UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

AMBIENT LEARNING MODEL FOR RESEARCH PROJECT SUPERVISION SUPPORT: AN APPLICATION OF MOBILE PHONE-CENTRIC AMBIENT INTELLIGENCE TECHNOLOGIES IN 'MOBILE-RICH' UNIVERSITIES.

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4th August 2016

DECLARATION

I, Simon Nyaga Mwendia, do hereby declare that this PhD research is my original work and where there's work or contributions of other individuals, it has been duly acknowledge. To the best of my knowledge, this dissertation has not been previously presented for a degree in any other University. No part of this dissertation may be reproduced without the prior permission of the author or the University of Nairobi.

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Offen im Denken

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DEDICATION

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ABSTRACT

Although there is high penetration of mobile phones among students in East African universities ('mobile-rich'), there is a certain category of students, such as research students, that do not own a personal computer ('computer-poor'). Such students are forced to move to fixed locations where they access internet connected computers for accessing electronic learning (E-Learning) content. This location dependent access to learning resources removes the flexibility that is needed in personalized learning.

As an attempt to address these limitations, we proposed a new ambient learning approach known as Open Ambient Learning (OMAL). The approach uses Mobile phone-centric Ambient Intelligent (M-AMI) technologies to integrate three concepts. First, mobile interface ambient learning utilizes mobile devices only to support learning. Second, cloud computing services refer to computing services that are provided over the internet. Thirdly, Open Education Resources (OER) refers to freely accessible learning resources. The approach aims at allowing flexible availability of supervisors to their research students that are in 'mobile-rich' but 'computer-poor ' learning settings, like the case in East African universities.

To achieve this objective, communication oriented design research methodology (CODSRM) was used to guide the study. The methodology had two main stages. First, development stage that entailed conducting a research survey, case based research and adopting creative process to design and develop OMAL model. During the survey research activity, both stratified purposive sampling and random sampling were used for selecting respondents whilst during the case based research activity, only purposive sampling was used to select target publications. Second, the evaluation stage that involved conducting an experimental design study to assess the flexible availability of research study materials afforded by OMAL model.

Pre-experiment results showed that more than 90% of the students in Kenyan universities own mobile phones but only about 16% of them use mobile applications to access research study materials. Post-experiment results indicated that, all the developed M-Learning approaches significantly increased flexible availability of research study materials and the highest margin was registered within the OMAL approach. Based on these results, we conclude that mobile phone-centric ambient intelligence technologies can be used to integrate ambient learning with open education resources and cloud computing services to enhance flexible availability of learning resources in the student project supervision process.

Key Words: Student project supervision**,** ambient learning, mobile phone-centric ambient intelligence, mobile learning, cloud computing, Open Education Resources.

GLOSSARY AND LIST OF DEFINITION OF TERMS

Ambient learning: A learning approach that combines existing learning paradigms (such as mobile learning) with ambient intelligence properties (embedment, context awareness, personalization, adaptation and anticipation properties) (Bick, 2007).

Ambient Intelligence (AMI): A digital environment with a natural interface that is characterized by embedment, personalization, context awareness, adaptation and anticipation properties (Bick, 2007; Mwendia, Wagacha, and Oboko, 2015).

Ambient Intelligence (AMI) Technologies: This is a set of techniques and applications that provide natural interface with characteristics of AMI (Mwendia et al., 2015).

Location Dependent (Fixed) Media: Stationary tangible devices or objects that extend action and communication space of a person situated at a specific physical location. They are also known as digital annotation of physical space (Mwendia et al., 2015).

M-Learner: A student that receives education services through mobile devices (Muyinda, Lynch, and Van der Weide, 2010).

M-Learning Context: Information that describes the situation surrounding a certain group of M-learners (Muyinda et al., 2010).

Mobile learning (M-Learning): Use of mobile devices for learning and learning support (Muyinda et al., 2010).

Mobile Device: Hand-held device that can be accessed anytime and can easily be carried anywhere (e.g. fit in a pocket) without breaking transmission signals (Mwendia et al, 2014).

Mobile Phone-centric Ambient Intelligence Technologies: AMI technologies that use mobile phones as a central device for enabling AMI (Liro, 2012).

'Mobile-Rich' but 'Computer**-Poor' Context:** A learning setting with high prevalence of mobile devices but low prevalence of computers (Mwendia,Waiganjo, and Oboko, 2013).

Open Education Resources (OER): Freely accessible learning resources such as course materials and multimedia applications (Butcher, 2011; Mwendia et al., 2014).

Research Project Supervision: A type of learning support for advanced university students who are undertaking research projects (Ismail, 2011).

Cloud Computing Services: Largely scalable IT-enabled capabilities that are offered as a service to external clients using Internet technologies (Plummer, Bittman, Austin, Cearley, and Smith, 2008).

ABBREVIATIONS

AI	Artificial Intelligence
AL	Ambient Learning
AMI	Ambient Intelligence
ANU	African Nazarene University
BBIT	Bachelor of Business and Information Technology
BCOM	Bachelor of Commerce
BSc IT	Bachelor of Science in Information Technology
CCS	Cloud Computing Services
CODSRM	Communication Oriented Design Science Research Methodology
COL	Common Wealth Open Learning
COLLIDE	Collaborative Learning in Intelligent Distributed Environments (COLLIDE)
IAIT	Immobile Ambient Intelligence technologies
ICCE	International Conference on Computers in Education
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KCAU	KCA University
KU	Kenyatta University
KEMU	Kenya Methodist University
MAIT	Mobile Ambient Intelligence technologies
M_AMI	Mobile phone-centric ambient intelligence
MKU	Mt Kenya University
M-Learning	Mobile Learning
OCSMR	Open Context Single Mode of Representation
OER	Open Education Resource
OMAL	Open Mobile Ambient Learning
OMMR	Open Mixed Mode of Representation
OSMR	Open Single Mode of Representation
UNESCO	United Nations Education, Scientific and Cultural Organization
UON	University of Nairobi
USIU	United States International University

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CHAPTER ONE

INTRODUCTION

1.1 Background

Research supervision is a key type of learning support for advanced university students engaging in research projects or writing their final theses. However, studies show that there are high proportions of university students who fail to complete their studies within the specified time and some students also abandon their studies all together on account of their research projects. Many factors are attributed to this, with the main problem being the research and supervision process (Ismail, 2011). One of the most common complaints from research students is the infrequent or erratic contact with supervisors, who might be too busy with other administrative tasks, have too many research students to supervise or are often away from the university premises (Muyinda, et al., 2008).

Information and communication technologies (ICT) like computers and mobile devices can be used to enhance access to education services that include research support services. However, some of the African universities are characterized by high penetration of mobile phones ('mobile-rich') but low prevalence of computers ('computer-poor')(Mwendia et al., 2013). This is revealed by results obtained from two previous studies conducted within East African universities (Kashorda and Waema, 2009, 2014).

The first study, showed that over 96% of university community members (students, staff and faculty) in East African universities had access to mobile phones and about half of them used mobile Internet. Among these, Kenya and Tanzania had the highest percentage of students using mobile internet, which was at 60%. It was also observed that about 50% of the students used cyber cafés to access computers and Internet. This indicated that the majority of students did not own personal computers. Nevertheless, the study did not collect data for establishing how, if at all, the students use their mobile phones to access electronic learning resources. Therefore, this should be a new area for research among these universities (Kashorda and Waema, 2009).

The second study conducted in 50 Kenyan universities showed that about 47% of students do not own laptops and the ratio of networked personal computers available per 100 students is approximately 3.8. It was also observed that approximately 53% of the students own smart phones but only 24.6% of them have good experience in using the handsets to access digital study materials hosted in university e-learning systems. It was also revealed that although some universities have started providing wireless access to Internet to students through Wi-Fi hotspots on university premises , approximately 25% of the 423, 664 students enrolled in 30 Kenyan universities still use cyber cafés for primary computer and Internet access (Kashorda and Waema, 2014). This is shown in Figure 1.1.

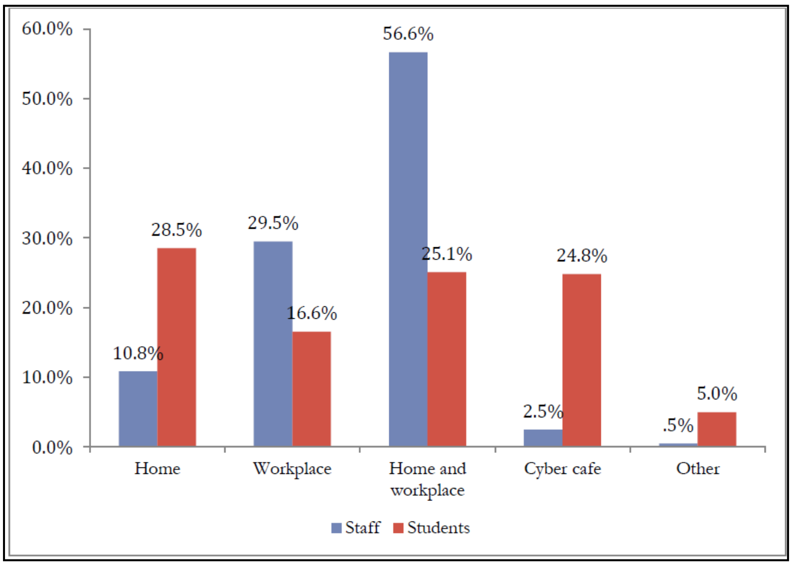

Figure 1.1: Location of Primary Access to Computers by Users in Kenyan Universities

Source: (Kashorda and Waema, 2014).

However, the study only collected data for establishing the prevalence of student-owned laptops and smartphones. The prevalence of other student-owned devices was not established. Examples are ordinary mobile phones (feature phones), tablets and desktops computers.

Muyinda et al.(2010) notes that the scenario where learners access study materials from few fixed locations with internet connectivity such as workplaces and cyber cafes (like the case of East African universities) eliminates flexible availability that is needed in personalized learning. According to Ally (2009), personalized learning recognizes difference, diversity and individuality in the ways that learning is developed, supported and delivered. The approach encourages educators to be more flexible and open by considering each learner’s needs, strengths, and interests while ensuring the highest standards possible (Grant and Basye, 2014).

The high prevalence of mobile phones in East African universities and poor access to personal computers creates the need for mobile learning approaches that can increase flexibility in the availability of supervisors to their students, thus allowing personalized learning (Muyinda et al.,2010; Mwendia et al., 2014). An example is ambient learning that aims at providing personalized learning environment by enabling access to adapted and high quality content at anywhere, anytime and anyhow (Mwendia et al., 2013). However, ambient learning is not widely adopted these universities (Mwendia et al., 2015). In order to experience the promises of ambient learning, there is need for increased research activities that are geared to increasing its implementation in contexts that are typical of East African universities.

Muyinda et al. (2010) observed that technical limitations of mobile phones (such as tiny screen and limited memory), high costs of mobile phones and poor network connectivity were some of the challenges that hindered the adoption of mobile learning for research supervision support in Makerere University, Uganda. Thus, there was need for innovative mechanisms that could address the indentified limitations in order to propel the growth of mobile learning as an approach for supporting research supervision in East African universities typical of Makerere University.

In our study, we argue that existing mobile learning approaches like ambient learning can be combined with other concepts and technologies to compensate technical limitations of mobile phones (Jansen et al., 2013; Mwendia et al., 2014). They include the following:

(i) Mobile Phone-centric ambient intelligence (M-AMI) technologies can help to enhance interaction with small screen of mobile devices by enabling context awareness and adaptation of content delivery. Examples include wireless technologies like Bluetooth sensors, embedded mobile applications and radio frequency identification (RFID) technologies that are used for sensing data about users (context) such as location, habit, moment, schedule, habit of user and engagement (Bick et al., 2007; Sharma and Jain, 2015).

(ii) Cloud computing services can help to increase memory capabilities of mobile devices through cloud-based repositories like DropBox and Google Drive (Jansen et al., 2013; Mwendia et al., 2014).

(iii) Open education resources (OER) which are freely accessible learning resources that can help to reduce the cost by using educational tools that allow free exchange of messages during collaboration. An example is instant messaging features of Mobile Learning Engine (MLE)-Moodle (UNESCO/COL, 2011).

Classification techniques that include mobile learning classification frameworks help to understand mobile learning, guide growth of future projects and research in this field. However, there is need for continuous review of these techniques to allow incorporation of new mobile learning projects and emerging trends (Martson and Cornelius, 2010). The current forms of M-Learning are classified using different criteria such as objective based criteria. Examples include the following:

(i) Classification based on 'education for all' (EFA) goals, which identifies six categories of mobile learning. These are, Early child care and education, Universal primary education, lifelong learning, adult literacy, gender parity and equality, and educational quality (UNESCO, 2012).

(ii) Classification according to mobile learning focus, which identifies three categories. These include a focus on learning outside the classroom, focus on what mobile devices can be used for, and a focus on the mobility of the learner (Pacheler et al., 2010;So, 2014).

However, these classifications are not exhaustive (UNESCO, 2012). For instance, none of them have described categories of ambient learning approaches (Mwendia et al., 2013). Consequently, the approach is not universally understood (Winkler et al., 2011). In order to realize the promises of ambient learning, there is need for increased research activities that are geared to categorizing and describing ambient learning applications (Mwendia et al., 2013; Mwendia et al., 2015).

1.2 Problem Statement.

Spear (2000) observed that one of the main challenges for research students is infrequent or irregular contact with their supervisors. The reasons for this scenario include the lecturers being too busy with other administrative responsibilities, being allocated too many students to supervise or being away from the university premises too frequently. As a result, there is low research output and generally this discourages students who would have decided to continue with their postgraduate studies (Mutula, 2011). In other cases, it becomes too 'difficult' for some research students to understand how to undertake their research or write a thesis. This leads to delaying students' completion schedule or failure to complete their degree programmes (Muyinda, et al., 2008; Ismail, 2011 ; Mwendia et al., 2014).

A sample case described by Mwebi and Simatwa (2013) observed that about 3.20% of graduate students enrolled in Kenyan universities repeat/ defer studies or drop out of university during the cycle of an academic year. Lack of lecturers/non- coverage of academic work (6.86%) and poor academic performance (6.49%) are some of the reasons attributed to these problems. Figure 1.2 shows a case of university of Nairobi from 2001 to 2007.

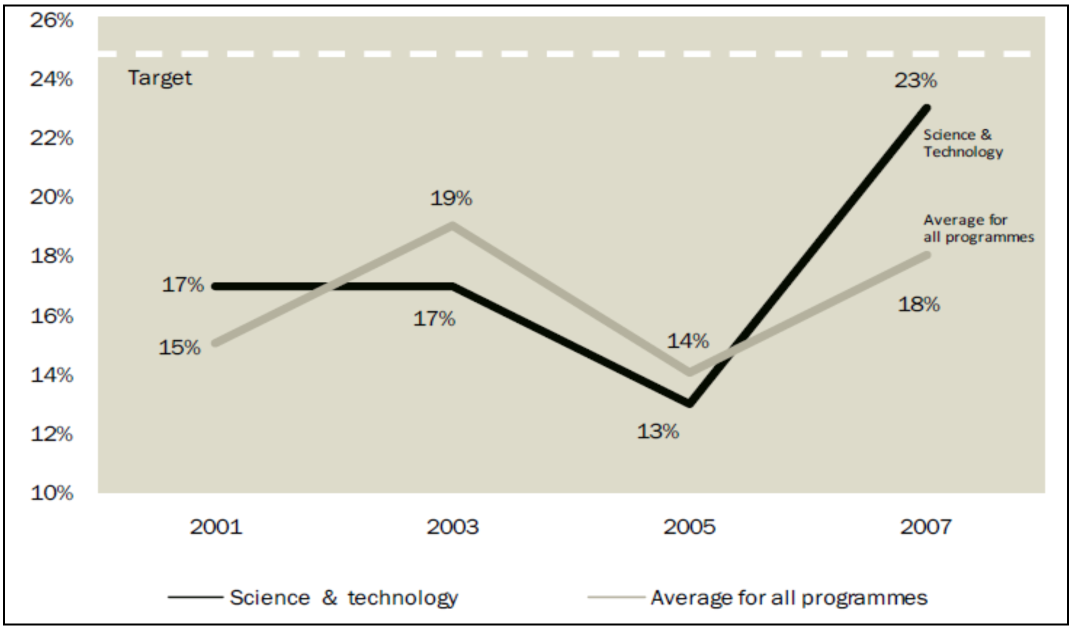

Figure 1.2: Graduation rates of Doctoral Programmes at University of Nairobi

Source: (Bailey et al., 2012)

Figure 1.2 shows that University of Nairobi's (UON's) average graduate rate for Science, engineering and technology (SET) programmes declined over the period 2001 to 2005, but then increased sharply in 2007. The increase in 2007 was attributed to extra 2000 SET students graduating in 2007 compared to 2005. The table also shows that the UON's average graduation rate for all programmes was about 17%, which indicates that its historical SET graduate output rate has been poor and below the set target of 25% (Bailey et al., 2012).

A similar case was observed between 2009 and 2010 with regard PhD output rates at UON and Kenyatta University (KU). During the graduation ceremony of September 2010, only 26 PhDs were awarded out of 4,473 graduating students in UON. This was a slight increase from only 13 PhDs out of 3,947 graduating students in 2009. A comparable situation was in KU, where only 22 PhDs were awarded PhDs during the year 2010. Considering that UON and KU are among the oldest universities in Kenya and maybe with some of the most advanced research facilities, it is evident that the situation might be at equivalent or worse in the rest of the Kenyan universities (Kigotho, 2011). According to the Commission of University Education (CUE), students are taking a long period of time to complete their studies. “These delays can compromise the quality of education,” said chief executive David Some when speaking during the 5th East Africa higher education quality assurance forum at Brackenhurst Conference Centre in Kiambu County, Kenya on May 6th 2015.

Although there has been attempts to address this problem using mobile learning, high usage costs and technical limitations e.g. small screen and limited memory of mobile devices inhibit their adoption (Muyinda, et al., 2008; Mwendia et al., 2014; Masika et al., 2015). Therefore, there is need for researchers to explore possible solutions for addressing these mobile learning challenges as an approach for enhancing flexible availability of research supervision services in settings that are similar to East African universities.

Although the objective of ambient learning promises to enhance flexible availability of learning support services like research supervision services, existing projects in this area presume availability of adequate infrastructures like computers and other location dependent sensors. The poor access to computers by students enrolled in east African universities (‘computer-poor’ settings) makes it hard to implement exist existing ambient learning approaches (Mwendia and Buchem, 2014; Mwendia et al., 2015). Additionally, the high penetration of mobile phones among students in East African (‘mobile-rich’ settings), introduces the need for ambient learning approaches that are mobile phone-centric.

1.3 Proposed Solution

As an attempt to address this challenge, we propose a new ambient learning approach that uses mobile-centric ambient intelligence technologies for integrating mobile learning with open education resources (OER) and cloud computing services in order to increase flexible availability of research project's supervision services in 'mobile-rich' but 'computer-poor ' learning settings typical of African universities.

1.4 Main Objective

The objective of this study is to describe a mobile learning (also known M-Learning) approach for enhancing flexible availability of research supervision services in settings that are typical to East African universities. That is, settings that are ‘computer-poor' but ‘mobile-rich’ (Mwendia et al., 2013; Mwendia and Buchem, 2014; Mwendia et al., 2014; Mwendia et al., 2015).

