utilising learning objects on mobile phones	The dimensions and sub-dimensions in the *MoLODUF* provide guidelines for developing applications for deploying and utilising learning objects on mobile phones.
The need for research on how to mitigate mobile phones limitations	This research has suggested mobile devices limitation mitigation measures based on blended technology use philosophy
The need for research on how to mitigate the high cost of m-learning and how to sustain m-learning	A formula for pinpointing the exact cost of m-learning for an m-learner (*TCMPC*) has been suggested. The research has also suggested an m-learning cost sustainability plan (*MLCSP*).

All in all, this study has been able to fill 12 out of the 13 (92.0%) research gaps identified in *Section 2.5* above. The research gap on the need to develop standard for m-learning object metadata is still outstanding and has been recommended as a future research area in *Section 7.3* below. The contributions in this research have several implications to theory and practice as provided in the section that follows.

7.2 Implication of the Research to Theory and Practice

7.2.1 Implication of the Research to Theory

The study has contributed to the fund of knowledge in information system in general and m-learning in particular. Most often, the contribution of [Design Research] is the artifact itself (Hevner *et al*., 2004, p.19). The artifact (*MoLODUF*) developed in this research provides a grain of contribution to the development of m-learning theories. M-learning is a young field with a dearth in theories (Sharples *et al*., 2005; Traxler, 2007). The learning processes identified in *MoLODUF* illustrate that learning pedagogies from the social constructivist learning theory, collaborative and interactive learning theory, conversational theory, reflective learning theory, problem-based learning theory and teaching and learning support theory can be adapted for a mobile learning environment based on the *MoLODUF*. The *MoLODUF* extends the knowledge base of e-learning by introducing mobility in existing e-learning frameworks and theories. It enables a blended approach to use of educational technologies.

When compared with other information systems research methodologies such as case study (Yin, 1984), systems dynamics (Williams, 2002) and others, Design Research methodology (AIS, 2007) is a relatively new methodology. The successful execution of this research study using this relatively new research methodology provides further proof that Design Research is a rigorous information systems methodology. It bestows confidence among information systems researchers about the scientific rigour of using Design Research methodology in information systems studies. It implies that information systems studies that combine research, design and practice can increasingly be executed using Design Research methodology.

7.2.2 Implication of the Research to Practice

Here we look at the implication of the research to the society/community, technical audience and university management.

i Implication of the Research to Society/Community

The *MoLODUF* provides guidelines for creating m-learning objects applications. Once m-learning applications are developed and embraced by the different societies/communities, lifelong learning will be entrenched in peoples' daily lives since mobile phones ownership and use has become pervasive. Learners will be enabled to utilize their mobile phones for learning

independent of time and location.

The m-learning applications that will be created from the *MoLODUF* have the ability to 'democratise' education. Education is a major key in bringing societies/communities forward and out of poverty. Hence *MoLODUF* has the ability to reduce poverty among societies/communities. The applications developed from *MoLODUF* can permit increased access to education by all deserving citizens. This presents an advantage of extending an education to many deserving citizens, who in the long run are empowered by this education to fight poverty.

.Applications developed from the *MoLODUF* can entrench the digital lifestyles of the increasing digital natives in our society. The implication here is that the education delivery model arising from the *MoLODUF* is more likely to appeal to the digital lifestyles of the youngsters (digital natives) than the traditional models, hence changing the learning and teaching landscape/scene.

ii Implications of the Research to the Technical Audience

M-learning system analysts, researchers, applications developers, technicians, instructional and graphic designers and content developers, telecommunications companies and mobile devices manufacturers, form the technical audience for m-learning. This technical community, for the very first time, now has a competence set of guidelines they can use to develop and evaluate m-learning environments, products and services.

In the *M-Learning Interface* dimension of *MoLODUF*, it is suggested that m-learning objects should be created for interoperability between mobile device and personal computer interfaces. The implication here is that creating an interoperable learning object which can cause the same learning experience in both mobile and PC interfaces is a daunting task which requires considerable programming and didactical skills.

Learning Comfort is one of the sub-dimensions in the *M-Learning Evaluation* dimension of the *MoLODUF*. This sub-dimension places an important requirement to mobile devices manufacturers to innovate mobile devices (3G, 4G and above) that can be used with foldable keyboards and screens. Such devices should have enough internal memory (and mechanisms for using external memory as well) and sufficient bandwidth to accommodate multiple media learning objects. The devices should be manufactured with pedagogic values in mind as are provided in the *MoLODUF*. In the meantime, the e-learning technology blend suggested in the *MoLODUF* as measure for mitigating mobile phones limitation can do as we wait for mobile technology improvements called for above.

iii Implication of the Research to University Managers

University managers are important m-learning stakeholders. It is them who make decisions as to whether m-learning artifacts are to be developed and/or implemented within their universities or not. The *MoLODUF* makes suggestions with important policy implications to universities.