1.5 Specific objectives

In the context of university level learning environment in developing countries, such as Kenya, the specific objectives of the study are:

i. To establish the features (e.g. challenges and motivations) that can be used to describe characteristics of the mobile learning context.
ii. To study objectives of M-Learning projects that have adopted current forms of M-Learning with a view of enhancing flexible availability towards ambient learning.
iii. To design an ambient learning approach that enhances flexible availability of research supervision services.
iv. To demonstrate application of ambient learning approach.
v. To compare the developed ambient learning approach with other forms of M-Learning in terms of flexible availability (accessible at anytime, anywhere, and anyhow).

1.6 Research Questions

In the context of university level learning in developing countries, such as Kenya, this study seeks to address the following questions:

(i) What are the challenges, motivations, among other features that can be used to describe the M-Learning context?
(ii) Are features of M-Learning context related to each other?
(iii) Are there cases of current M-Learning forms that focus on university level learning in East African universities?
(iv) If cases of current M-Learning forms exist, which M-Learning context features and objectives are related to those cases?

(v) Which is the appropriate model that can be used to describe an ambient learning approach for enhancing flexible availability of research supervision services in the identified learning context?

(vi) How can ambient learning approach be used to support provision of research supervision services?

(vii) Is there any relationship between current forms of M-Learning approaches and flexible availability of M-Learning relationships and if it exist can it be moderated by age, gender and experience?

(viii) How does the level of flexible availability afforded by ambient learning compare to other current forms of M-Learning?

The eight research questions can be mapped to specific objectives as illustrated in Table 1.1.

Table 1.1: Mapping of Research Questions to specific objectives

Specific Objectives	**Research Questions**
i. To establish the features that can be used to describe characteristics of the M-Learning context.	i. What are the challenges, motivations, among other features that can be used to describe the M-Learning context? ii. Are features of M-Learning context related to each other?
ii. To study distinguishing objectives of M-Learning projects that have adopted current forms of M-Learning with a view of enhancing flexible availability towards ambient learning.	ii. Are there cases of current M-Learning forms that focus on university level learning in East African universities? iii. If cases of current M-Learning forms exist, which M-Learning context features and objectives that related to those cases?
iii. To design an ambient learning approach that enhances flexible availability of research supervision services.	iv. Which is the appropriate model that can be used to describe an ambient learning approach for enhancing flexible availability of research supervision services in the identified learning context?
iv. To demonstrate application of ambient learning approach.	v. How can ambient learning approach be used to support provision of research supervision services?
v. To compare the developed ambient learning approach with other forms M-Learning in terms of flexible availability.	vi. Is there any relationship between current forms of M-Learning approaches and flexible availability of M-Learning relationships and if it exist can it be moderated by age, gender and experience? vii. How does the level of flexible availability afforded by ambient learning compare to other current forms of M-Learning?

1.7 Significance of the study

There are several benefits that can be associated with this study. These include the following:

- Flexible Availability: M-Learning is described an educational approach that is mobile and more flexible than previous electronic learning systems (Jansen et al., 2013). As one of the existing M-Learning approaches, ambient learning promises to allow learning to take place anywhere, at any time, and anyhow (Paraskakis, 2005; Mwendia et al., 2014). The achievement of this objective is expected to enhance availability of research supervision services by increasing the number of access locations (anywhere), access times (any time) and access strategies (anyhow).
- Reducing Costs: Mobile phones can be used to quickly inform students about any changes with regard to digital content within their courses by use of Short Message Service (SMS) text messaging (Nix et al., 2010), among other means, thus saving travelling costs to university premises. In addition, incorporation of Open Education Resources (OER) reduces communication cost and the need for authoring new content. This can be achieved by using freely available study materials (e.g. Youtube videos) and enabling tools that support free sharing of information during collaboration (UNESCO, 2011). Examples of such tools include Moodle Mobile and MLE-Moodle that allow free sharing of information during collaboration without asking for permission, payment of access fees or licenses (Mwendia et al., 2014).
- Improving Quality: OER allows improving quality of learning materials through peer review activities such as mixing, adding and mixing (Park, 2013). This means freely available materials can be accessed, updated, and uploaded again as new versions of the previous materials.
- Overcoming Limitations of Mobile Devices: According to Jansen et al.(2013), cloud computing services can be used to overcome certain limitations of mobile devices and computers especially, to enhance accessibility and interoperability in technology-enhanced learning scenarios.
- Personalization: Ambient learning aims at enabling access to personalized learning content. This can be achieved by use of mobile phone-centric technologies like

embedded mobile application to enable adaptation of learning content (Sharma and Jain, 2015; Mwendia et al., 2014).

1.8 Scope of the Study

Since there is high proliferation of mobile phones and low computer prevalence among universities in East African countries (Kashorda and Waema, 2009), this study was limited to exploring how mobile phones can be used to address the identified research supervision challenges encountered by learners enrolled in these universities.

1.9. Achievements of the Study

The achievements of the study can be expressed using the following indicators.

(a) Research Network

During this study, the principle researcher collaborated with other researchers from Kenya and Germany. They include researchers from University of Nairobi, Beuth University of Applied Sciences, Berlin and University of Duisburg, Essen.

(b) Book Chapters

Two book chapters have already been published through IG-Global books publishers. The first book chapter was entitled 'Culture Aware M-Learning Classification Framework for African Countries' that is published in chapter five of a book entitled 'Cross-Cultural Online Learning in Higher Education and Corporate Training'. It provides a discussion on various aspects related to cultural variability dimensions and mobile learning projects launched in African universities (Mwendia et al., 2014). These include the following:

- An overview of digital context in African countries, which indicates that there is high prevalence of mobile phones but no prevalence of computers in African universities.
- Descriptions of cultural variability dimensions that exist in African countries. That is, Power Distance (PDI), Individualism (IDV), Masculinity (MAS), Uncertainty Avoidance (UAI) and Long-Term Orientation (LTO).
- A classification framework that provides a theoretical framework for categorizing emerging cross-cultural mobile learning projects launched in African countries. The framework describes four categories of mobile learning projects. These are, (i) In-country mobile learning projects, (ii) Regional mobile learning projects, (iii) Continental m-learning projects, and (iv) Global m-learning applications projects.

- A description of influences of cross-cultural mobile learning projects launched in African countries. That is, fostering collectivism and power distance cultures, redesigning of instructional methods and resources for cultural contexts, harmonization of culture, and promoting intercultural communications.

The second book chapter is entitled 'Ambient Learning Conceptual Framework for Bridging Digital Divide in Higher Education' and it is published in chapter fifteen of a book named ' Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies'(Mwendia et al., 2015). The chapter contains the following information:

- A description of theoretical conceptual framework that can help to instantiate ambient learning applications in different contexts. For instance, the framework depicts two types of ambient intelligence technologies. That is, (i) Mobile ambient intelligence technologies that can be embedded on mobile devices (such as smartphones) to enable learning support services, and (ii) Immobile ambient intelligence technologies that can be embedded on fixed locations to facilitate learning support services.
- A description of two ambient learning contexts. These are (i) 'computer rich' and 'mobile rich' ambient learning context, which is distinguished by adequate ICT infrastructure of both mobile and immobile ambient intelligence technologies, and (ii) 'computer poor' but 'mobile rich' ambient learning context, which is distinguished by poor ICT infrastructure of immobile ambient intelligence technologies but adequate infrastructure of mobile ambient intelligence technologies (Mwendia et al., 2015).

(c) Conference Papers

Three conference papers were published during the course of the study. The First conference paper is entitled '3-Category Pedagogical Framework for Context Based Ambient Learning' and it is published in two digital libraries. These are, (i) Proceedings of 'IST-Africa 2013 Conference', and (ii) IEEE Xplore Digital Library. The paper contains the following information (Mwendia et al., 2013):

- Three important findings from literature review. First, Mobile learning is still in its infancy stage at both the conceptual and practical levels and has not been formally incorporated in main stream education systems. However, the number of mobile learning projects is on the increase as a result of mobile phone proliferation. Second, there has been lack of a theoretical framework that categorizes ambient learning based on mobility of available devices within the learners' context and dominant pedagogy. Finally, that ambient learning can be modified to suit the current learner's context.

- An ambient learning classification framework that describes three categories of ambient learning. They include Fixed Interface Ambient Learning category that is suitable for learning settings with high prevalence of location dependent devices like computers, Mobile Interface Ambient Learning category that is appropriate for learning contexts with high prevalence of mobile devices like mobile phones, and Hybrid Interface Ambient Learning category that can be implemented in learning settings with high prevalence of both fixed and mobile devices.

The second paper is entitled 'Open *Mobile Ambient Learning: The Next Generation of Mobile Learning for 'Mobile-rich' but 'Computer-poor' Contexts*', which is published in the proceedings UNESCO Mobile Learning Week 2014. The paper describes three types of mobile learning types that are differentiated by their objectives (Mwendia and Buchem 2014) . They include the following:

(i) Context-sensitive learning, which aims at allowing learners to access learning according their current context e.g., activity, location or social relations

(ii) Mixed reality learning, which aims at enhancing the meaning of learning content by enabling learners to participate in a media-rich learning environment and,

(iii) Ambient learning that aims at delivering learning content at anywhere, anytime and anyhow by placing digital artefacts within the learning environment of the learner.

In addition, the UNECO paper presents the observation that existing European projects in ambient learning category assume availability of adequate fixed ICT infrastructures such as computers. However, these infrastructures are not readily available in some settings like African based universities despite high prevalence of mobile phones among learners. To address this gap, a new ambient learning approach named Open Mobile Ambient Learning (OMAL) is proposed. The approach aims at utilizing mobile devices to enhance adoption of ambient learning applications in settings typical of African countries.

Finally, the third paper is entitled 'Supporting E-Learning in Computer-poor Environments by Combining OER, Cloud Services and Mobile Learning' that was presented during the proceedings of international conference of computer education (ICCE) 2014 in Nara, Japan.

The aim of the paper is to describe system architecture of OMAL system and to demonstrate how it can be used for research supervision support. This is achieved using a use case scenario to illustrate how a typical research student can interact with the system (Mwendia et al., 2014). Following a competitive nomination process, the paper was nominated for best technical design nominee (BTDN) award in the field of Class, Ubiquitous Computing, Mobile technologies and Enhanced Technological Learning (CUMTEL). Consequently, a certificate of achievement was issued to all authors of the paper.

(c) Prototype Development

In order to demonstrate how the proposed model can be used, a prototype was developed. The components of the prototype include, (i) ambient intelligent mobile application that was running smartphones for allowing personalized access to cloud computing services and OERs, (ii) Context Manager, which was used for integrating and managing learners' context, (iii) Context database that was used for storing information about learners (learners' context), and (iv) Content manager, which was used for integrating OERs (Mwendia et al., 2014).

In order to evaluate the effectiveness of OMAL prototype in terms of enabling flexible availability, three other prototypes were designed and developed. They include Open Mixed Modes of Representations (OMMR) application, Open Single Mode of Representation (OSMR) application, and Open Context Aware Single Mode of Representation (OCSMR) application. All the four prototypes were piloted with post graduate students and later used for providing research services during experimental design study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, we review existing literature. The chapter is organized into six main sections. Section 2.2 presents a global overview of current Information and communication technology (ICT) trends with a particular focus of Africa and Kenya. Section 2.3 introduces the concept of mobile learning (M-Learning) and discusses theories of M-Learning, current forms of M-Learning approaches, types of M-Learning contexts as well as mobile technologies. Section 2.4 discusses three concepts that can be combined with M-Learning to enhance address limitations of mobile technologies. These are ambient intelligence technologies, cloud computing services, and Open Education Resources (OER). Section 2.5 discusses research project supervision process and its dynamics as well as how it can be supported through M-Learning. Section 2.6 describes the conceptual framework for the research. Section 2.7 outlines hypotheses and lastly section 2.8 provides a summary of the chapter.

2.2. Current Information and Communication Technology (ICT) Trends

According to Measuring the Information Society Report that was published by International Telecommunications Union (ITU) (2014), the world has witnessed a boom in mobile phone subscriptions in recent years. By the end of 2014, mobile-cellular subscription was approximately 96% of 7 billion people on earth with an annual growth rate of 2.6%. During the same period, penetration in developing countries was estimated to be growing twice as much as in developed countries (3.1% compared with 1.5%, respectively). In this review, we focus on ICT trends in African countries and a case study of Kenya as representation of East African countries.

2.2.1 Current ICT Trends in Africa.

For the last 10 years leading to 2014, African countries which have been experiencing a high growth rate of mobile phone penetration (ITU 2014). This can be attributed to several factors which include proliferation of mobile phone networks and low prices of mobile phones. For instance, by the end of 2011 mobile phone networks had connected about three quarters of the population in many African countries by the year 2011 (Rao, 2011).

With regard to mobile-broad band, Africa is leading all the 6 regions of the world with a growth rate of 40%, which is twice as high as the world average. This growth rate has contributed to an increase in mobile-broadband penetration from 2% in 2010 to about 20% by end of 2014 as illustrated in Figure 2.1.

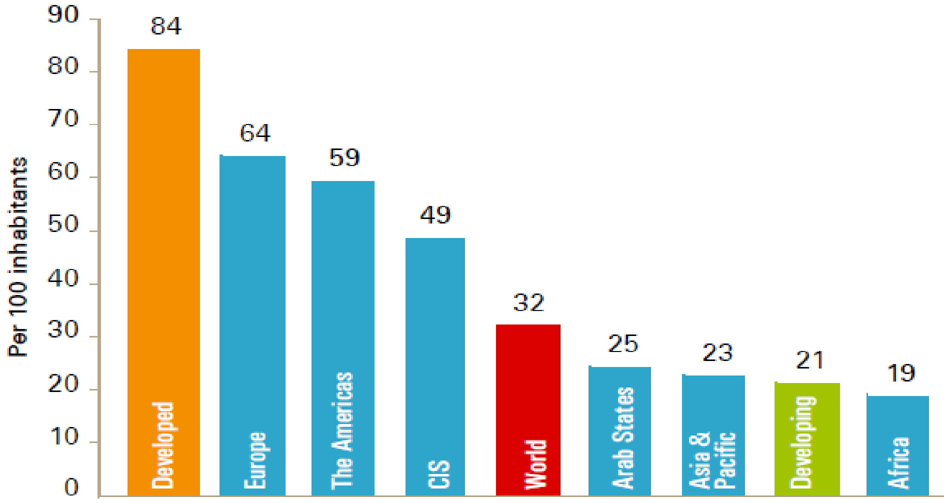

Figure 2.1: Active mobile-broadband subscriptions by region.

Source: (ITU 2014)

However, African regional Information and Communication Technologies Development Index (IDI) was the least among all the 6 world regions by 2014. Seychelles (4.97) and Mauritius (5.2) were above the global IDI average of 4.77. Additionally, South Africa, Cape Verde and Botswana had an IDI that was slightly above developing country average of 3.8 but below the global average (ITU, 2014). This is illustrated in Figure 2.2.

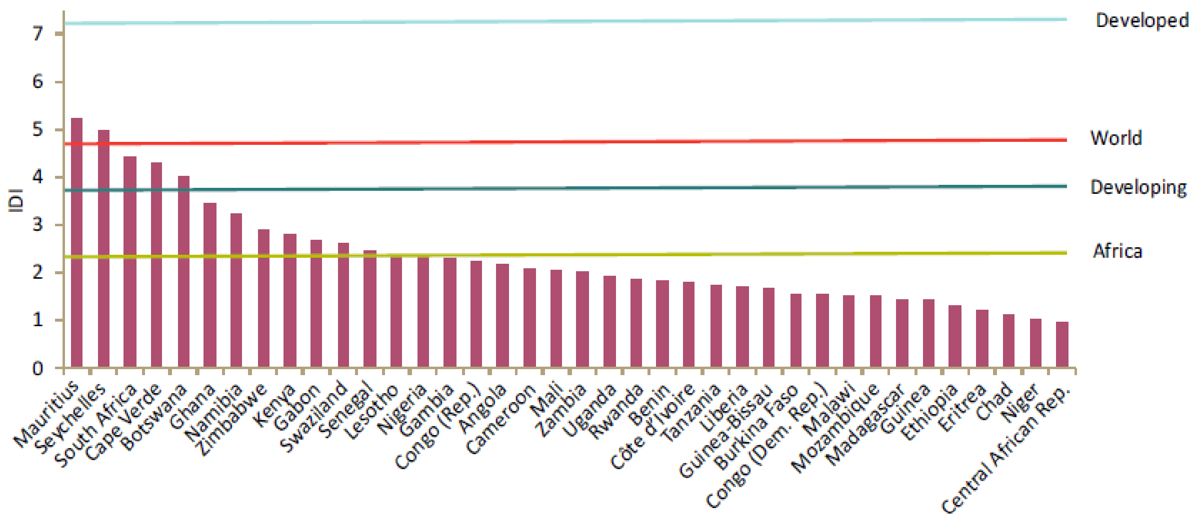

Figure 2.2: African countries IDI Values Compared to Global IDI Values,

Source: (ITU 2014)

The low IDI values in African countries can be attributed to a high percentage of Least Connected Countries (LCCs) in this region (70%, n=29) as indicated in Figure 2.3.

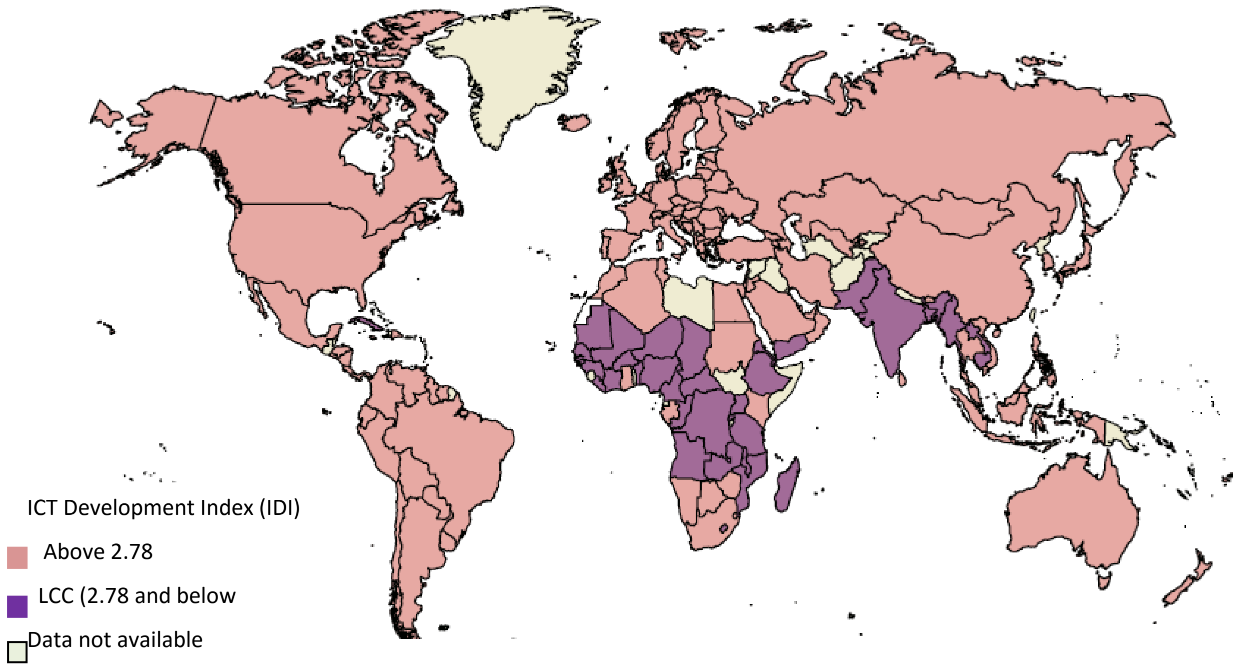

Figure 2.3 Least Connected Countries

Source: (ITU, 2014).

According to the ITU (2014) report, LCCs are countries that closely match least developed countries and whose levels of ICT access and usage is extremely low (2.78 IDI and below). Looking at Figure 2.3 it can be viewed that majority of the LLCs are in Africa followed by Asia. The report attributed several factors to low IDI values in LCCs. These include the following:

- Limited Fixed broad band penetration rate, which was 6% in comparison to 27.5% in developed countries by end of 2013, with growth rates still decreasing. In Africa, the fixed-broadband subscription penetration rate was 10% during the same period.
- Poor computer access among households in LCCs. That is, there is less than 5% penetration rates of computer access in households in all LCCs, of which majority are in Africa.

2.2.2 ICT Trends in Kenya

By end of 2013, Kenya was ranked number 9 in Africa and 123 globally with an IDI value of 2.79, which was above LCCs average IDT value of 2.78 but below global IDI of 4.77 (ITU, 2014). According to Communications Commission of Kenya (CCK) Annual Report of the

2012 - 2013 period, mobile telephony is the main driving factor for the vibrant ICT sector in Kenya. The report revealed that during the year 2012-2013, mobile subscriptions grew marginally from 29.7 million (75.4%) in mid-2012 to 30.5 million (about 77.3% penetration rate) in mid-2013. These penetration rates were less than the average global rate of 91.2%, developed countries average rate of 123.6% and developing countries average rate of 84.3% by end of 2012.

During the same period of study, internet penetration rate increased from 7.7 million (i.e. 35.5% penetration level) in the year 2011/12 to 12 million (48.3% penetration level) in the year 2012/2013. This penetration level was above developing countries average (17.5 %) and global average (35.7%). About 99.3 % of the total internet subscriptions were mobile subscriptions. This was attributed to affordability of mobile data bundles offered by mobile phone operators and the growing popularity of social media (e.g. Facebook and twitter) that is easily accessible by means of mobile phones. However, high speed fixed Internet/Fibre optic subscriptions expanded with a lower growth rate of 17.9%.

In Kenya, though there is high prevalence of mobile phones, the use of computers, desktop or laptops, is generally low. A study conducted by Waema and Ndungu (2012) observed that by the end of 2011, approximately 21.2% of households used computers. This was the second highest percentage of computer usage in Africa after South Africa's 29.1%. The study also found that laptop ownership in eleven African countries was less than 50%. These included Kenya, which had 23.8% of laptop ownership. With regard to desktops, ownership was less than 50% in all the 11 eleven countries investigated, with Ghana taking the lead with 48% followed by Rwanda with 45.3% and South Africa 44.4% respectively. In Kenya, desktop ownership was found to be approximately 35.7% as shown in Figure 2.4.

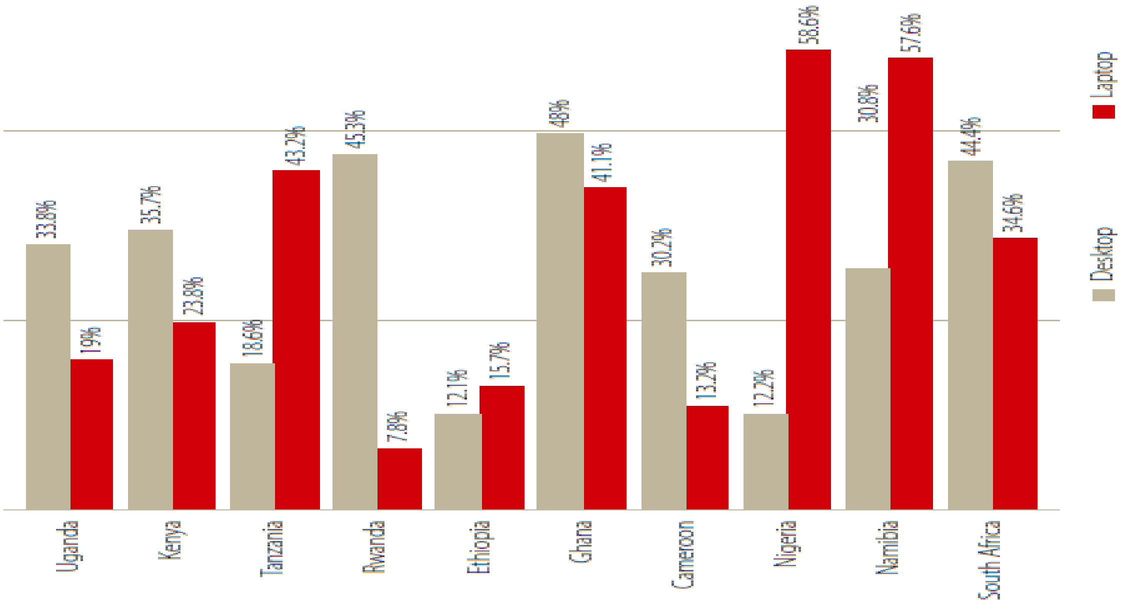

Figure 2.4: Desktop and Laptop Ownership in African Countries

Source: (Waema and Ndungu, 2012).

Literature on communication media contexts demonstrates that mobile phones are most used medium of communication among Kenyans. According to (Muthoki, 2012), research conducted by TNS RMS East Africa revealed that 73% of Kenyans like to access Internet through phones and 67% use social media to search brands, while 50% of them would be happy if they purchase products through social networks. It was also observed that results that 19% of Kenyans used their mobile phones to seek more details about products advertised on television; while 21% used phones to gather more information about product availability in stores. Another study carried out by InMobi (2013) showed that Kenyans spent as much as 29% of time on mobile phones per day, followed by watching television (24%), used desktop/laptop to access online resources (12%) and others like reading newspaper (9%) and used a Tablet device (4%) as shown in Figure 2.5.

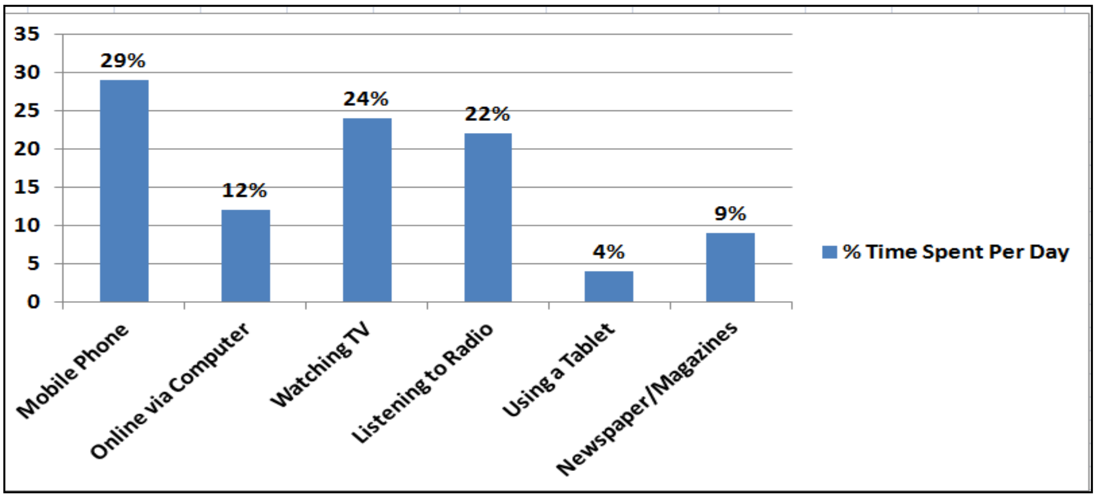

Figure 2.5: Percentage of Time Spent on Media

Source: (INMOBI, 2013).

The popularity of mobile phones has also been observed within Kenyan education sector. A study conducted by Kashorda and Waema (2014) in 50 Kenyan universities showed that more than half (53%) of students own smartphones. In some cases this percentage is even higher. For example, Lundén et al (2015) found that about 76% (n=206) students enrolled in Technical University of Mombasa (TUM) use smartphones to consume news, followed by Laptop (18%,n=56), desktop computer (8%,n=24) and tablet (0.6%,n=2).

The proliferation of mobile phones in African countries including East African countries calls for suitable mobile phone-centric approaches that can address challenges encountered in these countries. Next, we look at mobile learning approaches that use mobile phones to increase flexible availability of learning support services like research project supervision.

2.3 Mobile Learning

In recent years, there has been increased focus on mobile learning (M-Learning) by researchers, educators, companies and policy makers, which has resulted in several definitions of M-Learning (Muyinda et al., 2010). According to Parsons and Ryu (2006), mobile learning is a form of electronic learning (E-learning) that uses mobile devices. Mobile devices in this definition refer to any devices that can be accessed anytime and carried anywhere without breaking transmission signals. Examples are: mobile phones and Personal Digital Assistants (PDAs). Some of the devices excluded from this definition are desktop computers and laptops because they cannot be carried anywhere without breaking transmission signal and their size makes it difficult for student to utilize them while 'on the move' (Caudill, 2007).

UNESCO (2013) defines mobile learning as the use of mobile technology, either on its own or together with other information and communication technology (ICT), to support learning anytime and anywhere. In this definition, mobile technology refers to variety of devices that are easily carried (portable), can access the internet, have multimedia functionalities, can enable a large number of actions, especially those associated with communication, and such devices are controlled and owned by an individual instead of an institution. Examples are: electronic readers (E-readers), mobile phones, tablets, portable audio players, hand-held gaming consoles, among others.

Globally, studies show that mobile phones have began to be utilized in some of the educational contexts. A review carried out by Baran (2014) found that utilization of mobile phones in teacher education contexts globally stands at 42.5%, followed by tablets (17.5%), personal digital assistants (PDAs)/Handheld PCs (17.5%), laptops (12.5%), and iPods (10%). It was also found that about 38% (n=14) of the research on mobile learning was carried out in the United States of America (U.S.A) teacher education contexts followed by Finland (0.8%, n = 3), Australia (0.8%, n = 3), and Tanzania (0.03%, n=1). This means that utilization of mobile phones for learning support (e.g. enabling teacher education) in East African countries is still low compared to other countries in the world. However, this review did not establish the prevalence of utilizing mobile phones in higher learning education contexts like East African universities.

A study conducted by (Mtebe and Raisimo, 2014) observed that mobile learning can help to support flexibility and ubiquity to learn anywhere and anytime with wireless Internet. However, the utilization of mobile phones to support mobile learning is not widespread in East African universities, despite the high prevalence of mobile phone handsets. Most of the existing mobile learning initiatives are either pilot projects or short message service (SMS) based applications that focus on secondary and primary education. It was also found that there is far too little that is known as to why mobile learning is not adopted. Research has been carried out to explore factors that hinder students' adoption and use of mobile learning in East African universities. However, the study did not establish the appropriate theoretical frameworks that can help to increase the understanding of mobile learning in East African universities.

Martson and Cornelius (2010) and Mwendia et al., (2013) argue that mobile learning classification frameworks can help to understand mobile learning, and provide guidelines to research and the development of future projects like ambient learning projects. In order to enhance understanding of mobile learning projects launched in East African universities, there is need for investigating existing classification frameworks that can be used to categorize such projects.

2.3.1 Existing Frame Works for Categorizing M-Learning

In an attempt to establish appropriate categorization of mobile projects for different learning environments, several mobile learning classification frameworks have been proposed by various researchers, namely, contextual frameworks, pedagogical frameworks, application-based frameworks and blended frameworks.

(a) Pedagogical Frameworks

Pedagogical frameworks facilitate explaining user activity by classifying mobile learning projects based on their dominant pedagogical theory (Deegan and Rothwel,l 2010). Examples include the following two frameworks:

(i) Six-category theory-based framework (Naismith, et al., 2004), which describes six categories of mobile learning. These categories are; Learning and Teaching support, Situated, Collaborative, Informal and Lifelong Support, Behaviorist and Constructivist;

(ii) Four-Category Pedagogical framework of mobile learning, which describes four categories of mobile learning based on two main features. First, transactional distance is described as the extent of psychological separation between the instructor and the learner. In order to determine whether transactional distance is high or low, three factors are considered. These are, *curricula* of the distance learning program, *communication* between instructors and learners, and *the role of students* in choosing what, how, and how much to learn. Second, M-Learning activity that can be individualized (no collaboration with instructor) or socialized (collaboration with instructor). The M-Learning categories explained by the framework are; high transactional distance and socialized M-learning Activity (HS), high transactional distance and individualized M-Learning activity (HI), low transactional distance and socialized M-learning activity (LS), and finally, low transactional distance and individualized M-Learning activity (LI) (Park, 2011).

However, Pedagogical frameworks have not considered design characteristics such as device usability, hence they are not inclusive. Additionally, there is a lot of overlapping between mobile learning categories. An example is a case of constructivist applications, which can also be characterized by situated and collaborative properties (Martson and Cornelius 2010).

(b) Contextual Frameworks

Contextual classification frameworks categorizes M-Learning projects according to M-learners' context (Deegan and Rothwell, 2010). Examples of such frameworks include the following:

i. Four-category context framework that classified mobile learning into four categories of learners' context; independent context, physical context, socializing context and formalized context (Frohberg, Goth, and Schwabe, 2009).
ii. Five-category context framework that improved four-category context framework by incorporating virtual context for classifying the SMS simulation projects in addition to formalized context, independent context, socializing context and physical context (Martson and Cornelius, 2010).

Nevertheless, contextual classification frameworks have not considered availability of ICT infrastructure. Consequently, such frameworks fail to describe categories of M-Learning projects that can be adopted in contexts with limited ICT infrastructure such as personal computers, as is the case with East African universities (Muyinda, Lubega, and Lynch, 2010) ;Mwendia, Waiganjo, and Oboko, 2013).

(c) Focus-based Frameworks

Focus based classification categorizes mobile learning according to main focus (i.e. objective) of the project. An example is a classification framework that describes the following three phases of M-Learning (Pacheler et al., 2010):

(i) First Phase category consists of M-Learning projects focus on exploring the appropriate mobile devices that can be used to support instruction and training.
(ii) Second Phase category consists of M-Learning projects that focus at supporting learning outside classroom. Potential affordances of this category are, museum visits, field trips, professional updating, personal learning organizers and bite-sized learning.

(iii) Third Phase category describes M-Learning projects that focus on the design of learning spaces, mobility of the learner, and on informal learning and lifelong learning. Affordances in this phase are, context-sensitive learning, mixed reality learning, and ambient learning.

The three phases are distinguished from each other by the main focus in each category. However, the three phases are not inclusive since they have not described sub-categories of current M-Learning projects like ambient learning (Mwendia, Waiganjo, and Oboko, 2013).

(d) Blended Frameworks

This category of frameworks considers more than one dimension when classifying M-Learning projects. For example, De Jong et al. (2008) classifies M-Learning applications based on five dimensions. They are:

(i) Context dimension that focuses on context parameters that are considered by the application itself for learning support.

(ii) Content is concerned with how the application is used to deliver learning content.

(iii) Purpose dimension that focuses on the objectives of designing the application.

(iv) Information flow dimension that focuses on the application information architecture such as one to one, one to many, many to one and many to many.

(v) Pedagogical dimension that considers the learning theories implemented within the application.

(e) Application-Based Classification

Application-based frameworks classify M-Learning applications on how they are used. For example, Rosche (2003) describes an M-Learning classification framework that identifies three categories of M-Learning based on usability perspective. These are collaborative data gathering applications, computer response systems and participatory simulations. However, the framework is not exhaustive since it only describes categories that were popular during the time of conducting the study (Deegan and Rothwell, 2010).

Based on this review, it can be seen that the existing classification frameworks have not classified mobile learning projects according to availability of enabling technology in the learning context. Consequently, it is not clear which category of M-Learning is appropriate for learning environments that are 'computer-poor' but ‘mobile-rich', typical of least connected countries (LCCs). This means that there is need for a classification framework that describes types of mobile learning applications based on accessibility or availability of enabling technology.

2.3.2 Types of Contexts in Mobile Learning

Context is defined variously by many researches depending on the purpose of the study. According to Melucci (2012), context refers to circumstances that define the setting for a statement, event or idea to allow full understanding and evaluation. Context can also be defined as any information that is used to specify the situation of an entity (Dey, 2000). Examples of entities are objects, people and locations.

Based on Dey (2000)'s definition, we argue that an entity can be a group of learners or an individual learner. In order to describe each of these entities in the context of M-Learning, context can be divided into two main categories, namely M-Learning context and M-learners' context.

(a) M-Learning Contexts

M-Learning context can be described as an immediate environment of a group of learners as a single entity. According to Muyinda et al. (2010), there are three features of M-Learning context. This is shown in Figure 2.6.

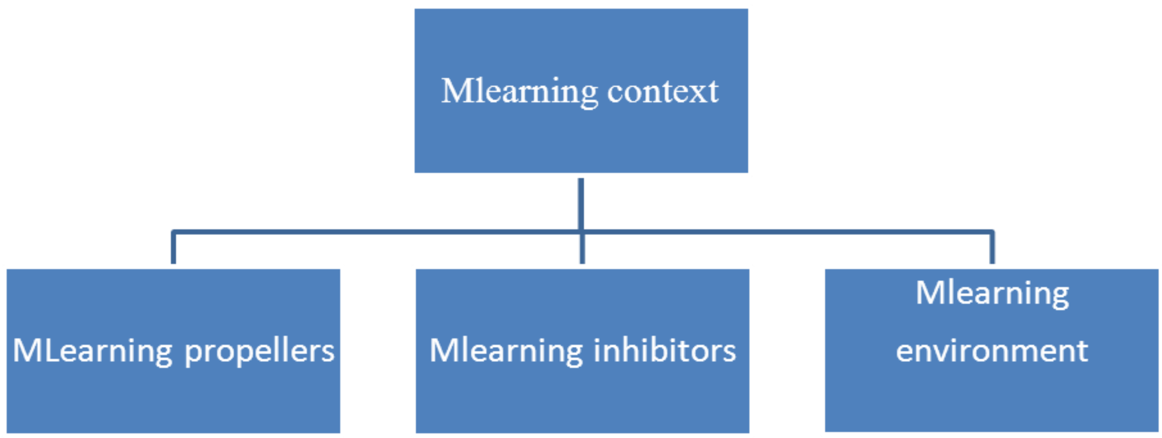

Figure 2.6: M-Learning Context
Source: (Muyinda et al., 2010).

- **Propellers of M-Learning**, which refers to features that drive the growth or development of M-Learning (Muyinda et al.,2010). These include the following (UNESCO, 2012):

(i) Exponential growth of mobile phone subscriptions, which is the main driver of M-Learning. This is a result of rapid advancements in mobile technologies, liberalization of telecommunication sector and decreasing costs for mobile devices as well as data plans

(ii) Systematic failures in traditional education delivery to meet 'education for all' goals (EFA) such as increasing the scale, scope, quality and equity of education.

(iii) Potential for enabling open and distance learning (ODL) through mobile phones especially in rural areas.

(iv) New ways that the youth are using mobile phones to communicate and share knowledge.

- **Inhibitors of M-Learning,** which refers to factors that hinder the growth of M-Learning Examples include the following (Muyinda et al.,2010; UNESCO, 2012):

  (i) Lack of Awareness among decision makers

  (ii) Technical limitations of mobile phones especially in poorer communities

  (iii) Limited mobile phone-based educational content and applications

  (iv) Anti-mobile phone sentiments within communities

  (v) Inadequate or lack of mobile network connectivity in some M-Learning contexts

  (vi) Cost of communication using mobile devices, which sometimes disrupts collaboration among research students

Therefore, there is need for mechanisms that can address these inhibitors with the aim of reaping full benefits of mobile learning and as a result widen its adoption. Examples of such mechanisms include: Cloud Computing services and Open Education Resources OER (Mwendia et al., 2014).