In the *M-Learning Cost* dimension of the *MoLODUF*, an *M-Learning Cost Sustainability Plan* (MLCSP) is suggested. This plan requires universities to set aside financial resources to sustain m-learning. The implication here is that m-learning has to be included as a budget item in university budgets. Similarly, in the *M-Learning Resources* dimensions, universities are required to set aside infrastructural, human and financial resources for use in m-learning. These resources also require votes in the universities' budgets. Where the budget votes are insufficient, universities will need to seek funding from their respective governments and donors to fund m-learning research, development and growth.

In the *M-Learning Ethics* dimension of the *MoLODUF*, it is suggested that institutions put in place m-learning code of conduct underpinned by the respective institutions' *M-Learning Policies.* The implication here is that implementation of *MoLODUF* in institutions will require formulation of m-learning policies or revision of existing e-learning policies, exercises which tend to be time consuming and expensive.

In the *M-Learning Connectivity* dimension of the *MoLODUF*, there is a *Mobile Network Service Providers* sub-dimension. This sub-dimension dictates the need for universities to forge a good working relationship with mobile network service providers. Mobile network service providers offer the necessary connectivity for m-learning to be realized. They offer promotional communications schemes, permit third party applications to be installed within their network backbones and undertake research into innovative mobile applications. They have the key to mobile communications tariffs. The implication here is that universities should forge a close working relationship with mobile network service providers or telecommunications companies. Universities should seek to formulate and sign memorandums of understanding (MoUs) with telecommunications companies for fair use of their mobile networks for learning and teaching purposes. The MoUs could be for: hosting third part m-learning applications, providing subsidized mobile communications tariffs, m-learning research and development or any other services and products found to benefit the relationship.

M-learning is an infant mode of learning objects delivery and in the *M-Learning Evaluation* dimension of the *MoLODUF*; m-learning implementers are implored to undertake an evaluation

to establish whether there is learning comfort and whether learning can take place on a mobile phone. The implication here is that universities should follow the *MoLODUF* competency set of dimensions and sub-dimensions to trial out m-learning and demystify the technical, pedagogical and organisational hypes and realities of m-learning. As a first step, universities can ensure meaningful and sustained use of m-learning by encouraging the development of an m-learning culture where text messaging is made the major channel of communication among university staff and students for the day to day operation communication.

In the *M-Learning Devices* dimension of the *MoLODUF*, cognizance is made of the fact that learners own a myriad of mobile phones with disparate generation orders, properties, capabilities and limitations. This mobile devices scenario is likely to constrain the implementation of m-learning objects deployment and utilisation. The implication here is that universities wishing to implement m-learning should advocate for comparable mobile devices with considerable capabilities. This may go to the extent of requiring m-learners to acquire GPRS enabled mobile phones or mobile phones with properties that are commensurate with learning process (es) voted for porting in m-learning.

In the *M-Learning Objects* dimension of the *MoLODUF*, there are *M-Learning Usability* and *Accessibility* sub-dimensions which all require the resolution of IPR issues before obtaining access to and utilising m-learning objects. The number one implication here is the need for financial resources to pay for closed access learning objects. The second implication for university managers relates to the management of IPR issues in the event of increased access to a multitude of learning objects occasioned by the surfacing of numerous m-learning applications instantiated from the *MoLODUF*.

In the *M-Learning Objects User* dimension of the *MoLODUF*, there is an *M-Learning Objects User Education* sub-dimension whose roles are to: educate mobile learning objects users about their handsets, provide technical skills for m-learning and sensitize the populace about m-learning. M-learning is still alien to most stakeholders' minds and hence attracts less financial and moral support from them. The implication here is for universities to popularize m-learning. Universities will have to provide seed money to kick start the innovation with the view of showcasing its potential and value to the education and business community. Once it is showcased and a business case is identified, telecommunications companies and other education stakeholders will get the necessary awareness about m-learning and possibly support it.

The *MoLODUF* comes in to address a gap of learning on mobile devices. Technology is ever

advancing and curriculum must change to be suited to changing societal needs and situations. Universities are now advocating for constructivistic, experiential student centered learning paradigms. Web 2.0 technologies are here with us in addition to mobile learning. University managers and curriculum developers will need to move very fast to take advantage of these student centered learning paradigms. The *MoLODUF* provides a right step in this direction.

When a multitude of m-learning applications are developed and m-learning adopted, there will be a lot of obsolete mobile waste. The implication here will be the need to incorporate electronic waste disposal policy within the m-learning policy so as to save the environment from degradation as a result of mobile phone waste.

7.3 Limitations to the Study

First and foremost, this work focused more on mobile phones than any other m-learning devices. This was dictated by the impressive statistics of ownership of mobile phones as opposed to other mobile devices. Other mobile devices such as PDAs, Tablet PCs and iPods were not popular amongst the target study population. The *MoLODUF* however, is global enough and encompasses all mobile devices and generations. It even allows for future capability growth in mobile devices.

Whereas prototyping is considered to be the best validation method for Design Research artifacts (Buranathiti *et al*., 2006), it was not used to validate the *MoLODUF* due to time and resource constraints. *MoLODUF* contains exogenous and endogenous dimensions and sub-dimensions which require considerable time and resources to implement in a prototype. However, an equally rigorous validation technique of using experts to validate the *MoLODUF* was adopted. After all, expert evaluation is a descriptive design evaluation method that can be used "…. to build a convincing argument for the artifact's utility" (Hevner *et al*. 2004, p.18). We intend to seek funding to implement, from the *MoLODUF,* an m-learning objects deployment and utilisation application as a post doctoral project activity.