- **M-Learning Environment,** which refers to settings surrounding mobile learning users (M-Learners) (Muyinda et al., 2010). It contains information of both M-Learning inhibitors and M-Learning propellers that are found in a certain M-Location. An example is Middle east and African (MEA) region that contains several M-Learning propellers and inhibitors (UNESCO, 2012). These are shown in Figure 2.7

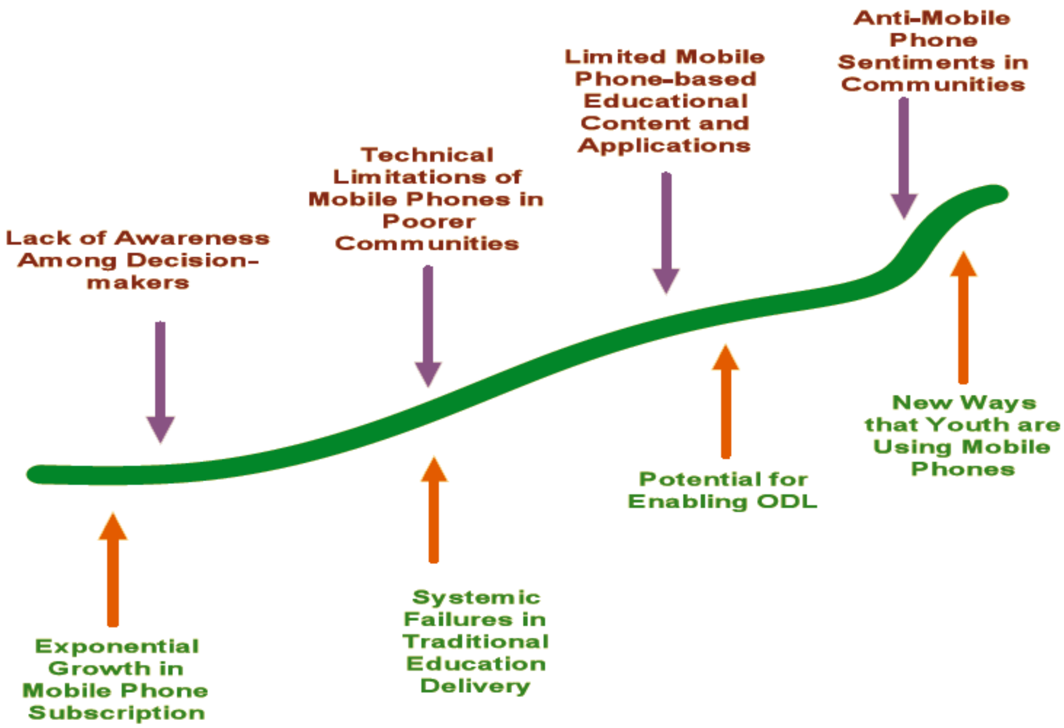

Figure 2.7: Propellers and Inhibitors of M-Learning in MEA M-Learning environment.

Source: (UNESCO, 2012).

(b) M-Learner's Context

Based on the definition provided by Dey (2000), Mobile learner's context can be viewed as any information that can be used to specify the situation of an individual learner as a single entity. Figure 2.8 shows the relationship between the different types of M-Learner's contexts.

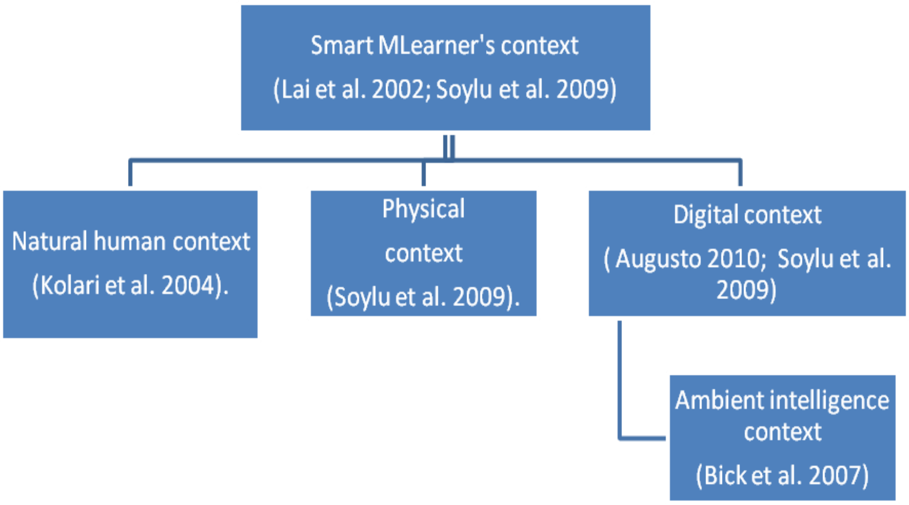

Figure 2.8: Categories of M-Learner's Context

As illustrated in Figure 2.8, sub-contexts of M-Learner's context include the following:

- **Physical context** holds information about physical (real) objects that surrounds the learner and are relevant to current learning activities. Examples are: (i) Location information such as absolute information and relative information; (ii) infrastructure information such as phone devices; (iii) Physical condition information such as noise level, brightness and changeable versus fixed conditions; and iv) learning establishments such as class room, university or conference room (Soylu et al., 2009).
- **Natural human context** contains information associated with natural situation of individual learners, which do not include current physical conditions. Examples are (i) user information such as personal habits, mental state, among others; (ii) social environment information such as social relations, collaboration or proximity of other people; and (iii) Task information such as activities performed by the learner (Schmidt et al., 1998 as cited in Kolari et al., 2004).
- **Digital context** consists of information about digital surroundings together with applications. Such information is represented in different formats such as text, videos, image, among others. Examples of digital environments are: Network environment that comprises internet or world wide web environment (Soylu et al. 2009;Augusto 2010).
- **Smart context** contains information about technologies that make adaptations and provide appropriate learner support. For example feedback, guidance or hints are provided according to individual learners' needs, in the right locations and at the right time. This is achieved through evaluating the situation of the learner, which includes natural context, physical context and digital context (Hwang, 2014). Therefore, smart context is viewed as a mapping of real world (i.e. both natural and physical context) and digital environments (Lai et al., 2002; Soylu et al., 2009). Smart context can be enabled by use of different types of context providers. These include: (i) Sensor-based collection, which use sensors to capture the situation of the learner. For instance, cameras are used to capture the presence of a learner. (ii) User based collection, which entails using an application that capture context when the user interacts with the it. For instance, a mobile application can be used to store activities in application logs or web logs (Soylu et al., 2009).

- **Ambient Intelligence context** holds information about digital environment that interacts with people through multimodal and natural interaction techniques such as speech, pointing, touching, eye gaze, gestures, among others (Maheshwaree, 2008). Characteristics of this environment are: embedding of devices in the immediate surroundings of the learner, personalization of learning services, adaptation of devices and anticipation of a learner's desires (Bick et al., 2007). Examples of ambient intelligence context are: (i) Ambient intelligence technologies such as sensors, smart mobile phones and computing and ad-hoc networks (ii) Artificial intelligence techniques that provide context awareness to determine the user's needs and adaptations (Kofod-Petersen et al., 2008). Such context can be collected using different types of context providers. They include: (i) sensor-based collection that uses sensors to capture the situation of the learner. For instance, cameras are used to capture the presence of a learner and (ii) user based collection, which entails using an application to collect context information about learners (Soylu et al., 2009). The term 'ambient Intelligence' is used interchangeably with 'smart environments'. However, they can be distinguished according to their main concerns. Smart environment is more concerned with the intelligent interconnection of resources (e.g. real and digital objects) and their collective behavior whilst ambient intelligence emphasizes on the intelligence factor. Despite these minor difference, both overlap enormously and share numerous common objectives, hence it is difficult to make distinction between the two contexts (Augusto, 2010).

2.3.3 Currents Forms of M-Learning Approaches

The challenge in the information-rich environments such as M-Learning environments is not to allow access to information at anytime and anywhere but to allow relevant content at the right time, in the right way and to the right person (El-Bishouty et al., 2010). This challenge can be defined as a 'flexible availability' challenge. That is, the challenge of enhancing access freedom in terms of content relevancy (what), access place (where), access time (when) and access strategy (how).

There are several current M-Learning approaches that attempt to address this challenge, namely, single mode of representation M-Learning approach, mixed mode of M-Learning approach, context aware-single mode M-Learning approach and ambient learning approach (Mwendia and Buchem, 2014; Mwendia et al., 2014). The four types of approaches can be identified through focus-based classification frameworks (Pacheler et al., 2010; UNESCO, 2012) but their characteristics are not exclusive.

(a) Single mode Representation M-Learning

Single mode representation (SMR) M-Learning can also be referred to as *unimodal* since it provides learning support through one mode of representation. Examples of unimodal formats are text files only, video clips only or audio clips only. During case based study, it was found that out of 14 reviewed cases in African universities, majority of them were associated with features of SMR M-Learning (42%, n=6). Among these, about 85% (n=6) cof them aims at supporting both collaboration and information services. In all cases (100%, n=7) the main driving factor was high prevalence of mobile phones among learners. Other factors included challenges associated with traditional distance learning education and E-learning systems such as lack of access to personal computers and electricity. However the development of this category was found to be mainly inhibited by technical limitation of mobile phones like limited memory (40%, n=3) followed by poor network connectivity (3%, n=2). The features of the six reviewed SMR M-Learning projects are discussed follows:

(i) **M-Research Supervision Initiative (MRSI) M-Learning Project (Muyinda, et al., 2008)** aimed at utilizing mobile phones to improve collaboration among research students and their supervisors at Makerere University. The main motivating factor was high prevalence of mobile phones among students enrolled in the university (96%) and non-availability of supervisors to the research students. However, the project could only allow supervisors to provide research support services like data collection guidance through short message service (SMS). Therefore, context awareness and mixed mode of representation were not adopted by the project

(ii) **Aga Khan University M-Learning Project (Onguko, 2010)** aimed at enhancing collaboration and provide administration information among certificate level learners in Mombasa, Kenya and Mvomero district of Tanzania. In this project learners and instructors used their mobile phones to exchange text messages such as notifications, course updates, inquiries and meeting dates' reminders. Motivating factors included, (a) readily available mobile phone technology, (b) isolation of learners during practicum, (c) the need to reduce time for visiting schools during practicum, and (d) The need to cut cost for course delivery without compromise on quality. Challenges encountered by the project included, (a) course content could not be delivered using short message service

(SMS) messages, (b) non-delivery of some SMS messages due to various reasons, for example students using more than one phone numbers that had not made available to their instructors, and (c) lack of integration with other learning tools such as Moodle due to technical challenges.

(iii) M-Learning project in University of Pretoria (UP) (Bon, Schryver, Hossan, and Jordaan, 2012; Brown, 2005) was motivated by two main factors. First, most of the students enrolled for distance learning education did not have access to personal computers. Second, there was availability of mobile phones among residential students (99.8%). The aim of the project was to communicating administrative information such as reminders for examination dates, date notifications for contact classes and calls for registration. This was facilitated using SMS technology. However, delivering advanced course content e.g. video clips and text documents was not feasible due to SMS technological constraints.

(iv) M-Learning project at Center for Distance Learning (CED) in Catholic University of Mozambique (UNESCO, 2012) was initiated in the year 2009 to support communication services through bulk SMS technology that allowed responding to the high number of student question at the time. The motivating factors for this project were mainly the types of challenges that the institution was facing. They include, (a) the high demand for obtaining formal teacher training at undergraduate degree level by teachers without qualification in Mozambique so that they could remain employed, with a 100% growth annually (b) inadequate infrastructure (e.g. poor or no access to internet and electricity) in remote areas where the students lived, (c) inadequate access to learning modules, and (d) poor-quality photocopies of study materials. Nevertheless, there were two challenges associated with the project. First, erratic network coverage was one of the main challenges experienced by the project, particularly because most students were using clone mobile phones. Secondly, the bulk SMS technology was broadcasting the same message to all students, thus they were not personalized to individual students. Thirdly, the technology was not delivering multimodal content like a mixture of video and audio clips.

(v) M-Learning project at Stellenbosch University (UNESCO, 2012;Mostert, n.d.) was initiated during the year 2009. The aim of the project was to support collaboration and administrative services using bulk and personal SMSs. This was complemented with a learning management system (LMS) to support online discussions among learners. The development of the project was largely motivated by fact that all enrolled teachers owned a mobile technological innovation, pedagogic necessity, funding opportunities and the observed inadequacies of conventional e-learning. However, out of 53 interviewed participants, 41% (n=22) used their phones to access the LMS while 58% (n=31) did not. Some of the observed reasons for not using mobile interface were: (i) Some teachers (17%, n=9) could sufficiently access internet from a computer, thus negating the need to use mobile interface and ii) Lack of access to internet-enabled phones (9%, n=5).

(vi) **Dynamic Frequently Asked Questions (DFAQ) project** (Hodgkinson-Williams and Ng'ambi, 2009) was started in 2002 at University of Cape Town. The aim of the project was to design an anonymous consultation environment for enabling learning among students with face-to-face interaction challenges. For example, mute students who cannot communicate verbally and those that cannot ask questions due to low self-esteem, lack of time in a large class, or shyness in small classes. The project was using World Wide Web as a platform and had two versions, namely, (a) Web version that had no SMS functionality for communication, and (b) Two-way SMS version that was used to deliver questions, consultation messages and administrative messages between students and lecturers. However, DFAQ project experienced pedagogical problems such as students with heterogeneous backgrounds, large class sizes, limited contact time, poor lecture attendance, students with difficulties of understanding English, limitations imposed by formal lectures and a lack of self-efficacy.

(b) Mixed Modes of Representation (MMR) M-Learning

This type of M-Learning aims at using mobile devices for allowing access to study materials represented in multi-modal formats such as text with video, audio with text or video with audio (Mwendia and Buchem, 2014; Mwendia et al., 2014). Out of 14 reviewed M-Learning cases in African universities, 36% (n=5) of them were found to be associated with features of MMR M-Learning. The development of this category was found to be mainly propelled by the availability of internet enabled mobile devices (100%, n=5) that could access electronic learning resources. The main inhibiting factors of this category were found to be delivery of irrelevant learning content (60%, n=3) and poor network connectivity (40%, n=2).

The five reviewed MMR M-Learning projects are described as follows:

(i) UI Initiative (Adedoja, Botha, and OGUNLEYE, 2012; Spaven, 2013) was started by University of Ibadan, Nigeria and funded by Partnership for Higher Education in Africa-Educational Technology Initiative (PHEA-ETI). The project was motivated by the need for supporting learning and access to multi-modal instructional content at any time and any place. Distance learning students could access course content on mobile platform using any internet- enabled mobile telephone such as: ordinary phones (e.g. Nokia, TechnoT9), smart phones (e.g. I-phone) or tablets. Courses supported by the project included Introduction to Instructional Technology, Primer Writing, The Production of Speech and The Study of Politics.

(ii) Click UP Mobile project (Bon et al., 2012;Tsunke, 2012) was started in July 2011 at University of Pretoria. The purpose of the project was to allow use of mobile devices for accessing core LMS features in an engaging and intuitive way. In order to use the system, users were required download 'Click UP Mobile' from their phone-specification store or use web-enabled phones/smartphones to access the web interface. Results from the project showed that Blackberry followed by Android were the predominant mobile platform being used to access E-learning. Services offered by the project included collaboration (e.g. discussion with peers and lecturers), information services (e.g. class announcements, notifications) and access to multimodal content.

(iii) Opencast M-Learning Project (Boyinbode, Bagula, and Ngambi, 2012) was initiated during the year 2012 in University of Cape Town (UCT), South Africa to facilitate learning for part time students, regular students and postgraduate students of Health Sciences Faculty. The project was motivated by several factors. First, the university had existing infrastructures such as laptops, desktops and Wifi hot spots installed in various rooms e.g. library, computer laboratory, and classroom and seminar rooms, among others. Second, internet was expensive outside campus, thus learners could use free wifi within UTC to download multimodal lecturer recordings through their mobile devices such as PDAs, mobile phones, iPods and iPads while on the move. Results of the project indicated that open mobile learning enables flexibility in terms of distance (e.g. access anywhere) and time (e.g. access anytime), allows collaboration among students (e.g. by using chat tools), cost effective (e.g. by use of free Opencast Matterhorn platform) and enhances learning experiences (e.g. by use of videos and audio lecture recordings). Nevertheless, lack of context awareness was one of the main shortfalls associated with the project.

(iv) Dunia Moja Project (Steinbeck, 2008; BCcampus and COL, 2008) aimed at using mobile technologies to support collaboration among international students and lecturers in the field of environmental sciences. The project was started in 2007 by 3 African institutions (University of the Western Cape, Mweka College of African Wildlife Management, and Makerere University) in collaboration with Stanford University. In this project students enrolled in partner universities used high-end PDAs to enable them download video from a central website and participate in discussions about global environmental issues through mobile blogging. Challenges encountered by the project included, (i) limited bandwidth and difficulties in accessing course content uploaded in the website due to poor network connectivity, (ii) limited ownership of mobile devices, which prompted the research team to provide students with smart phones (n=35) that could facilitate internet access, and sending both multi-media and email messages.

(v) ILU M-Learning project (Ikarambu, 2011) was launched during the year 2010 at International Leadership University in Kenya. It aimed at enabling students to use their smartphones access video lectures, coursework assessments and collaboration with peers in a virtual classroom. The project was driven by two main reasons. First, high prevalence of mobile phones in Kenya compared to low prevalence of computer access especially in the rural areas where some of the students came from. Secondly, mobility property of mobile phones makes it easier to carry unlike computers which cannot be used while on the move. However, the project required adequate storage server for holding course contents (e.g. video lessons). This meant that the university had to invest in provisioning of repository services especially to cater for scaling up of the project.

(c) Context Awareness Single Mode Representation (CSMR) M-Learning

CSMR M-Learning aims at utilizing mobile devices and for delivering single mode study materials according to context of individual learners. Context aware systems are sensitive to location and/or learners' activities (Pacheler et al., 2010;Mwendia and Buchem, 2014). Within the context of African universities, only one case was found to contain characteristics of CSMR M-Learning. That is, M-Learning Project at CET in University of Cape Town (UCT) (Kekwaletswe and Ng'ambi, 2006; Kekwaletswe, 2007) that aimed at creating context aware consultation system for enabling collaboration among learners. The system enabled learners know the presence of the current social network (lecturers, tutors and knowledgeable peers) that follow him or her while moving across contexts (e.g. different geographical locations).

The project was driven by four main factors: (a) both the learner and related social network are not fixed to specific locations, (b) existing learning environments for supporting knowledge transformation ought to move with learner, (c) the social network and the learner ought to be aware of the social presence of existing resources while involved with location independent tasks, and (d) high prevalence of mobile phones in UTC (98%). Nevertheless, the project did not evaluate whether presence and context-aware consultation system can be used to support learning using mixed representations such as video and audio content.