7.4 Direction for Future Research

In the *m-Learning Ethics* dimension of the *MoLODUF*, it is guided that m-learning must be culturally appropriate. This suggestion was adduced from the results of the study which established that a new form of vocabulary had emerged in a quest to maximize the use of a 160 character text message in an SMS. This revelation opens up a new direction for future research in the area of digital communications skills for m-learning. One of the research questions in this research area

could be, 'what learner support terms, abbreviations and acronyms should be adopted in an acceptable vocabulary for m-learning?' Another research question could be, 'how can the limited character SMS-based learning object be optimized for collaborative and interactive m-learning?'

Still in the *M-Learning Ethics* dimension of the *MoLODUF*, there is a *Security* and *Privacy* sub-dimension whose brief is to ensure that the security and privacy of information of individual nature on an m-learner's mobile phone is kept safe and confidential. Just like any other information systems field, not enough research has been undertaken in the area of security and privacy for information in m-learning and therefore this present a new problem for research. One of the research questions to be paused under this research area could be, 'how can an m-learner manage m-learning information on his/her mobile phone amidst the competing needs for resources on the same mobile phone from non-m-learning information?' Another research question might be, 'how will Bluetooth-based collaborative and interactive learning impact on the m-learners' security and privacy?'

In the *M-Learning Interface* dimension of the *MoLODUF*, a call for learning objects interoperability is sounded. Learning objects interoperability requires standardized design and development of learning objects based on standardized learning objects metadata. Whereas several metadata standards exists for learning objects design and development, this study has established that there are no ratified metadata standards for m-learning objects that can interoperate in mobile and PC environments. More research needs to be undertaken in the area of m-learning objects metadata standards. One of the research questions that can be paused in this research area might be, 'what attributes are required in the metadata of a learning object that can interoperate in PC and mobile interfaces?'

Learning is said to have occurred if there is change in the learner's observable behaviour (Skinner, 1968). Thus "the key to learning is retention - remembering and understanding the material in order to implement it" (Mescan, nd, p.2). In the *M-Learning Evaluation* dimension of the *MoLODUF*, there is a *Learning Equity* sub-dimension whose mandate is to ensure that there is learning equity between m-learning and other learning models. Designing learning objects that can ensure the same learning experience when used in a mobile or PC environment is still a matter of further research. One of the research questions here might be, 'what design aesthetics should be put in a learning object that can assure equal learning experiences in mobile or PC environments?' Another research question might be, 'what learning comfort measures should be introduced in m-learning to ensure similar learning comfort as in other learning models?'

The usability of the *MoLODUF* was only tested using domain expert evaluation. Future work will involve the development of a complete m-learning objects deployment and utilisation application/environment underpinned by the *MoLODUF*.

7.5 List of Awards and Publication Got From this PhD Research

The *Conclusion* processes step of Design Research methodology requires that knowledge generated be communicated so as to generate new research problems. This was done/is still being done through participating in research competitions and publications in journals, edited books and conferences.

7.5.1 Award Won

1. Part of this PhD research, titled, "*Managing mLearning Costs in Low Income Societies of Africa*" won 'A Highly Commended Research Award' from Emerald (See http://info.emeraldinsight.com/research/awards/2009_alcs_mgmt.htm).
2. This PhD research work won the Postgraduate Student Research Project of the Year Award of the Uganda Communications Commission Annual Communication and Innovation Awards 2010 (See http://www.ucc.co.ug/award/index.htm).

7.5.2 Refereed Journal Articles

1. Muyinda, B. P., Lubega, J., & 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.
2. Muyinda, B. P., Lubega, J., & Lynch, K. (2009). A model for scaffolding traditional distance learners for constructivistic online learning. *Makerere University Journal for Higher Education (MAJOHE), 2*(2009), 155-176.
3. Muyinda, B. P. (2007). MLearning: pedagogical, technical and organizational hypes and realities. *Campus-Wide Information Systems, 24*(2), 97-104.

7.5.3 Journal Papers in Press

1 Muyinda, B. P., Lubega, J., Lynch, K. Weide, T. (2010). Mobile learning objects deployment and utilization in developing countries. Accepted in *International Journal of Mobile and Blended Learning (ISSN: 1941-8647).* In Press

2 Muyinda, B. P., Lubega, J., Lynch, K., Van Der Weide, T. (2010). Managing mLearning Costs in Low Income Societies of Africa. Submitted to *Campus Wide Information Systems* ©Emerald Publishers

3 Muyinda, B. P., Lynch, K. Lubega, J.,., Van Der Weide, T. (2010). A Model for Mobile Learning Adoption and Implementation in Africa (MLAIMA). About to be submitted to *International Journal of Instructional Technology and Distance Learning*