(d) Ambient Learning (AL) Projects

The aim of ambient learning projects is to use available devices (e.g. mobile devices and location dependent devices) to allow for a practical, easy-to-use E-Learning service that ensures anywhere, any time and any how access to personalized, high quality learning content (Paraskakis, 2005). This approach is distinguished from other E-learning services by three main features. First, multi-modal broadband access allows delivery of online E-learning materials at anytime, anywhere and anyhow. This is achieved through various broadband networks such as internet and use of different modes of interactions that include combining text with video formats, text-to-speech read-out tools, among others. Second, content management enables searching and integration of existing knowledge catalogues and e- learning resources (e.g. text, audio and video clips) through meta-data language. Third context management allows capturing and use of context information to deliver relevant content. Examples of context information are previous experience, interests, available device, tasks, personal profile, among others (Kofod-Petersen et al., 2008; Mwendia et al., 2013; Mwendia and Buchem, 2014).

Out of all the 14 reviewed cases in African universities, only 13% (n=2) of them that had features of the ambient learning approach. Both of them were found to be using natural interfaces that are embedded on location dependent objects (e.g. class room smart board) and mobile devices (such as mobile phones). In both cases, the main driving factor was found to be collaboration between African universities and Germany universities (100%, n=2). This is a key pointer of inadequate capacity of supporting ambient learning projects among African universities. However, none of the ambient learning cases was found to be using mobile devices only (Mwendia et al., 2015). The two ambient learning projects are explained as follows:

(i) **Intelligent Classroom (IClass) Project (Ramadan, Hagras, Nawito, Faham, and Eldesouky, 2010)** was started in Germany university in Cairo, Egypt. The project aimed at providing learning support in a classroom using ambient intelligent technologies such as sensors embedded on location dependent objects (e.g. furniture) and radio frequency-identification (RFID) cards. Examples of services provided included, (i) determining class attendance rate (97% accuracy), (ii) regulating class room temperature so that learners can be comfortable during learning, and (iii) profiling users based on their speeches. However, IClass project encountered some challenges. Firstly, the presence of some of users was not correctly detected (3%). This was attributed to two reasons; (a) some students were inserting their RFID cards in their wallets and inserting them in back pockets, thus making it difficult for RFID readers to detect the ID, and (b) some of the students were carrying RFID cards for their classmates, thus the RFID reader identified wrong user. Secondly, the IClass provided a fixed learning environment that could not move with the learner. This meant that learners had to attend the IClass physically for them to access study materials displayed on the smart board. Thirdly, the project involved use of expensive intelligent infrastructure and expertise, which may not be afforded by African-based universities.

(ii) **Digital Lecture Hall (DLH) Project (Mühlhäuser and Trompler, 2002; Rößling et al., n.d.)** was initiated by Darmstadt University of Technology, Germany in collaboration with University of Johannesburg, South Africa. The project aimed at augmenting existing teaching venues for smooth conversion from traditional teaching to different types of technology enhanced teaching that use both mobile and location dependent devices (e.g. smartphones, computers, among others). The target students included students located in Tanzania, Ghana and other remote areas. Services offered by DLH project included (i) Collaboration support that enabled students listening to a lecture in a large hall, to individually participate in open discussions. This was realized using screen placed in digital hall for displaying a list of incoming questions from students so that lecturer could answer them during ongoing lecture, (ii) Mixed representation learning, which involved recording of audio and video lectures to allow access during off hours, and (iii) context awareness learning that was enabled through talking assistant (TA). The tool consisted of location awareness functionalities for allowing orientation of cameras to capture location of a given speaker (student or lecturer) during an ongoing lecture. Nevertheless, DHL project was associated with high cost for acquiring infrastructure for implementing the project. Examples are: a repository for storing video and audio recordings, cameras for capturing live lecture videos and smart boards for displaying the course content.

Looking at the affordances of the four reviewed M-Learning approaches, ambient learning seems to be more promising (Mwendia et al., 2014). This is illustrated in Table 2.1.

Table 2.1: Similarities and Dissimilarities of Reviewed M-Learning Approaches.

M-Learning Approach	Any Place Access	Any time Access	Anyhow Access	
			Mixed representation	Personalization
Single Mode Representation (SMR)	√	√	×	×
Mixed Modes of Representation (MMR)	√	√	√	×
Context Aware Single Mode (CSMR)	√	√	×	×
Ambient Learning	√	√	√	√

Key: √ = Afford; × = Does not Afford.

As illustrated in Table 2.1, ambient learning allows access to personalized and multi modal content at anytime, anyplace and anyhow (Kofod-Petersen et al., 2008; Mwendia et al.,2013, 2014; Mwendia and Buchem , 2014) whilst the other three types of M-Learning lack one or two of these aspects. Nevertheless, ambient learning is not commonly understood and widely adopted (Winkler et al., 2011).

2.3.4 Theories of Current Mobile Learning Approaches

The current forms of M-Learning approaches are explained by some of the existing M-Learning Theories, namely, Context awareness learning theory, Collaborative learning theory and Cognitivist learning theory (Keskin and Metcalf, 2011; Naismith, et al., 2004).

(a) Cognitivist Learning Theory

Cognitivist learning theory describes learning that involves reorganizing or acquiring cognitive structures that helps to process and store information. Examples of technologies/media that are used to support cognitivist learning are: animations, images, video, audio and text. Some of the current M-Learning approaches adopt cognitivist learning, namely ambient learning, single mode representation M-Learning and Mixed modes of representation.

(b) Situated Learning Theory

Situated learning theory explains learning that places learners in "realistic" environment so that they can actively interact and participate with real situations to acquire knowledge (Tawei Ku and Chang, 2013). A good example is Mobile Research Supervision Initiative (MRSI) that was introduced in Makerere University on 1st August 2005 for enabling distance learning students to finish their final year field research project. In this project, students in the field (i.e. realistic situation) used their mobile phones to receive Short Message Service (SMS) messages for guiding them on various aspects of research such as field data collection, providing addresses to useful literature sources and encouraging the 'lonely' students in the field to collaborate amongst themselves (Muyinda Lubega and Lynch, 2008).

However, situated learning theory explains a type of learning approach that lacks the context awareness property. For example, the same learning content is broadcasted to more than one situated learner, who might be interested in different aspects of that content such as different topics. Consequently, some of the students might receive content that is irrelevant to their current stage of learning. Therefore, there is need for mobile research supervision initiatives that introduce the context awareness property when adopting situated learning theory.

(c) Context Awareness Learning Theory

Context awareness learning theory explains learning that entails using information from the environment to allow personalization of learning activities. The theory focuses on describing contextualized learning activities such as contextualized learning, navigation and retrieval of learning materials, contextual event notification, context-dependent content management, context-aware communication, and contextualized user interface. Both ambient learning M-Learning approaches and context aware M-Learning approaches are founded on this theory. Context awareness learning based on location can be divided into two categories, namely, context-aware location-independent learning and context-aware location-dependent learning.

(i) Context-aware location-dependent learning theory describes a type of learning that enable access to learning content based on the learner's current location (Yau and Mike 2010). For example, Mobilogue (Giemza, Malzan, and Hoppe, 2013) provides learning support that is dependent on location awareness. In this project, a mobile application is used to send multi-modal content (e.g. multimedia data and tests) related to the current location of the learner and makes a suggestion for next location.

(ii) Context-aware location-independent learning theory describes a learning approach that uses mobile applications for accessing context-sensitive learning content anywhere (Yau and Mike, 2010). That is, learning is not restricted to a specific range of locations. For example, TenseITS (Cui and Bull, 2005) as cited in (Yau and Mike, 2010) allows students to learn English language tenses based on three learning contexts that are entered by the students. These are: available time, concentration level and frequency of interruption.

(d) Collaborative Learning Theory

Learning is facilitated, promoted and improved through interaction and collaboration between learners. Mobile devices are used to enable communication among learners through technologies such as short message service (SMS) (Muyinda et al., 2010). Most of the current M-Learning forms support collaborative learning. They include ambient learning, single mode representation M-Learning, context awareness M-Learning and Mixed mode of representation M-Learning.

2.3.5 Mobile Technologies

Mobile technologies enable transformation of content and activities into mobile scenarios, e.g. supporting downloading of learning content from a knowledge base (i.e. content repository) to a mobile device (such as a mobile phone) through a wireless network and is displayed to the learner automatically.

According to UNESCO Mobile Learning Week Report 2011, mobile technologies can be defined as a combination of operating systems, hardware, networking and software including learning platforms, content and applications. In this definition, hardware consists of mobile technology devices such as basic phones, smartphones, tablets, electronic readers (E-Readers), personal digital assistants (PDAs) and memory sticks, among others (UNESCO, 2011).

Studies show that almost every student in African universities owns a mobile phone (either a dumb phone or a smart phone). This means mobile phones are one of the most popular mobile devices among students in this region. This is shown in Table 2.2.

Table 2.2: Results from previous studies in African based universities

University	**Own Mobile Phones**	**Smart phones**
University of Cape Town (CED (2010) as cited in Ramber Patient (2013)	98%	×
Makerere University (Paul Muyinda, Lynch, and van der Weide 2010)	97%	×
A South African University (Uys et al. 2012)	×	60%
Catholic University of Mozambique (Henzinger Gerald 2011)	99%	×

Key: × = Data not Available

As noted in UNESCO Mobile Learning Week Report 2011, mobile phones are evolving rapidly and their integration into education introduces value added functions. The benefits associated with value added functions of mobile phones are promoting the shift towards mobile learning from traditional learning paradigms that use printed materials, e.g. hand books (UNESCO, 2011) . This is shown in Table 2.3:

Table 2.3: Value-adding Functions of Mobile Phones over Printed Materials.

Mobile phones	Printed Materials
Collaboration support enables learners to communicate with others through feedback channels e.g. social media.	Does not provide collaboration support due lack of feedback channel.
Multi-modal support allows access to dynamic content such as video and audio clips.	Can only support static content such as text and images.
Content in the same learning object can be updated dynamically through cutting and paste features.	It is not possible to dynamically update content. Materials can only be replaced and that translates to extra cost.
Enable instantaneous access to a large and growing number of sources of information e.g. linking the user to peers, instructors and internet resources that include journal and conference papers.	Does not allow instantaneous access to other sources of information.

Based on the identified value-added functions of mobile phones, there is need for utilizing mobile to support current forms M-Learning approaches like SMR, CSMR, MMR and AL. Nevertheless, technical limitations (e.g. small screen and limited memory) and cost of using mobile phones are some of the factors that hamper large scale adoption of mobile learning approaches (Muyinda et al., 2008; Mwendia et al., 2014). This call for innovative mechanisms can help to address limitations of mobile technologies including mobile phones.

2.4 Mechanisms for Enhancing M-Learning Adoption

Combining mobile learning with other mechanisms that can address limitations of mobile technologies is likely to increase the adoption of mobile learning in East African universities (Mwendia et al., 2014). Examples of such mechanisms include ambient intelligence technologies, cloud computing services, and Open Education Resources (OER).

2.4.1 Ambient Intelligence (AMI) Technologies

Ambient Intelligence is described as an electronic or digital environment that utilizes context and is sensitive as well as responsive to the presence of people (Minguez, 2009). The main goal of Ambient Intelligence technologies is to facilitate easier interaction between human beings and digital information technology. There are three main categories of ambient intelligence technologies (ALCAÑIZ and REY, 2005;Chandrasekhar et al., 2011):

- **Ubiquitous computing** which refers to use of computers everywhere. It is characterized by two main properties. First, ubiquity is the property of allowing access to computation at “everywhere”. For example, several computing devices can be installed in an office to interact with users at the same time. These include smart board, displays, a smart watch, a mobile phone, a notebook and a tablet. All of them can be networked wirelessly to support mobile and remote access. Second, transparency is the property of allowing computing devices to be available in an invisible way. This is achieved by embedding microprocessors into everyday objects such as mobile devices, desks, a book, clothing or furniture (ALCAÑIZ, and REY, 2005).

- **Ubiquitous Communication** which allows objects to exchange information with each other and the user through ad-hoc and wireless networking. This can be achieved using several technologies such as Global System for Mobile (GSM) Communication, General Packet Radio Service (GPRS) and Universal Mobile Telecommunications System (UMTS) (ALCAÑIZ and REY, 2005).
- **Intelligent User Interface** which enables the users of the AML environment to control and interact with the environment using two mechanisms. First, natural mechanism which refers to techniques that allow the user to interact with the system without using input devices. For example, using human finger for touching an image on a touch screen of computer or using an infrared beam to point a tag that is embedded on the environment (Maheshwaree, 2008). Second, personalization mechanisms which refer to techniques that supports adaptation of user interfaces to provide users with relevant information. Examples include the following:

  (a) Semantic searching approach which uses ontology to dynamically recognize and adapt learning services based on learner's context such as learning, time, goals and surrounding environment, among others. This approach is used when the the user does not know about the documentation before searching. Thus, the user is required to input one or two keywords for allowing categorization of search results according to user expectations (Guha et al., 2003; Soulah-Alila et al., 2013).

  (b) Artificial intelligence (AI) techniques which enable context awareness to determine the user’s needs and the appropriate response (Kofod-Petersen, et al., 2008). An example is Greedy Best-first search method that uses an evaluation function to find the most promising information among available alternatives. However, Greedy Best-first search method has three limitations. Firstly, it is not optimal since it may return a solution that is not the best. Secondly, the evaluation function uses static heuristics to estimate the cost of progressing from the current state to the goal node. Thirdly, the method is not complete as it does not guarantee reaching the goal (Elaine Rich, Knight, and Shivashankar B Nair 2009).

Various researchers have proposed different models for implementing ambient intelligence technologies. These include the following:

(a) Ambient Intelligence System Model (Augusto, 2010)

This model describes an ambient intelligence system architecture that consist of three main components namely Environment, Interaction constraints and Interactors. This is shown in Figure 2.9.

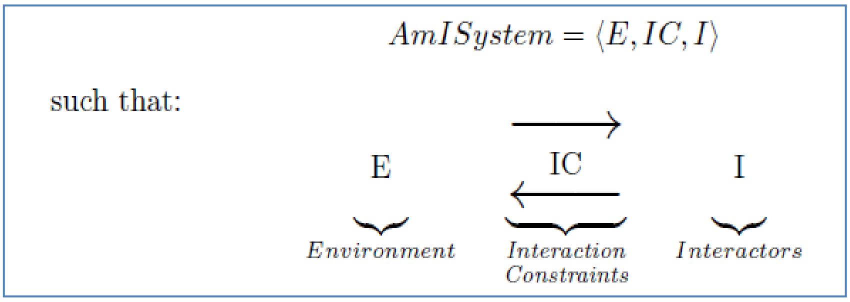

Figure 2.9: Ambient Intelligence System Model.

Source : (Augusto, 2010).

(i) Environment (E) represents physical situation elements (i.e. physical context) such as an airplane, a hospital house, a street, a factory, a city, an airport, a bus station or a train.

(ii) Interactors (I) refers to the set of elements that interact with the environment through intelligent interfaces. For example, people and robots, among others.

(iii) Interaction constraints (IC) describe various techniques that are used to implement an intelligent interface. Some of these techniques can be described using the following model:

IC = {S, A, C, IR} where:

S is a collection of sensors for capturing information from the environment (E),

A is a collection of actuators for acting and influencing environment,

C is a group of contexts of interest that distinguish situations in the environment to be acted upon, and

IR is a set of interaction rules for establishing the protocol on how the system will integrate all the previous elements (i.e. I and IC elements) together to make decisions and trigger actions.

Bick et al. (2007) describes an ambient learning framework that implements adopts AMI system model to support M-Learning. This is shown in Figure 2.10.

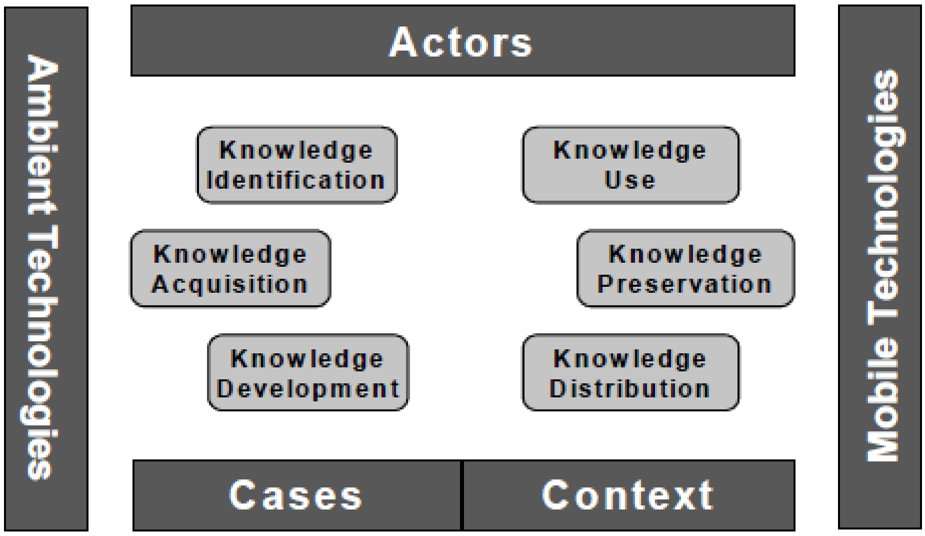

Figure 2.10: Ambient Learning Framework
Source: (Bick et al., 2007).

As indicated in Figure 2.10, ambient learning framework proposed by (Bick et al., 2007) contains the following components:

(i) Ambient Intelligence (AMI) Technologies that are embedded in immediate environment of the learner. In this framework, environment is represented by specific location or specific object (such as a machine) in the learning institution. AMI Technologies are differentiated from mobile technologies by embedment in location dependent objects and incorporation of context awareness capability. Examples of AMI technologies are: Bluetooth base stations and radio frequency identification chips that can be embedded on devices. This framework identifies five fundamental characteristics of ambient intelligence technologies for M-Learning support. These are:

1. Embedment: Integration of various network devices into the environment
2. Context-Aware: Recognition of learners and their situation when using these devices
3. Personalized: Tailoring of services towards the needs of targeted learners.

4. Adaptive: The devices can change according the needs of learners.
5. Anticipatory: Anticipating the desires of learners without conscious mediation.

(ii) Actors, which represent Interactors elements of AMI system model. In this framework, they consist of learners that benefit from the services provided by an ambient learning system. Learning services are adapted based on the preferences and characteristics of targeted learners such as gender, name and competencies, among others. Examples of actors include professionals that require constant training due to dynamic nature of their work (such as sales persons) and high school students that need additional study materials for supplementing the face to face lecturers, among others.

(iii) Context, which contains main factors that influence learning processes. Examples are learner preferences and learner characteristics such as competencies, gender, role, and name, among others.

(iv) Cases that describe previous M-Learning projects that can be used to derive adequate solutions for new learning processes. They include previous learning experiences encountered by actors during learning.

(v) Building blocks of knowledge management, which describe activities for managing knowledge. They are knowledge identification, knowledge preservation, knowledge distribution, knowledge development and knowledge acquisition.

(b) Mobile Phone-centric Ambient Intelligence (M-AMI) Architecture (Liro, 2012).

As indicated Figure 2.11, M-AMI Architecture consists of the following building blocks:

(i) Environment (E) contains information about immediate surroundings of the learner such as other people, other phones, physical conditions, location, time, day and month.

(ii) User comprises information about users that include: user profile, user activity, mental context and social context.

(iii) Mobile phones provide a user interface, network connection service and capability to run mobile applications.

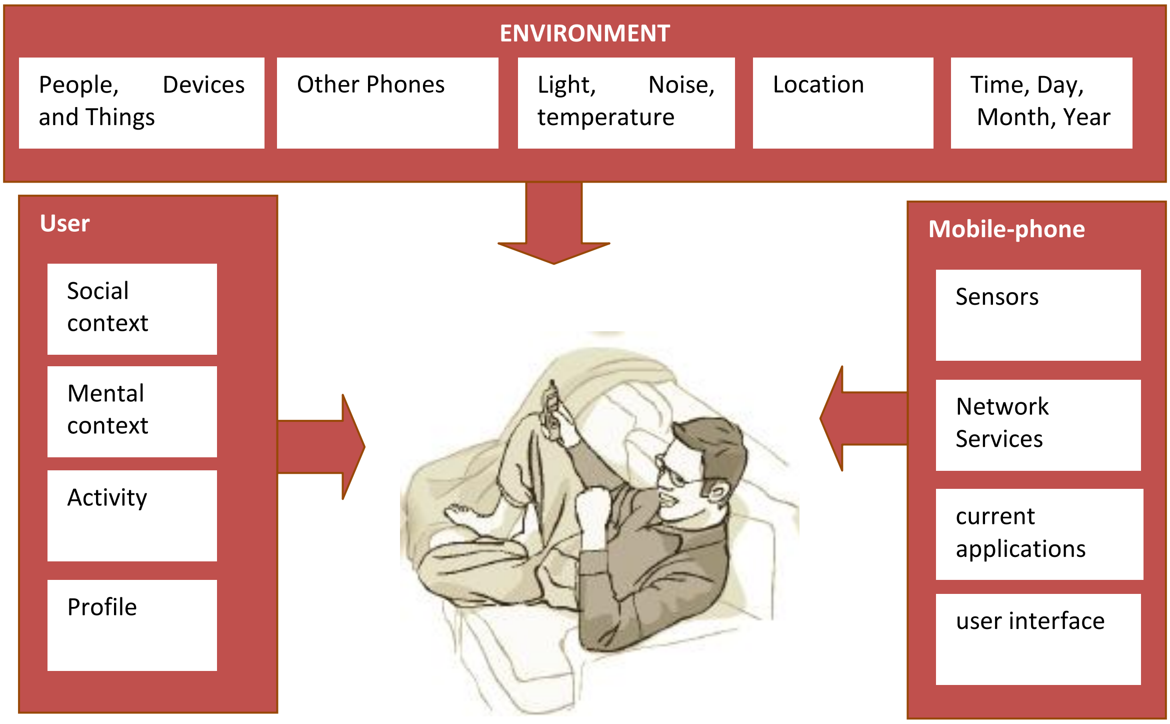

Figure 2.11: Mobile Phone-centric Ambient Intelligence (M-AMI) Architecture

Source: (Liro, 2012).

AMI technologies that implement this architecture can be described as mobile phone-centric ambient intelligence technologies (M-AMI). That is, technologies that use mobile phone as a central device to enable characteristics ambient intelligence for easier interaction between human beings and digital information technology (Mwendia et al., 2015).

Studies show that there are several M-Learning projects that have implemented M-AMI technologies to enhance delivery of digital study materials. This includes cases described by Chen, Chiang and Yu (2014), Giemza et al. (2013), and Leonard Low and Margaret O'Connell (2006). These are explained as follows:

- **Context-aware Dynamic learning environment for Multiple Objectives (CDLEMO) Project** (Min Chen et al., 2014) demonstrates how mobile-centric ambient intelligence technologies can be used to support M-Learning. This is shown in Figure 2.12.

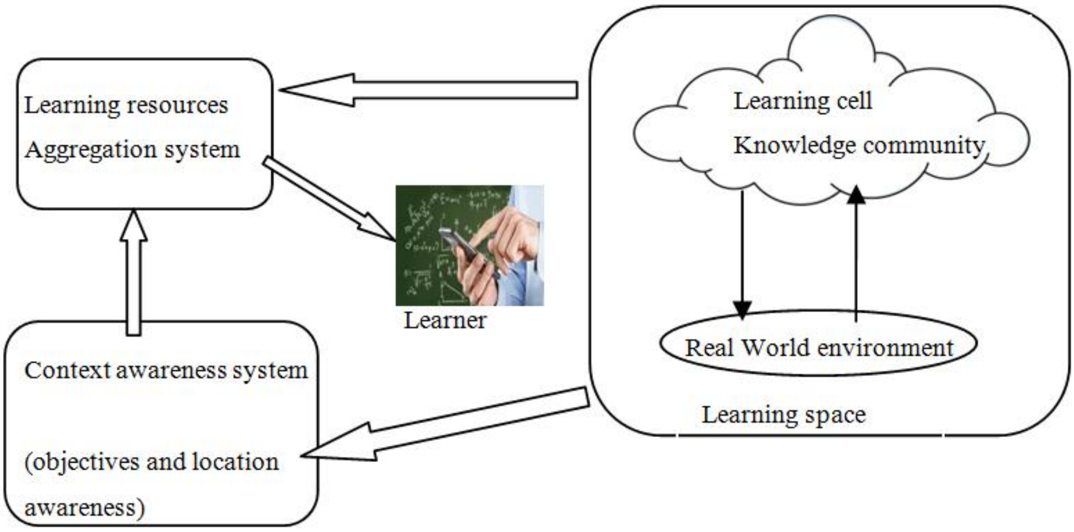

Figure 2.12: (CDLEMO) Project architecture.

Source: (Min Chen, Chiang, and Yu 2014).

Figure 2.12 shows that digital study materials are organized dynamically based on learner's current situation that includes both objective and absolute location. Aggregated learning resources comprise information of flowers and associated pictures. The context-aware system uses current learner's context to deliver corresponding digital learning resources that include pictures and information of the flowers in the immediate neighbourhood of the learner. In this project, smartphones use Geographical Positioning System (GPS) technology to identify the location of the flower or learners and intelligent mobile application to deliver relevant digital study materials.

- **Mobilogue Project** (Giemza, Malzan, and Hoppe 2013) is a location-aware mobile learning application that enables educators and learners to author and deploy learning support using mobile devices like smartphones. The tool can be used to support learning in informal learning contexts like museum visits and field trips, and formal learning contexts like classrooms. The aim of the project is to enhance the simplicity and flexibility of content deployment and authoring. However, the application can only support learning in specific locations with embedded quick response (QR) tags that can be scanned using smartphones. This means that the application cannot be used to support location independent learning services.
- **Leonard Low and Margaret O'Connell (2006) Project** is another case of mobile phone-centric ambient intelligence technologies. In this project, nursery plants are tagged with

2D dimension barcode that is captured using a mobile phone. The captured bar code is then translated into a web link, which appears on the screen of the learner's mobile phone. Finally, the learner selects the web link presented in order to access Information about the nursery plant as indicated in Figure 2.13. However, the learner can only access information about nursery plants that are tagged with barcodes. This project is therefore an example of context aware situated learning that is dependent on location with barcode tags.

Figure 2.13: An Example of Mobile phone-centric- situated learning technology

Source: Leonard Low and Margaret O'Connell (2006)

The reviewed examples of mobile- phone centric ambient intelligence (M-AMI) technologies shows that information about physical environment can be used for delivering relevant learning resources to the learner. However, not all relevant learning resources are related to the current physical environment of the learner. For example, online study materials preferred by the learner may only relate to current research activity but irrelevant to absolute location of the learner (e.g. at a bus stop or at home). Therefore, there is need for an ambient system model that uses mobile phone as a central device and allows delivery of relevant study materials without considering physical context surrounding the learner.

2.4.2 Cloud Computing Services

Cloud computing has been defined differently by various researchers. In this study, we adopt definition of Cloud Computing as a type of computing that involves providing largely scalable IT-enabled capabilities as a service to external clients through Internet technologies (Plummer et al., 2008).

There are several advantages that are associated with adopting cloud computing (Apostu et al., 2013). They include:

(i) Cost efficiency: Cloud computing is probably the most cost efficient mechanism to adopt, maintain and upgrade. This is achieved by using of cloud services to reduce the costs for purchasing software and licensing fees for multiple users by offering flexible payment options. Examples of such options include using as pay-as-you-go, one-time-payment, and other scalable options that allow an organization to pay only for the required services.

(ii) Almost Unlimited Storage: Cloud computing provides almost unlimited storage capacity. This can be achieved through use of repositories available over the internet.

(iii) Backup and Recovery: Data stored in the cloud can be backed up and restored easily than using physical devices that might be destroyed locally. Additionally, majority of cloud service providers are normally competent enough to support recovery of information.

(iv) Automatic Software Integration: In the cloud, users are not required to do extra work of customizing and integrating their applications as per their preferences. This is because cloud computing supports automatic software integration.

(v) Easy Access to Information: Users can access the information from anywhere and anytime so long as Internet connection is available.

(vi) Quick Deployment: The entire cloud computing system can be completely functional in a matter of minutes. The duration taken will depend on the exact type of technology to be implemented.

According to Jansen et al. (2013), there are four categories of cloud services that can be used to overcome certain limitations of mobile devices, especially to enhance accessibility and interoperability in technology-enhanced learning scenarios. They are:

(i) Cloud-based Communication Services, which can help exchange of information between learners in collaborative learning scenarios. For example, using chatting features in Facebook to support group discussions.

(ii) Cloud-based Repository Services, which can facilitate integration of learning objects in the cloud. For example, storage services offered by Amazon Simple Storage Service (S3), Dropbox, YouTube, Instagram and Flickr.

(iii) Cloud-based Production Services, which can facilitate creation of new content and/or improvement of its quality. For instance, Mindmeister is a web based application that is used to create mind maps.

(iv) Cloud-based Processing Services, which can help to process or analyze data, particularly large amounts of data. A good example is' Amazon Elastic Map and reduce' service that is used to analyze huge data sets with minimal effort.

There are several examples of use of cloud computing services for M-Learning. They include the following:

(a) Cloud-based Mobile Learning Interface Project (Boyinbode and Akintade, 2015)

This is a case of cloud-based mobile learning interface that was initiated at Federal University of Technology, Akure, Nigeria. The aim of the project is to allow delivery of knowledge to learners through their mobile devices from the cloud (centralized shared resources) at anytime and anywhere. The design of the system has been demonstrated using a mobile learning application that integrates rich text, rich immersive media graphics and web services. In order to use the application, students are required to download and launch it on their mobile phones. The application requests for the username and password before allowing the user to access learning materials from the cloud as long as there is internet service. However, users must select the relevant course through navigation. This requires addition time and effort.

(b) Work environment with social, personal and open technologies (WesPOT) Project (Mikroyannidis et al., 2012; Mikroyannidis, 2014).

This project supports creation of mashups through cloud-based and mobile applications in order to perform scientific investigations. The tools enable teachers and students to create and modify research related content by interacting with available inquiry components as widgets. Examples of research content include hypotheses, questions, answers, notes, reflections and mind maps, among others. Students can also select their preferred tools in order to personalize their inquiry environment including connecting basic workflow components to learning management systems such as Blackboard, Moodle and LifeRay. Additionally, learners are allowed to share their inquiry workflows, provide feedback to each other and collaborate through major social networks like Facebook

However, WeSPOT project has two main limitations. First, Mobile and learning analytics tools are mainly used for Data Collection and Data Analysis phases of the inquiry based learning mode (IBL). This means all the other services are performed through computers, which may not be readily available to all learners. Second, the project adopts location dependent context awareness learning that links inquiry projects to certain locations only.

Based on reviewed applications, it is clear that integration of cloud based services into educational services can benefit both learning institutions and learners. However, there is need to investigate fruitful combination of cloud computing services and mobile learning based on their potential functions for educational usage (Jansen et al., 2013).

2.4.3 Open Educational Resources (OER)

According to Butcher (2011), Open Educational Resources (OER) refers to any learning resources such as course materials and multimedia applications, which have been constructed for teaching and learning and are openly accessible for use by educators and learners, without requiring them pay royalties or license fees. Cloud-based applications can be used to facilitate networking, sharing, communication, and the production and publishing of OER (Ally and Samaka, 2013). An example is 'OER Knowledge Cloud' that was initiated by UNESCO for identifying, collecting, storing and allowing free access to OER by researchers, industry, students or any other interested parties (UNESCO/COL, 2014). Some of the benefits for incorporating OER in mobile learning include:

(i) Improving quality of learning materials through peer review activities such as adding and mixing (Park, 2013).

(ii) Reducing communication cost by using OER tools that support free exchange of messages during collaboration without asking for permission, paying access fees or licenses (UNESCO/COL, 2011). Examples include: Moodle Mobile and Mobile Learning Environment (MLE)-Moodle, which are freely available mobile engines (plug-in) for enabling learners to access Moodle courses from mobile browsers. Features provided by these plug-ins are: online messaging, quiz, forum, lesson, task, resource, survey, choice, wiki (read only) and database (search and query). However, both plugins are designed to access functions of Moodle, hence may not allow access to functions of other open source learning management systems (Piguillem et al., 2012).

African Nazarene University is one of the Kenyan universities that have adopted OER concept into their curriculum resources, particularly in area of teacher education. Some lecturers in teacher education enrich their classroom teaching and learning experiences by adapting and using online resources that are available from the MIT Website (OER Africa, 2014). Such resources include the following:

(i) LaTex software that helps to write mathematics papers, articles and books, among others.

(ii) "Microsoft Mathematics" software, which provides a graphic calculator that can support step by step equation solving as well as for plotting in 2Dimensions and 3 dimensions.

(iii) "Graph", which is Open Source software that is used for drawing mathematical graphs in a coordinated system.

Nevertheless, students using OERs available in MIT website are required to browse (navigate) for relevant resources. This requires extra time and effort. Additionally, some of the OERs like e-books and free softwares cannot be accessed through mobile phones due to memory limitations and compatibility issues. Therefore, there is need for innovative solutions like cloud-based repositories that can help to expand memory limitations of mobile devices and ambient intelligence technologies that can enhance access to relevant OERs without being required to navigate or search for the content (Mwendia et al., 2014).

2.5 Research Project *S*upervision Process

Supervision can be defined as an activity carried out by someone occupying a formal role within an institution, which has clear expectations and accountabilities to both the person supervised and the institution that provides the environment (context) for the supervisory relationship (Chiappetta-Swanson and Watt, 2011). According to Hockey (1996), supervising students research projects is a complex social process that requires employment of strategies by supervisors to enable research students complete their research project on time. This complexity is strengthened further by the fact that the process is dynamic in nature.

The strategies chosen by supervisors and associated execution methods depend on various factors, which are fluid in nature. There are two common strategy models adopted by supervisors (Spear, 2000; Skarakis-Doyle, 2008; Chiappetta-Swanson and Watt, 2011). They are:

(i) Group-based apprenticeship supervision model that is characterized by strong interaction and sharing of research responsibilities between supervisor and student. For example, when conducting an experiment, the supervisor and student may organize daily meetings. Usually, this model is adopted when students' research is closely connected to the supervisor's research and is more popular in laboratory sciences.

(ii) Individual apprenticeship model that prevails wherein student research is largely independent from the supervisor's research, and hence not related to his scholarly output. This model is more common in arts and humanities and is characterized by irregular and rare meetings with the supervisor, whose interval can even be more than one month (Hockey 1996).

2.5.1. Dynamics of Research Project Supervision

Effective supervision consists of four main factors that enable understanding of the research process and timely completion of research projects (Skarakis-Doyle, 2008). Firstly, flexibility that ensures use of different strategies that are adapted to needs of different students. That is, adapting to the substantial differences among students instead of applying the same strategy over and over again. Secondly, availability in terms of being accessible at the required time (when), for instance to provide informal and confidential discussions. Thirdly, mentorship, that is the association between the student and supervisor that aims at developing the student scholarly, professional and personal. This includes monitoring student's progress through the steps towards completion of their degree, commitment towards providing assistance and offering resources that facilitate students to find success and fulfill their professional pursuits. Finally, respect that involves treating each other with reverence or high opinion during supervision process. Figure 2.14 shows relationships between the four factors and timely completion of degree programs.

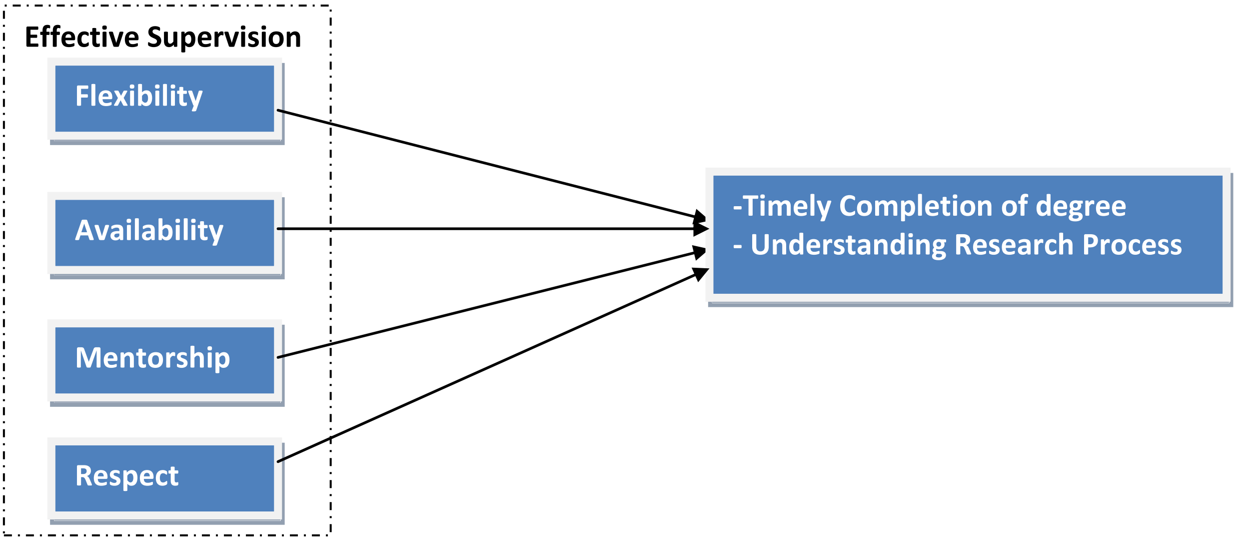

Figure 2.14: Dynamics of Student Project Supervision

Source: (Skarakis-Doyle 2008).

2.5.2 Use of M-Learning in Research Project Supervision

Studies show that mobile learning mostly occurs outside formal learning contexts and tends to become personalized through the use of personal mobile devices such as mobile phones. Consequently, one major challenge of mobile learning research is obtaining data on user demographics and usage of specific mobile devices. Previous researchers focused largely on investigating student perceptions, attitudes and motivations toward mobile learning, but few focused on strategies and practices. This means that there is need for more research on mobile teaching and learning strategies and how these strategies are implemented for learning support (Baiyun Chen and Aimee Denoyelles, 2013).

Mobile Research Supervision Initiative (MRSI) at Makerere University described by (Muyinda, Lubega, and Lynch, 2008) is an example of using M-Learning application for Research supervision. The project aimed at improving collaboration among research students and their supervisors using mobile phones. Short message service (SMS) was used for provide guidance on research aspects such as providing addresses of literature materials and sending notifications of deadlines.

However, the results from the project indicate that use of mobile phones for supporting research supervision process is associated with several challenges. The challenges include busy schedule of the students undertaking research, supervisor is not available at certain times, research process is costly and inadequate time allocated for the research project paper. The study concluded that the above mentioned challenges show that there is need for a robust approach that enables supervisors and their research students to keep in constant touch. This is likely to encourage research students to continue with their research, an activity that is viewed by some students as complicated and 'difficult' (Muyinda, Lubega, and Lynch, 2008).

2.6. Conceptual Framework

In order to guide this study, a conceptual framework has been formulated based on reviewed literature. In this section, we describe the variables in the framework and including their relationships.