7.5.4 Edited Book Chapters

1. Muyinda, P. B., Lynch, K. & Lubega, J. (2008). Mobile Research Supervision Initiative (MRSI) at Makerere University. In Aisbett, J., Gibbon, G., Rodrigues, A. J., Kizza, M. J., Nath, R. & Renardel, G. R (Ed)., *Strengthening the Role of ICT in Development*, Kampala: Fountain Publishers, ISBN: 978-9970-02-871-2.
2. Muyinda, B. P., Lynch, K., & Mugisa, E. (2007). Mlearning: The education use of mobile communications devices. In Kizza, J. M., Muhirwe, J., Aisbett, J., Getao, K., Mbarika, V.W., Patel, D., & Rodrigues, A.J. (Ed.), *Strengthening the Role of ICT in Development***.** Kampala: Fountain Publishers. ISBN: 978-9970-02-730-9

7.5.5 Conference Papers and Presentations

1 Muyinda, B. P., Lubega, J., Lynch, K., Van Der Weide, T. (2010). A Model for Mobile Learning Adoption and Implementation in Africa (MLAIMA). *A paper presented at the 5th International Conference on ICT for Development, Education and Training (e-Learning Africa 2010), Lusaka, Zambia*, 26th – 28th May 2010.

2 Muyinda, B. P., Lubega, J., Lynch, K., Van Der Weide, T. (2010). Mobile learning objects deployment and utilization in developing countries. *A paper presented at IADIS Mobile Learning 2010,* Porto, Portugal, 19th – 21st March 2010

3 Muyinda, B. P., Lubega, J., Lynch, K. (2009). A Framework for Introducing and Sustaining Constructivistic Online Learning amongst Traditional Distance Learners in Africa. *A paper presented at the 4th International Conference on ICT for Development, Education and Training (e-Learning Africa 2009)*, Le Meridien Hotel, Dakar Senegal, 27th -29th May 2009

4 Muyinda, B. P., Lubega, J., Lynch, K. (2008). An Evaluation of the Mobile Research Supervision Initiative (MRSI) at Makerere University. *A paper presented at the 3rd International Conference on ICT for Development, Education and Training (e-Learning*

Africa 2008), International Conference Centre, Accra, Ghana, May 28-30, 2008.

5 Muyinda, B. P., Lynch, K., Mugisa, E. (2007). Mlearning: The education use of mobile communications devices. *A paper presented at SREC 07 Conference - Strengthening the Role of ICT in Development*, Kampala, Uganda, August 5-7, 2007

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QNNA'RE IDNo. ----------
(for official use only)

APPENDIX A: SURVEY QUESTIONNAIRE

QUESTIONNAIRE FOR A PHD RESEARCH TITLED "DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES"

Dear Sir/Madam,

I am a PhD student at Makerere University in my initial stages of preparing a thesis. I am undertaking a survey to fulfill the objectives the following objectives, to establish the context of learners with direct bearing to m-learning, to establish the state of m-learning practice and prospects for its development and growth in Africa, to establish factors that influence learning objects deployment and use on mobile phones, to develop a framework for instantiating applications for deploying and utilizing learning objects on mobile phones in different contexts and to validate the framework developed. The information obtained herein will be used in building a mobile learning objects deployment and utilisation framework for developing countries. The concept 'mobile learning' or 'm-learning' is used in this research to mean learning with the aid of mobile devices such as mobile phones, PDAs, smart phones, personal digital assistant, and MP3/4 devices. Learning objects are learning materials broken down in small educationally meaningful chunks.

I kindly request you to sacrifice 25 to 30 minutes of your precious time to complete this questionnaire. Kindly complete the questionnaire as truthfully as possible.

Do not disclose your identity. The information provided herein will be treated with utmost confidence and will only be used for the purpose of this research.

Thank you

Muyinda Paul Birevu
PhD Student, Makerere University

GENERAL INSTRUCTIONS

1. The majority of questions in this questionnaire require to 'tick a box' so are quick to complete
2. For questions with numbered responses, simply tick the number of your preferred response
3. For questions with no numbered responses, tick all responses which apply to you
4. For open-ended questions, provide your responses in the gaps provided
5. Please do not write in the boxes on the right hand side of the question, as they will be used for coding purpose.

AVENUES FOR RETURNING THE QUESTIONNAIRE

The Questionnaire can be either physically picked up by the researcher or his research assistants or dropped at the reception desk of the Department of Distance Education in the Institute of Adult and Continuing Education (CCE), Makerere University or can be posted to:

Muyinda Paul Birevu (0772-406919)
Makerere University
IACE, Department of Distance Education
P.O. Box 7062, KAMPALA

} Addressed envelop with postage stamp is included

SECTION A: LEARNER CHARACTERISTICS

PART A: BACKGROUND INFORMATION

1 Gender ***(Tick only one)***

Male [1]	Female [2]
1	2

2 Age ***(Enter your age here)*** _____

3 Programme Category ***(Tick only one)***

Science [1]	Humanity [2]
1	2

4 Mode of study ***(Tick only one)***

Distance education (external) student [1]	Fulltime (internal) student [2]
1	2

5 Year of study ***(Circle only one)***

Year 1 [1]	Year 2 [2]	Year 3 [3]	Year 4 [4]	Year 5 [5]
1	2	3	4	5

6 Marital status ***(Tick only one)***

Single [1]	Married [2]
1	2

7 Employment status ***(Tick only one)***

Employed [1]	Unemployed [2]
1	2

8 What was your last education level before joining your current programme of study at the University ***(Tick only one)***