2.6.1 Variables

As shown in Figure 2.15, the framework consists of four variables identified from the literature, namely, (a) M-Learning Context (MC), (b) M-Learning approaches (MA), (c) flexible availability, and (d) moderators.

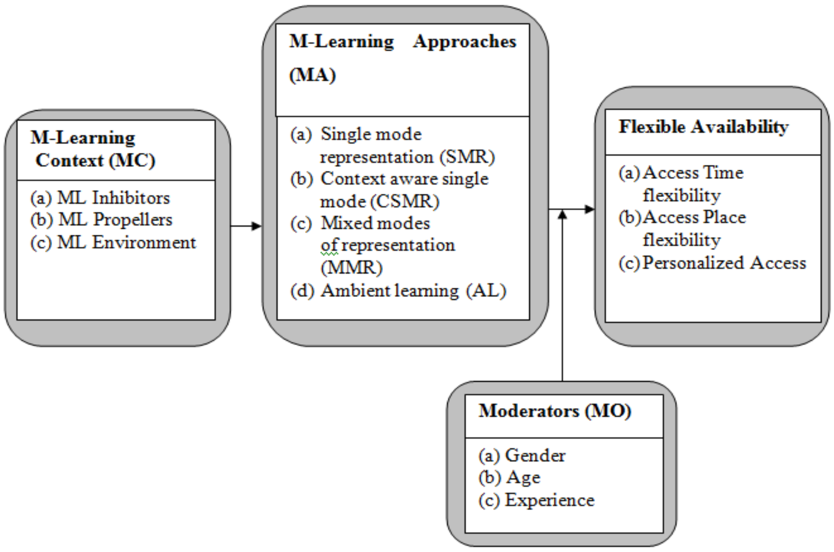

Figure 2.15: Conceptual Framework

(a) M-Learning Context (MC)

M-Learning Context layer describes information about mobile learning environment of a certain group of learners. This variable is derived from Muyinda et al. (2010) Framework, which describes the following three sub-dimensions.

(i) M-Learning Inhibitors, which refers to obstacles to the development and growth of M-Learning. Its Indicators are mobile phones physical features' limitations and high cost of mobile learning, among others.

(ii) M-Learning Propellers, which refers to factors that help development and growth of M-Learning. Its indicators include high penetration of mobile phones and liberalization of the telecommunication sector, among others.

(iii) Learning environment that explains the situation relating to the learner. Examples of its indicators include mobile connectivity, access to desktop computers and types of phones that can be accessed by learner, among others.

(b) M-Learning Approaches (MA)

This variable describes M-Learning pedagogical approaches, which aims at enhancing flexibility that is needed in personalized learning. Its sub-dimensions are differentiated by their objectives. They include:

(i) Single mode representation M-Learning that aims at supporting learning outside the classroom using low-end mobile devices. Its indicators include content delivery using text only (Onguko 2010).

(ii) Context aware single mode M-Learning, which aims at allowing access to study materials represented in single mode format by considering learner's current context. Its indicators include awareness of learners' context and access to single mode formats like text documents only or video clips only (Pacheler et al., 2010b; Mwendia and Buchem, 2014).

(iii) Mixed modes of representation M-Learning, which aims at improving the meaning of learning content by allowing learners to participate in a media-rich environment. Its Indicators include using a mixture of audio, video and text to present the same learning content (Mwendia and Buchem, 2014).

(iv) Ambient learning that combines characteristics of ambient intelligence characteristics and requirements of M-Learning approaches such as context awareness and mixed modes of representation (Bick et al., 2007; Winkler et al., 2011). Its indicators are characteristics of both mixed modes of representation and context sensitive M-Learning.

(c) Flexible Availability (FA) of Supervision Services

Flexible Availability (FA) of supervision services can be defined as access to research supervision services at anytime, anywhere and anyhow. Examples of research supervision services comprise access to research study materials, research guidance from supervisors and collaboration with other learners (Naidu, 2006; Muyinda, et al., 2008; Skarakis-Doyle, 2008). Its sub-dimensions are:

(i) When Access flexibility (When): This is flexibility that describes freedom to choose access times and pace (Gordon, 2014). Its indicators include anytime access duration per session and access times frequency per week/day.

(ii) Access place (Where) flexibility: This type of flexibility consists of places where learners can access learning content (Gordon, 2014). Its indicators include: anywhere, home, cyber and university, among others.

(iii) Anyhow access: This type of flexibility describes the freedom to access different modes of content representation. Its indicators are single mode such as accessing only accessing text documents only and multimode representation formats such as accessing a mixture of text documents and video or audio clips (Skarakis-Doyle, 2008).

(iv) Personalized access (Adapted Access): This type of flexibility allows the learner to access different study materials according to his learning needs. Its indicators are context awareness, anticipation of learning needs, personalization of content and adaptation of devices, among others (Bick et al., 2007; Gordon, 2014)

(d) Moderators (MO)

Based on reviewed literature, we argue that flexible availability of research supervision services are influenced by M-Learning approaches. This relationship may be moderated by gender, age and/or experience (Muyinda, et al., 2008 ; Venkatesh and Xu., 2012). A moderator refers to a variable that describes the circumstances under which the strength of a relationship changes (Bucy and Tao 2007). In our conceptual framework, the variables of moderators are explained as follows:

(i) Gender: Represents information about gender of the learner. Its values are: male and female (Wang et al., 2009 ; Venkatesh and Xu, 2012).

(ii) Age: Describes information about age of the learner. Its values include young, middle or old (Wang et al., 2009 ; Venkatesh and Xu, 2012).

(iii) Experience: Consists information about the duration that learner has used the technology. Its values include number of weeks, days or months that a learner has used a certain technology for M-Learning (Yaneli, Imed, and Said, 2014).

2.6.2 Relationships between Variables

Results obtained from previous studies show that features of M-Learning context can influence the type of mobile learning implemented. This view is confirmed by UNESCO Mobile Learning Week 2011 Report, which states that there is no 'one-size-fits-all' mobile learning solution. That is, mobile learning initiatives have contexts and are often country- and community- specific, and therefore one mobile application cannot always be adopted as is in another context. This can be attributed to the fact that each country or context has its own grouping of forces and drivers (UNESCO, 2011). There are two cases that can be used to illustrate this view. First, the most popular type of mobile learning initiatives in East African countries is single mode of representation (SMR) applications that focus on primary and secondary education. This is due to a significant number of low end phones employed in this region (Hellström, 2010). Such phones cannot be used for accessing internet but can be used to place and receive text messages and audio calls (Muyinda et al., 2010). Second, MXit mobile instant messaging service is often cited as an educational tool in South Africa whilst most mobile learning applications in Niger use SMS only (UNESCO, 2011). Therefore, we view M-Learning context e.g. a country as an independent variable that determines the type of mobile learning approach to be implemented. This is shown in Figure 2.15. However, there is no study that has been carried out to establish how the two variables are related within the context of African universities. This opens the opportunity for investigating such an association.

According to Mtebe and Raisimo (2014), mobile learning provides students with flexibility and ubiquity to learn anywhere and anytime through mobile devices connected to Internet. Ambient learning, which is one of the reviewed mobile learning approaches, promises to enhance such flexibility by enabling anyhow access in addition to anytime and anywhere access (Kofod-Petersen et al., 2008; Mwendia et al., 2015). Therefore, the type of mobile learning approach implemented by an institution can determine flexible availability of learning resources as shown in Figure 2.15. However, there is need for investigating the level of flexible availability that can be afforded by ambient learning with respect to research project supervision support in comparison to other M-Learning approaches.

Previous studies show that differences in age, gender and prior experience of using mobile devices moderate the effect of adopting mobile learning approaches. These include the following studies:

(i) Abu-Al-Aish and Love (2013) study, which observed that prior experience of mobile devices moderates the effect of effort expectancy, performance expectancy, influence of lecturers, personal innovativeness and quality of service on behavioral intention to adopt mobile learning.

(ii) Wang, Wu, and Wang (2009) study, which revealed that *age* differences moderate the effects of social influence and effort expectancy on m-learning use intention, and that *gender* differences moderate the effects of social influence and self-management of learning on intentions to adopt mobile learning.

Nevertheless, no study has investigated whether *age, gender* and *experience* of using mobile devices can moderate the relationship between mobile learning approaches and flexible availability of research project supervision. This creates the need for conducting a research that evaluates moderation effect of the three variables (age, gender and experience of using mobile devices) on such a relationship.

2.6.3 Operationalization of Variables

The variables for this study have been operationalized as shown in Table 2.4.

Table 2.4: Operationalization of Variables

Variables	Sub-Dimensions	Indicators	Values	Scale
M-Learning context (MC)	1.M-Learning Propellers	- Mobile phones penetration - Wireless networks.	- Phone ownership - Network providers	Nominal Ordinal
	2.M-Learning Inhibitors	- Mobile device limitations - Cost of mobile learning	- Phones limitations - Access costs	
	3.M-Learning environment	- Access to power supply - Course unit - University type	- Internet access at different places. - IT, non-IT courses - Private, Public	
M-Learning approaches (MA)	1.Context sensitive mobile learning,	- System awareness of a) Learning subtask b) Course. c) Learner identity aware (username, password) Etc.	- System awareness of a) Proposal and SRS b)BIT2206,Bit3205 c) User name, Pass word	Ordinal Nominal
	2.Single mode of representation	- One mode of representation only	-Text/SMS access only - Video only	
	3. Mixed mode of epresentation	-Multiple modes representation	-Video, Text/SMS	
	4. Ambient learning	- Context sensitive indicators - Mixed mode representation indicators	- Context sensitive values - Mixed mode representation values	
Flexible availability (FA)	1. Access Times Choices.	- Freedom to choose Access Times	8am - 5pm, 5 - 8.30, 8.30 - 8, any time.	Ordinal Nominal
	2. Access Place choices	- Freedom to choose Place choices	home, cybercafé, varsity, anywhere	
	3. Personalized Access	-Freedom to access content based learning needs	- Access content based On context e.g. current task	
	4. Anyhow Access	Freedom to choose different modes of content	Accessing text and video formats	
Moderator (MO)	1 Gender	- Male, female	M,F	Nominal
	2 Age	- (age brackets)	<20, 20-25, 26-30.....	Ordinal
	3 Experience	- Duration of mobile devices to access study materials	1semester,2 Sem,3 Sem ...	Ordinal

2.6.4 Operationalization of Data Sources and Analysis Techniques

Data sources and data analysis techniques associated with the identified variables have been operationalized using the Table 2.5.

Table 2.5: Data Analysis Techniques

Variables	Data Sources	Analysis Techniques
M-Learning context (MC)	Students enrolled in Kenyan universities	1. Descriptive statistics such as mean and mode 2. Inferential non-parametric tests for significance in skewed data. These include chi-square and Kruskal-Wallis
M-Learning approaches (MA)	1. Publications on M-Learning projects in African universities. 2. Kenyan university students that will participate in experimental research	1. Typology analysis techniques for categorizing M-Learning approaches. 2. Descriptive statistics such as mean and mode.
Flexible availability (FA)	1. Kenyan university students that will participate in experimental research	1. Descriptive statistics such as mean and mode. 2. Paired sample T-Test for comparing between pre and post experiment results. 3. Inferential non-parametric tests for significance in skewed data. These include chi-square and Kruskal-Wallis
Moderator (MO)	1. Kenyan university students that will participate in experimental research	1. Descriptive statistics such as mean and mode. 2. Comparison tests between pre and post experiment results. That is, paired sample T-Test 3. Inferential non-parametric tests for significance in skewed data. These include chi-square and Kruskal-Wallis

2.7 Hypotheses

Based on reviewed literature, we formulated the following null hypotheses (Ho) and alternate hypotheses:

H01: There is no relationship between M-Learning approaches and flexible availability of research supervision services.

H11: There is statistically significant relationship between M-Learning approaches and flexible availability of research supervision services.

H02: Experience, age and gender have no moderating effect on relationship between M-Learning approaches and flexible availability of research supervision services.

H12: Experience, age and gender have a statistically significant moderating effect on relationship between M-Learning approaches and flexible availability of research supervision services.

H03: Flexible availability that ambient learning can afford is not statistically significantly higher than the one afforded by variants of M-Learning approaches (i.e. OSMR, OCSMR and OMMR).

H13: Flexible availability that ambient learning can afford is statistically significantly higher than the one afforded by variants of M-Learning approaches.

H04: Flexible availability that ambient learning affords is not statistically significantly higher than that of existing M-Learning approaches

H14: Flexible availability that ambient learning can afford is statistically significantly higher than that of existing M-Learning approaches

2.8. Literature Review Summary

During the last one decade, African countries have experienced proliferation of mobile phones (Rao, 2011). However, majority of the countries are categorized as least connected countries (LCC) since their ICT development index (IDI) is very low (<2.78). For example, less than 5% households have access to personal computers (ITU, 2014).

This trend has been replicated in East African universities within the region where almost every student owns a mobile phone/device (more than 90%) but half of them (about 50%) do not own a personal computer. As a result, they are required to move to limited fixed places such as cyber cafés for computer and internet access. Forcing learners to access learning resources from specific locations removes flexibility that is required in personalized learning (Muyinda et al., 2010; Kashorda and Waema, 2014). According to Ally (2009), personalized learning recognizes difference, diversity and individuality in the ways that learning is developed, supported and delivered. For instance, learners are allowed to choose access location, access time and access method. In order to achieve personalized learning among learners with poor access to computers, there is need for innovative solutions that can help to improve flexibility of accessing digital learning resources.

Student supervision process aims at enabling research students to complete their research projects within the stipulated time. However, inadequate availability of research supervision services makes it difficult to achieve this goal (Muyinda, Lubega, and Lynch 2008). Among the existing M-Learning approaches, ambient learning appears to be most promising in addressing this problem (Mwendia et al., 2014). For instance, the approach aims at delivering personalized high quality content anywhere, any time and anyhow whilst the objectives of other M-Learning approaches lack one or two of these aspects. Examples of such approaches include single mode M-Learning, context aware single mode M-Learning and mixed mode of representation M-Learning. However, ambient Learning has not yet reached a state of common understanding (Winkler et al., 2011) and is not widely implemented in East African universities (Mwendia et al., 2014).

The reviewed applications of Mobile-phone Centric Ambient Intelligence technologies (M-AMI) show that information about physical context and digital context can be combined to provide ambient smart environment for delivering relevant learning resources (Min Chen, Chiang, and Yu, 2014). Nevertheless, not all relevant learning activities are related to the physical environment of the learner. For example, access to learning materials and collaboration with other learners may only be related to learning objectives of the learner but not his immediate physical location such as home or bus stop.

Therefore, there is need for a M-AMI system model that can be used for providing flexible availability of research supervision services like supervision guidance and access to research materials. Such a model should aim at delivering services that are relevant to the learner in order to meet his research needs.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Design science research methodology (DSRM) was selected to guide the development of prototypes used in this study. This is because it is guided by several principles that make it preferable for application in M-Learning approaches. The principles include the following:

(i) The goal of the methodology is to develop and evaluate information technology artefacts for solving identified organizational problems e.g. M-Learning problems in universities.

(ii) A rigorous process for designing artefacts is adopted to solve problems, evaluate the designs, make research contributions and communicate the results to relevant audiences.

According to Ken Peffers, Tuure Tuunanen, Marcus A. Rothenberger, & Samir Chatterjee (2008), DSRM describes six research activities. They are shown in Figure 3.1.

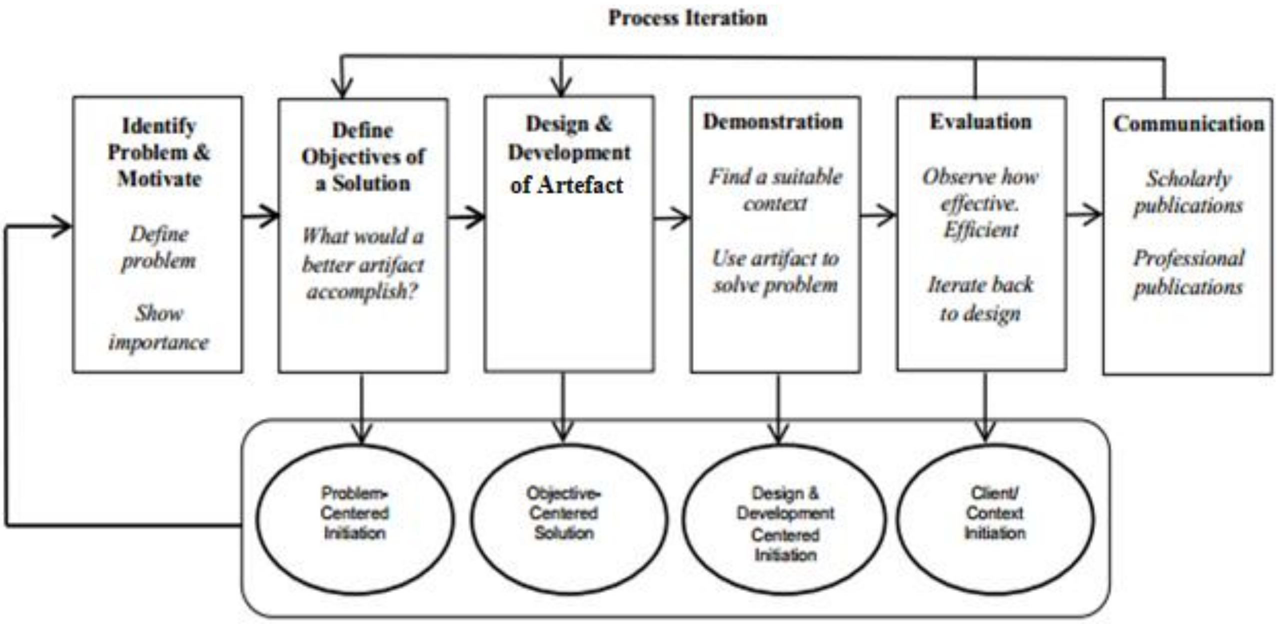

Figure 3.1: Design Science Research Methodology (DSRM) Process Model

Source: (Ken Peffers et al., 2008)

As illustrated in Figure 3.1, DSRM process describes the following six research activities:

(i) Problem identification and motivation task, which entails defining the specific problem and justifying the importance or benefit of a solution.

(ii) Defining objectives for a possible and feasible solution that are derived from problem definition. The resources needed for this stage include knowledge about problem statements and possible solutions, if any, and their usefulness. Objectives can be quantitative, for example in terms of attaining quantifiable or qualitative results, for example in terms describing a new artefact.

(iii) Designing and development of the artefact, which requires determining the desired functionality and architecture of the artefact. Resources required include research objectives and knowledge of theory that can be used to achieve those objectives or realize the possible solution if any. The output of this activity can be any object that represents contribution of the study. Examples are: models, methods, instantiation or new properties of informational, social or technical resources.

(iv) Demonstration of the artefact that is done to exhibit the adoption of the developed artefact. Methods of demonstration include experimentation, case study, simulation, proof or some other appropriate activity. Resources required for this stage include knowledge of how to use the artefact for solving the identified problem.

(v) Evaluation of the artefact, which requires observing and measuring how well the artefact supports a solution to the identified problem. This is achieved through performing comparisons. For example, comparing the objectives of the developed artefact and the actual observed results obtained from using the artefact. At the end of this stage, the researcher(s) can decide whether to repeat design and development stage or to continue on to communication stage. The resources required for this stage are knowledge of relevant metrics and analysis techniques.

(vi) Communication activity entails publishing or presenting study results to the relevant audience such as practicing professionals and other researchers. This is achieved through the following two ways. First, writing scholarly publications such as journal papers or professional publications such books. Second, presentation of results in public forums such as conferences, seminars or symposiums. Resources required for this stage include knowledge of the culture of the discipline in which the artefact is being developed and used.