A' level [1]	Grade III Teacher Certificate [2]	Diploma [3]	Bachelor's degree [4]	Others (Specify) [5]
1	2	3	4	

PART B: LEARNER'S LOCATION

9 The place where you usually conduct your learning activities is generally ---- ***(Circle only one)***

Rural [1]	Urban [2]	Semi-urban [3]
1	2	3

10 Which of the following best describes your usual learning environment? ***(Tick only one)***

Is always quiet [1]	Is sometimes noisy [2]	Is always noisy [3]
1	2	3

11 Indicate your level of agreement to the statements in A to C below by ticking the number that applies to you

Key:

1 = Strongly disagree	2 = Disagree	3 = Agree	4 = Strongly agree

A	Mobile telephone connectivity is present at all times in all the place(s) where I conduct my learning activities	1	2	3	4		
B	Internet connectivity is present at all times in all the place(s) where I conduct my learning activities	1	2	3	4		
C	I have constant power supply in all the place(s) where I conduct my learning activities	1	2	3	4		

PART C: GENERAL ICT SKILLS AND ICT ACCESS ISSUES

12 In what ways would you describe your knowledge of computers and their use? ***(Tick only one)***

Excellent [1]	Very good [2]	Fairy good [3]	Basic [4]	No Knowledge [5]	
1	2	3	4	5	

13 How would you describe the frequency of use of the following ICTs for conducting your learning activities? ***(In each of A to D below tick only one option)***

ICT	Never [1]	Irregu-larly [2]	Once a week [3]	2-3 times a week [4]	4 times a week [5]	≥ 5 times a week [6]		
A. Internet	1	2	3	4	5	6		
B. Mobile Phone	1	2	3	4	5	6		
C. E-Mail	1	2	3	4	5	6		
D. Learning Management Systems (e.g. Moodle, Blackboard, KEWL, etc)	1	2	3	4	5	6		
E. CD ROM	1	2	3	4	5	6		
F. Computer applications other than the above	1	2	3	4	5	6		

14 Where do you usually access the Internet? ***(Tick whichever is applicable to you)***

	At home	
	At the University where I study	
	At my workplace	
	At an Internet Café	
	My friend's office/home	
	I never use the Internet	

PART D: MOBILE AND ONLINE LEARNING COST ISSUES

15 The majority of times I have communicated on a mobile phone with other people --- (*Tick only one)*

	I have always used my own mobile phone	
	I have always used someone else's mobile phone	

16 Who is your mobile network provider? (*Tick whichever applies to you)*

	Celtel	
	MTN	
	UTL/Mango	
	Warid	
	None of the above	

17 Who pays the bulk of your mobile phone bill(s) *(Tick only one)*

	I do not have a mobile phone [1]	
	Myself [2]	
	My parents [3]	
	My husband/wife/partner [4]	
	My employer [5]	
	My university [6]	
	Others (specify) [7]_____	

(For each of the Questions 19 & 20 below, enter a number in the space provided)

18 How many free text messages (if any) do you get included in your payment plan per month? ___

19 How much bonus airtime worth (if any) do you get included in your payment plan per month? _____

20 What is your average mobile phone bill per month?_____

21 Have you ever heard about the term 'm-learning'? *(Tick only one)*

Yes [1]	No [2]	
1	2	

22 For what purpose (s) do you make mobile phone calls? *(Tick whichever is applicable to you)*

	Leisure/entertainment	
	Learning/education	
	General communication	
	Transacting profit oriented business	
	Participating in lottery	
	Participating in radio/TV talk shows	
	Others (specify)_____	

23 For what purpose do you send text messages (SMSs)? *(Tick whichever is applicable to you)*

	Leisure/entertainment	
	Learning/education	
	General communication	
	Transacting profit oriented business	
	Participating in lottery	
	Participating in radio/TV talk shows	
	Others (specify)_____	

24 If you were to use your mobile phone for learning, suggest a sustainable way for meeting the mobile phone bills ***(Write your suggestion in this box)***

PART E: LEARNING STYLES, PREFERENCES, NEEDS, HABITS, ATTITUDES AND CULTURES

25 Evaluate each statement in A to Y below by circling or ticking the appropriate number

Key:

1 = Strongly disagree	**2 = Disagree**	**3 = Agree**	**4 = Strongly agree**

A	I subscribe to online communities (e.g. Yahoo messenger, MSN messenger, etc) where I share learning experiences with others	1	2	3	4		
B	I am fluent in the use of social networking media such as blogs, iPods, podcasting/audioblogs, wiki, yackpack, flickr, etc.	1	2	3	4		
C	Through collaborative engagement with my peers via social networking media, I have been able to generate some useful learning materials/content	1	2	3	4		
D	While undertaking my learning activities, I can simultaneously engage in discussions with other people via my mobile phone or computer with no interruptions to my learning concentration	1	2	3	4		
E	While undertaking my learning activities, I can simultaneously listen to music from my iPods or MP3/4 player or mobile phone or radio or TV with no interruptions to my learning concentration	1	2	3	4		
F	While undertaking my learning activities, I can simultaneously watch TV programmes with no interruptions to my learning concentration	1	2	3	4		
G	I prefer peer-to-peer group learning to teacher-led classroom learning	1	2	3	4		
H	I prefer independent learning to group learning	1	2	3	4		
I	I prefer learning by doing and making meaning out of the content	1	2	3	4		
J	I usually initiate my own learning activities ahead of my teacher/lecturer	1	2	3	4		
K	I actively participate in contributing solutions to group based assignments	1	2	3	4		
L	I always find time on a daily basis to engage in out of class learning activities	1	2	3	4		
M	Using my mobile phone, I have ever interacted with my classmates outside the classroom environment	1	2	3	4		
N	Using my mobile phone, I have ever interacted with my teachers/lecturers outside the classroom environment	1	2	3	4		
O	I prefer problem-based learning challenges that employ my prior experiences	1	2	3	4		
P	I prefer practically based learning activities which allow me to practice and use theory	1	2	3	4		
Q	I prefer learning activities in which time is provided to think before I act	1	2	3	4		
R	I prefer learning activities which have logical, rational and clear aims	1	2	3	4		
S	I prefer learning at my own pace to learning in timed periods	1	2	3	4		

T	I prefer reading printed e-mails to the ones on the computer screen	1	2	3	4		
U	When I want an e-mail printed, I print it myself	1	2	3	4		
V	When I want to make corrections in a word/excel document, I first print it	1	2	3	4		
W	I prefer reading a printed document to a document on a computer screen	1	2	3	4		
X	Whenever I discover an interesting website, I bring my friends to my computer to see it	1	2	3	4		
Y	Whenever, I send an e-mail to a colleague, I follow it up with a 'did you get my e-mail' phone call	1	2	3	4		

26 Please list the learning activities you engage in while outside the classroom environment?

SECTION B: MOBILE LEARNING ACTIVITIES

27 Mobile phones can be used for ----- ***(Tick whichever you know)***

	Sending/receiving reminders of learning events	
	Sending/receiving coursework advice to/from classmates	
	Sending/receiving examinations/test tips to/from classmates	
	Receiving guidance on learning activities from lecturers	
	Receiving administrative messages from the University	
	Discussing topics covered in a given course	
	Undertaking simple multiple choice quizzes	
	Supplementing print based learning materials/content	
	Keeping in touch with classmates	
	Keeping in touch with university officials	
	Accessing/delivering online learning materials/content	
	Other (please specify)	

28 I use my mobile phone to undertake the following learning activities ***(Tick what applies to you)***

	Send/receive reminders of learning events	
	Send/receive coursework advice to/from classmates	
	Send/receive examinations/test tips to/from classmates	
	Receive guidance on learning activities from lecturers	
	Receive administrative messages from the University	
	Discuss topics covered in a given course	
	Undertake simple multiple choice quizzes	
	Supplement print based learning materials/content	
	Be in touch with classmates	
	Be in touch with university officials	
	Access/deliver online learning material/content	
	I don't use a mobile phone for learning	
	Other (please specify)	

29 I usually use my mobile phone for learning when I am --- *(Tick whichever is applicable to you)*

	At home	
	Traveling	
	In classroom	
	In the library	
	In meetings	
	In my workplace	
	Anywhere	
	I don't use a mobile phone for learning	

30 At what time do you mainly use your mobile phone for learning? *(Tick only one)*

7:00 am to 1:59 pm [1]	2:00Noon to 6:59pm [2]	7:00pm to 11:59 pm [3]	12:00 am to 6:59 am [4]	Any time [5]	I don't use phone for learning [6]	
1	2	3	4	5	6	

SECTION C: MOBILE LEARNING DEVICES AND TECHNOLOGIES

31 Which of the following mobile networking technologies are accessible on your mobile phone? *(In each of A to E below, tick only one option)*

Technologies	Accessible [1]	Not Accessible [2]	Not Sure [3]	I don't have a mobile Phone [4]		
A. General Radio Packet Services (GPRS) – a technology for mobile phones connectivity (mobile network)	1	2	3	4		
B. Bluetooth – you can wirelessly interconnect your mobile phone with a computer	1	2	3	4		
C. Wireless Access Protocol (WAP) – You can access the Internet on your mobile phone	1	2	3	4		
D. Global positioning system (GPS) – You can use coordinates on your mobile phone to identifying your locations on the earth	1	2	3	4		
E. Radio Frequency Identification (RFID) – a technology that automatically responds by providing contextualized information on the spot	1	2	3	4		

32 With my mobile phone, I can --- *(In each of A to L below, tick only one option)*

Capability	Yes [1]	No [2]	Don't have a mobile Phone [3]		
A. Make/receive voice calls	1	2	3		
B. Send/receive text messages	1	2	3		
C. Take/send/receive a photograph	1	2	3		
D. Access the Internet	1	2	3		
E. Send/receive e-mails	1	2	3		
F. Interconnect it to other devices using bluetooth technology	1	2	3		
G. Use it to record audio and play it back	1	2	3		
H. Use it to record and view movies	1	2	3		
I. Use it to view documents and images	1	2	3		
J. Use it to read, edit and handle computer files	1	2	3		
K. Install some software on it	1	2	3		
L. Interact with the software I installed on it	1	2	3		

SECTION D: - MOBILE LEARNING CONTENT/OBJECTS

33 My usual learning content/objects are in ---------- form *(Tick only one)*

Paper based [1]	Electronic [2]	Paper based & Electronic [3]	
1	2	3	

34 I learn the most when a learning activity is expressed in terms of -- *(Tick only one)*

Text [1]	Video [2]	Audio [3]	Graphics [4]	Mixed media [5]	
1	2	3	4	5	

SECTION E: MOBILE LEARNING ENVIRONMENTAL ISSUES

35 What is your opinion towards the general concept m-learning? *(Write in the box)*

36 What do think could be the public's perception towards mobile learning? *(Write in the box)*

FINAL WORD

Reminder of Questionnaire Return Instructions
The Questionnaire, can be either physically picked up by the researcher or his research assistants or dropped at the reception desk of the Department of Distance Education in the Institute of Adult and Continuing Education (CCE). or can be posted to:

Muyinda Paul Birevu (0772-406919)
Makerere University
Institute of Adult and Continuing Education
Department of Distance Education
P.O. Box 7062, KAMPALA

} Addressed envelop with postage stamp is included

PHD CANDIDATE:
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MANY THANKS FOR YOUR TIME AND PATIENCE

APPENDIX B: MOBILE TELECOMMUNICATION SERVICES PROVIDERS' INTERVIEW GUIDE

PROJECT TITLE: DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES

At the Start

1. Introduction
2. Explain the study, obtain verbal consent
3. Outline the purpose of the Interview
4. Seek for some organizational and interviewee's particulars

Interview Questions

5. What is your view on the issue of delivering and utilising learning objects onto learners' cell phones?
6. How can limitations of mobile phones be mitigated to permit deployment and utilisation of learning objects on mobile phones?
7. What do you think are the favoring factors to m-learning in Africa
8. What do you think could be the barriers to m-learning in Africa?
9. What do you think could be the most sustainable way for implementing m-learning activities in educational institutions?
10. What is your view towards the general concept of m-learning?

Summing the Interview

17. Do you have any questions/comments on any issues related to mobile or e-learning?
18. Conclusion

APPENDIX C: E-LEARNING PROVIDERS AND UNIVERSITY ADMINISTRATIVE AND ACADEMIC STAFF INTERVIEW GUIDE

PROJECT TITLE: DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES

Section A: General questions

1. Interviewer introduces himself and gives the purpose of the study
2. Type of organization (such as College, university, etc…)
3. Location: Country; rural; urban; ….
4. What is your role in the organization?
5. What are the major learning content or information sources for learners in your university?

Section B: Mobile learning (m-learning) questions

Definition: m-learning: A form of e-learning which employs wireless, tiny, handheld and portable devices to extend and deliver learning to learners (Luis de Marcos *et al.*, 2006).

6. How are you using m-learning in your university?
7. What classroom learning activities do you think could benefit from m-learning?
8. What out-of-the-classroom learner support services do you think could benefit from m-learning?
9. What do you think are the favoring factors for m-learning in your university?
10. What do you think are the barriers to m-learning in your university?
11. What resources have you put in place in your institution to enable the development, deployment and utilisation of m-learning objects?
12. In your opinion, what human resources and technological infrastructure are needed to enable the development, deployment and utilisation of m-learning objects?
13. What is your view on the issue of delivering learning objects onto learners' cell phones?
14. How can limitations of mobile phones be mitigated to permit deployment and utilisation of learning objects on mobile phones?
15. Does your organization have an m-learning policy?
16. What do you think could be the most sustainable way (cost wise) for implementing m-learning activities in educational institutions?
17. In your opinion, what learning object media type (text, audio, graphics, video, etc) is suitable for delivery on mobile phones of learners?
18. What is your view towards the general concept of m-learning?
19. Please add any other comments

APPENDIX D: INSTRUCTIONAL DESIGNERS' AND CONTENT AND SOFTWARE DEVELOPERS' INTERVIEW GUIDE

PROJECT TITLE: DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES

Section A: General questions

1. Interviewer introduces himself and gives the purpose of the study
2. Type of organization (such as college, university, etc…)
3. Location: country; rural; urban; ….
4. What is your role in the organization?

Section B: Mobile learning (m-learning) questions

Definition: m-learning: A form of e-learning which employs wireless, tiny, handheld and portable devices to extend and deliver learning to learners (Luis de Marcos *et al.*, 2006).

5. Provide some suggestions on how m-learning could be/has been effectively integrated with existing learning management systems?
6. What do you think could be the most sustainable way (cost wise) for implementing m-learning activities in educational institutions?
7. What do you think are the favorable factors for m-learning
8. What do you think are the barriers to m-learning
9. What is your general view towards m-learning

Section C: M-learning objects delivery and utilization

Definition: m-learning objects: Learning content which can be accessed by and delivered on mobile devices such as mobile phones (Trifonova and Ronchetti, 2006).

10. Has your organization developed any m-learning objects?
11. What resources have you put in place in your institution to enable the development, deployment and utilisation of m-learning objects?
12. In your opinion, what human and technological infrastructure resources are needed to enable the development, deployment and utilisation of m-learning objects
13. What is your view on the issue of delivering and utilising learning objects onto learners' cell phones?
14. How can limitations of mobile phones be mitigated to permit deployment and utilisation of learning objects on mobile phones?
15. In your opinion, what learning object media type (text, audio, graphics, video, etc) is suitable for delivery on mobile phones of learners?
16. Do you have any additional comments on any issues related to m-learning?

APPENDIX E: INTERVIEW DATA CODE MASTER LIST

AcademicSupport	MLearningNetworkingTechnology
AdministrativeSupport	MLearningObject
AsynchronousCollaboration	MLearningObjectDelivery
CollaborativeLearning	MLearningObjectDevelopment
InteractiveLearning	MLearningObjectMediaType
LearnigObjectTransformation	MLearningObjectRepository
MLearningAdoption	MLearningObjectStandard
MLearningAsSupplement	MLearningObjectUtilization
MLearningAsSupplement	MLearningOutOfClassroom
MLearningAwareness	MLearningPossibility
MLearningBarriers	MLearningPractice
MLearningBlending	MLearningResources
MLearningCostHigh	MLearningTechnologicalDevelopment
MLearningCostSustainability	MobileDeviceCapability
MLearningDevice	MobileDeviceLimitation
MLearningDisabler	MobileDeviceLimitationMitigation
MLearningEnabler	MobilePhonePermeation
MLearningExamples	NegativeMLearningPerception
MLearningFavours	PostiveMLearningPerception
MLearningImplementation	PullStrategy
MLearningInClassroom	PushStrategy
MLearningInDistanceEducation	SynchronousCollaboration
MLearningIntegration	

APPENDIX F: INTERVIEW GUIDE FOR VALIDATING THE *MoLODUF*

PROJECT TITLE: DEPLOYING AND UTILIZING LEARNING OBJECTS ON MOBILE PHONES

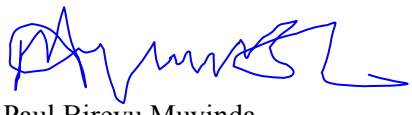
Dear Sir/Madam

Re: Validation of a Proposed Framework for Creating Applications for Deploying and Utilising Learning Objects on Mobile Phones

I am a PhD (Information System) student at Makerere University. Following from my earlier interview with you and other e- and m-learning stakeholders, I have among other outputs, developed a mobile learning objects deployment and utilisation framework (*MoLODUF*). The framework is based on twelve (12) dimensions each of which has sub-dimensions. The dimensions include: m-learning costs, learning processes, m-learning objects, m-learning devices, m-learning resources, m-learning connectivity, m-learning objects user, m-learning interface, m-learning evaluation, m-learning ethics, m-learning policy and m-learning context. The validity of this framework has to be measured so as to confirm whether the framework can be relied upon for instantiating/creating m-learning applications for deploying and utilising learning objects on mobile phones. The framework is herewith attached.

As one of the experts in e-learning, mobile learning, software development, telecommunications, information systems, IT or distance learning, you have purposively been selected to provide information that will help me validate my framework. You are therefore kindly requested to spare a few minutes to listen to my explanation of what MoLODUF is and later respond to the questions I will ask concerning the attached framework. Your responses will be used purely for the purpose of validating my framework and will be kept confidential.

I remain yours sincerely,



Paul Birevu Muyinda
PhD (Information Systems) Student
Makerere University

1. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-learning Costs' with two (2) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
2. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'Learning Processes' with seven (7) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
3. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Objects' with eight (8) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
4. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Devices' with four (4) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
5. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Resources' with three (3) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
6. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Connectivity' with four (4) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
7. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Objects User' with three (3) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement.
8. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Interface' with two (2) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement
9. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Evaluation' with four (4) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement
10. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Ethics' with three (3) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement
11. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Policy' with two (2) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement
12. As is shown in the proposed *MoLODUF* (attached herewith), there is a dimension named 'M-Learning Context' with three (3) sub-dimensions. Please give your level of agreement (Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4)) to the inclusion of this dimension and each of its respective dimensions in the proposed *MoLODUF*. If you wish, please give support view (s) for your level of agreement
13. The twelve (12) dimensions shown in the proposed MoLODUF attached herewith constitute a mobile learning objects deployment and utilisation framework (*MoLODUF*). What is your level of agreement to this statement - Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (4).

THANK YOU FOR ENABLING ME TO COMPLETE MY PHD