However, DSRM has three limitations. First, communication activity is incorporated as the final step for conducting research (Ken Peffers et al., 2008), which may be too late for a long term study (e.g. PhD study takes at least 3 years) to be used by the relevant audience. Secondly, it is difficult to generalize artefacts when using design and development research methodologies (Saltuk & Kosan, 2014). This is because the methodologies adopt longitudinal research approach instead of cross-sectional research approach. Finally, it is difficult to generalize artefacts when using design and development research (Saltuk & Kosan, 2014). This calls for incorporation of other methods in Design science research methodologies to facilitate generalization.

3.2 Research Methodology

In our study, we argued that there is the need to establish an appropriate design based research methodology that incorporates other methods that can allow generalization and integration of communication after every research stage/activity to allow timely communication of results.

To address this limitation, a new design science based methodology known as Communication Oriented Design Science Research Method (CODSRM) was derived from design science research method (DSRM) proposed by Ken Peffers et al.(2008). CODSRM interleaves the communication activity in every research stage in DSRM to facilitate immediate communication of results to relevant audience and obtaining early feedback for the purpose of improving the proposed artefact.

In order to guide execution of research activities, other enhancements were made to DSRM. They include the following:

(i) Survey research method (Visser, Krosnick, and Lavrakas, 2000) was adopted to carry out problem analysis and formulation by using specific data collection methods e.g. using a questionnaire.

(ii) Case based research method (Fritz, 2008) was applied to establish the objectives and motivations for developing an artefact.

(iii) Creativity process (Liang, Proctor, and Salvendy, 2011) was used for guiding the designing and development of the proposed artefact as well as evaluating its effectiveness.

(iv) Use-case scenario (Mannio and Nikula, 2001; Alias et al., 2011) was used to demonstrate how the developed artefact can be used by target users.

(v) True Experimental design (Levy and Ellis, 2011) was applied for guiding the execution of evaluation activity.

(vi) Inverted-T approach, which was derived from phased approach (Craig et al., 2008) was to guide the adoption of the whole methodology.

The improved DSRM is called Communication Oriented Design Science Research Methodology (CODSRM). This shown in Figure 3.2

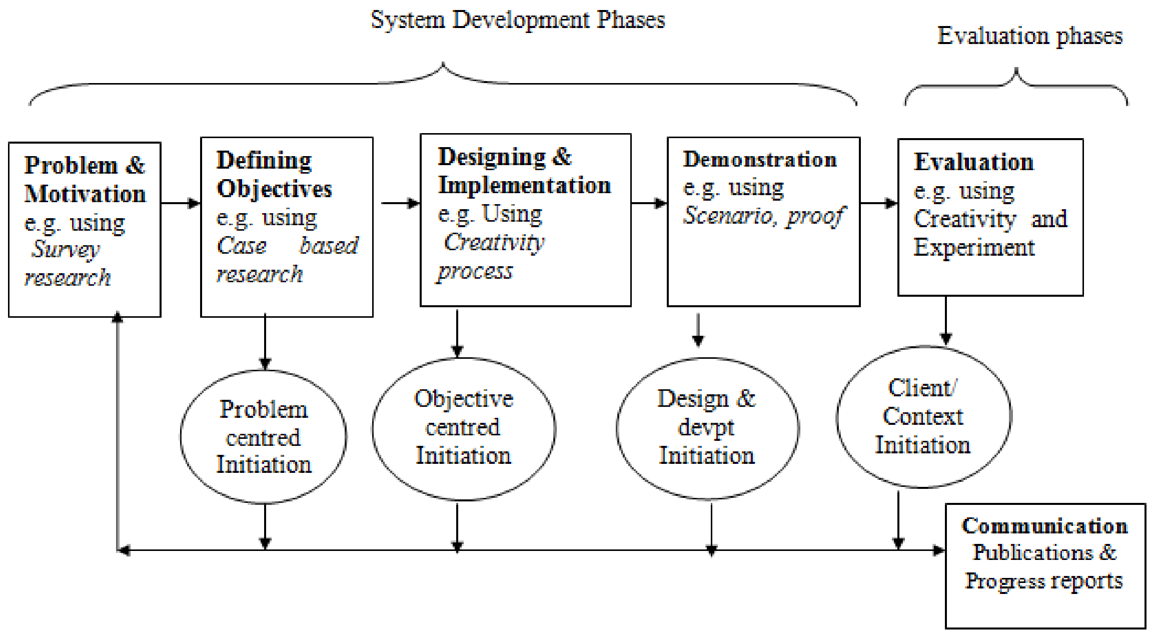

Figure 3.2 Communication Oriented Design Science Research Methodology (CODSRM) (Derived from Ken Peffers et al.(2008))

Research activities of CODSRM were associated with methods and objectives of the study. This is shown in Table 3.1.

Table 3.1: Using CDSRM to execute this study

CODSRM Methodology	**Objectives**	**Research techniques**	**Indicators**
1.Problem identification, Motivation & Communication	Ob 1: To ascertain Mobile prevalence (identify motivation). Ob2: To establish characteristics of mobile learning context (problem definition)	- Survey Research - Publishing - Reporting	- Questionnaires - Survey Data -Publications - Progress reports
2.Define objectives & Communicate	Ob 3 : Study current types of M-Learning (define objectives)	- Case based research - Reporting	- Publication (s) - Progress reports
3. Design, develop & communicate	Ob 4: Designing and developing ambient learning model (artefact)	- Creative Process - Publishing - Reporting	- Prototype -Publication.
4. Demonstrate artefact & Communicate	Ob 5: Demonstrate use of ambient learning model (artefact)	- Use case scenario & Proof example. - Publishing - Reporting	- Use case example - Proof example -Publication
5. Evaluate artefact and Communicate	Ob 6: Evaluate ambient learning model	- Creative process - Experiment -Publishing -Reporting	- Prototypes - True expérimental study

3.2.1 Adoption Approach for Research Methodology

To address the problem of generalization, phased approach described by Craig et al. (2008) was enhanced to form a novel adoption approach named 'Inverted-T' adoption approach. This is shown in Figure 3.3.

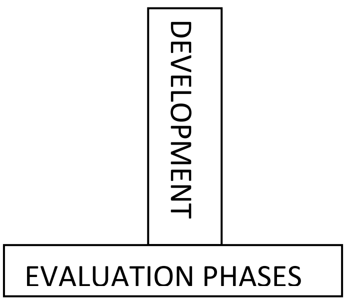

Figure 3.3 Inverted-T Adoption Approach for CODSRM.

(Derived from Craig et al., (2008) model)

As indicated in Figure 3.3, Inverted-T approach was used to describe the following two categories of CODSRM phases:

(i) **Development phases:** This category of phases explained the process of developing proposed ambient learning approach. They include Identification of problems and motivations phase, defining objectives phase, design and implementation phase and demonstration phase.

(ii) **Evaluation phases:** These described the process of evaluating the developed ambient approach. They included generalization evaluation phase and effectiveness evaluation phase.

3.3 Identifying Problems and Motivations Phase

The purpose of this phase was to help in achieving the first objective. That is, to establish the features (such as challenges and motivations) that can be used to describe characteristics of mobile learning context. Based on reviewed literature, the high prevalence of mobile phones among students is viewed as one of the motivating factors for mobile learning development whilst limitations of mobile phones are described as one of the inhibiting factors. As an attempt to verify these views with the Kenyan context, a research survey was conducted in six private and three public Kenyan universities. The study focused on ascertaining the current level of digital prevalence and associated challenges in university level M-Learning context.

3.3.1. Target Population

The purpose of the section is to specify the target respondents of the study. The use of existing literature helps to justify the identified target respondents.

According to statistics abstract 2013 published by Kenya national bureau of statistics(KNBS), during the period between year 2008/09 to 2012/13, majority of enrolled students in public universities were undergraduate students 87.5% (n=644, 508) compared to post graduate students (8%, n=63, 279) and other groups (4.3%, n=9, 585) such as diploma and certificates (KNBS, 2013) (see Figure 3.4). Based on this data, undergraduate students were purposively selected as the target population of survey research. Since the focus of survey was to investigate current status of M-Learning context in Kenyan universities, target population was reduced to undergraduate students that utilize computing devices e.g. mobile devices or computers for accessing E-learning resources. Computers were considered in the survey for the purpose of performing comparison analysis between access to mobile devices and access to computers.

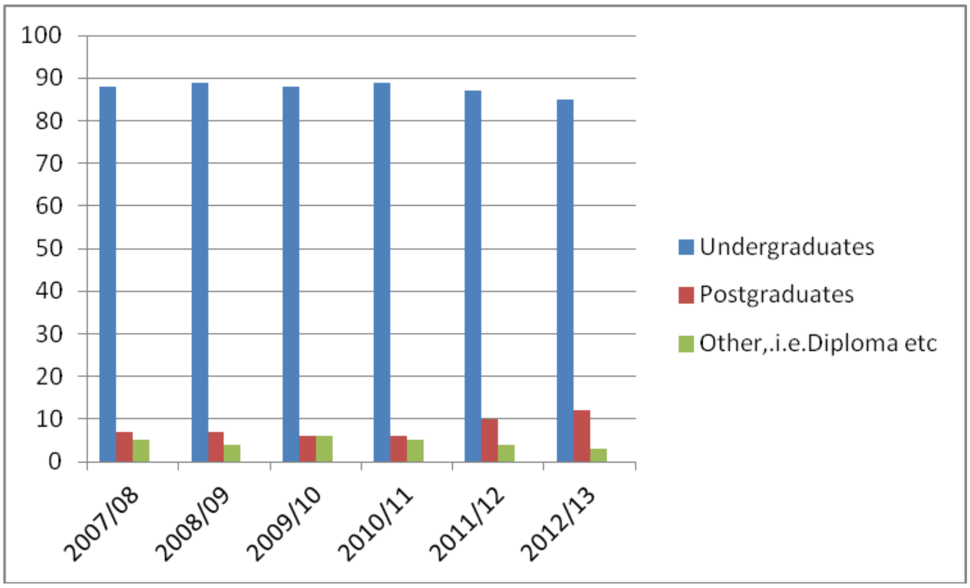

Figure 3.4: Percentages of Enrolled Students between 2008/09 and 2012/13

Source: (KNBS, 2013).

3.3.2 Data collection Instruments

Survey research used a questionnaire as the data collection instrument based on two main reasons. First, it is described as a suitable tool for collecting standardized data from a large number of respondents (Institute of Lifelong Learning, 2009). Secondly, questionnaires are also viewed as an appropriate tool for collecting information from the perspective of the users of E-learning and M-Learning technologies (Kirakowski, 1997).

3.3.3 Reliability and validity Measurements

To ensure reliability and validity of the questionnaire, several measures were taken. They include: conducting pilot study, carrying statistical test of reliability using Cronbach's alpha test and consulting experts.

(a) Pilot Study

The questionnaire was distributed to 28 undergraduate students that had registered in two Kenyan universities. This is shown in Table 3.2.

Table 3.2: Number of respondents in pilot study

University	Frequency	Percent
JKUAT	11	39.3
KCA	17	60.7
Total	28	100.0

As described in Table 3.2, about 39% (n=11) of the students had enrolled in Jomo Kenyatta University Agriculture and Technology (JKUAT) while 61% (n=17) of them had registered in KCA University (KCAU). Observations made during pilot study include the following: i) the questionnaire was too long (too many questions), ii) There were numerous inconsistencies in the data collected, which resulted in a Chronbanch's alpha value (0.60), which is acceptable according to (Mugenda and Mugenda, 1999), iii) There was a high response rate in private university (17/20) compared to public university (11/20).

(b) Consultations with Experts

The researcher consulted five experts to gather their views regarding the questionnaire. Table 3.3 shows details of the four consulted experts:

Table 3.3: Feedback obtained through consultations

Experts	**Qualification Details**	**Feedback Comments**
Expert 1	- Associate professor In applied statistics at Co-operative University College of Kenya (CUCK). - Former director of E-learning In JKUAT	- Questionnaires can be distributed to a large number of students above the required sample size (n=385) so that inconsistent cases can be deleted during data analysis. - Merge some questions using a table.
Expert 2	- PhD Student, Project Planning & Management (Information Systems), - Msc in Project Planning & Management Co-ordinator and lecture at School of Computing, University of Nairobi	- Questions that appear redundant can be removed. - Questionnaires have typos. - Some questions need restructuring
Expert 3	Chairman, Department of Computing and IT (CIT)- Kenyatta University	- Target of 200 students per university in 10 universities seems to be too large -Questionnaire seems to cover a lot but can take alot of time to fill - Perform a pre-test to see whether students are okay with the questions.
Expert 4	- PhD in Educational Planning and Economics - Lecturer, Dept. of Educational Management, Policy and Curriculum Studies At Kenyatta University	- Categorize respondents into computing and non-computing - Questionnaire has very many questions.
Expert 5	- Dean, Faculty of Computing and information Management (FOCIM), KCA University	The minimum sample size should be 385 respondents.

Based on the results obtained from piloting of questionnaire and consultations with experts, we adopted the idea of increasing the sample size beyond the required minimum of 385 respondents to allow for the removal of inconsistent cases and the achievement of minimum sample size requirement (n=385).

3.3.4 Sample Size

According to Mugenda and Mugenda (1999), if the target population of survey is more than 10,000, the sample size can be determined using the following formula:

$$n = \frac{Z^2 pq}{d^2}$$

Equation 3.1: Formula for calculating Minimum Sample Size

Where:

n= minimum sample size if population >10000

Z= the standard normal deviation at the required confidence level.

p = proportion of population with required characteristics

q =1-*p*

d= the level of significance set.

If there is no estimate available for proportion of population (P), the recommended proportion of the target population =0.5, Z-statistic = 1.96, and significance level = 0.05. That is, Z = 1.96, p = q = 0.5, and d = 0.05. In this study there was no reliable estimate of target population proportion, thus using the function. The minimum sample size (n) was computed as follows:

Sample size (n) = $(1.96)^2 * (0.50) * (0.50) / (0.05)^2$ *= 384 respondents*

Equation 3.2: Applying Formula for calculating Minimum Sample Size

More than 1000 questionnaires were distributed to sampled universities but only 612 questionnaires were consistently filled to be considered for data analysis. The objective was to collect data from as many E-learning users as possible so that we could obtain a representative sample of the target population, namely, users of technology supported learning.

3.3.5 Sampling Methods

During survey research, two sampling methods were selected, namely, simple random sampling and stratified purposive sampling.

(a) Simple random sampling

In our study, simple random method was used to choose individual respondents that were using computing devices (either mobile or computer) to access digital study materials hosted by the university's E-learning system. The method was selected because it ensures that all respondents have equal chance of being selected (Tongco, 2007).

b) Stratified Purposive Sampling

Stratified method involves choosing the most appropriate sample that is likely to answer a specified research question. That is, particular subjects are deliberately chosen to provide important information that cannot be gotten from other sources. If the respondents are known to the researcher, they can be stratified into categories (Marshall, 1996; Teddlie and Yu, 2007). During survey, purposive sampling method was used to select universities, degree programmes and learning modes in order to allow generalization of results as shown in Figure 3.5.

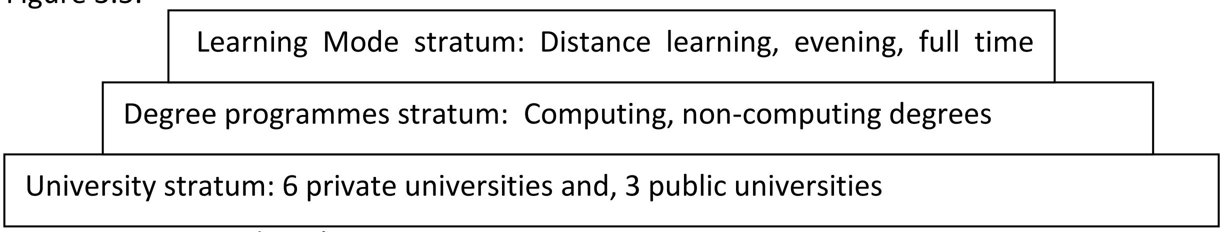

Figure 3.5: Respondents' strata

Learning mode stratum incorporated different modes of study adopted by sampled universities. They included part time, distance learning, full time study, weekend evening and school based learning mode. Questionnaires were distributed to different modes of study to enhance generalization of results across learning modes within sampled universities.

University stratum included 9 Kenyan universities that were easily accessible and had adopted E-learning or M-Learning technologies. These include following:

(i) Three public universities. That is, University of Nairobi, Kenyatta University and Multi-Media University.

(ii) Six private universities. That is KCA University, United States international University (USIU), Kenya Methodist University (KEMU), African Nazarene University, Mt Kenya University and Daystar University.

Degree programmes stratum incorporated only undergraduate degree programmes that were purposively selected. This is because they represented the largest proportion of university students population according to statistics abstract published by (KNBS, 2013). For the purpose of our study, these programmes were then divided into the following two categories:

(i) Computing degree programmes, which focus on providing education related to information, communication and technology (ICT). They included Bsc IT (n=130), BBIT (n=73), BSc Computer Science (n=22), and Information Systems Technology (n=29).

(ii) Non - computing degree programmes - that were offering non - ICT education, namely, Tourism management (n=3), BA Journalism (n=3), Bachelor of International Relations (n=3), among others.

The number of selected computing degree were few (n=5) because respondents that had registered in these degrees were easily reachable and in large numbers.

3.3.6 Results from Identifying Problems and Motivation Phase

This section provides a description of results obtained from survey research that was conducted using questionnaires in 6 private universities and 3 public Kenyan universities between July 2013 and November 2013. Based on a conceptual framework, the main variables tested during the study include: M-Learning environment, M-Learning propellers, M-Learning Inhibitors and M-Learning services.

(a) M-Learning Environment

The study observed that the mobile learning environment can be described by two main sub-variables. That is, a) higher learning institutions and b) students with mobile devices.

(i) Higher Learning Institutions

Higher learning institutions can be described as formal learning institutions that provide education whose successful completion is marked by the award of a university degree such as masters, bachelors or doctorate (ADA, 2010). Such an institution can be divided into two categories. That is, (a) private universities that are established with funds other than public funds, and (b) public universities that are maintained or supported by use of public funds (Parliament of Kenya, 2012). Table 3.4 shows a list of public and private universities from which the data was collected.

Table 3.4: Number of Respondents per Institution

	Type of Institution	Frequency	Percent	Valid Percent	Cumulative Percent
Kenyatta University (KU).	Public	95	15.5	15.5	15.5
KCA University (KCAU).	Private	62	10.1	10.1	25.7
Kenya Methodist University(KEMU)	Private	23	3.8	3.8	29.4
United States International University (USIU).	Private	132	21.6	21.6	51.0
African Nazarene University	Private	53	8.7	8.7	59.6
University of Nairobi (UoN)	Public	116	19.0	19.0	78.6
Multi Media University (MMU)	Public	33	5.4	5.4	84.0
Mt Kenya University (MKU)	Private	71	11.6	11.6	95.6
Daystar University	Private	27	4.4	4.4	100.0
Total		612	100.0	100.0	

As indicated in Table 3.4, the study results show that out of 612 respondents, approximately 40% (n=244) were registered in public universities of which majority were registered in University of Nairobi (n=116). In addition, about 60% (n=368) were registered in private universities of which most of them had registered in USIU (n=132).

In both public and private universities, respondents were categorized into computing and non-computing students based on types of degree programmes they were registered for. This is shown in Figure 3.6.

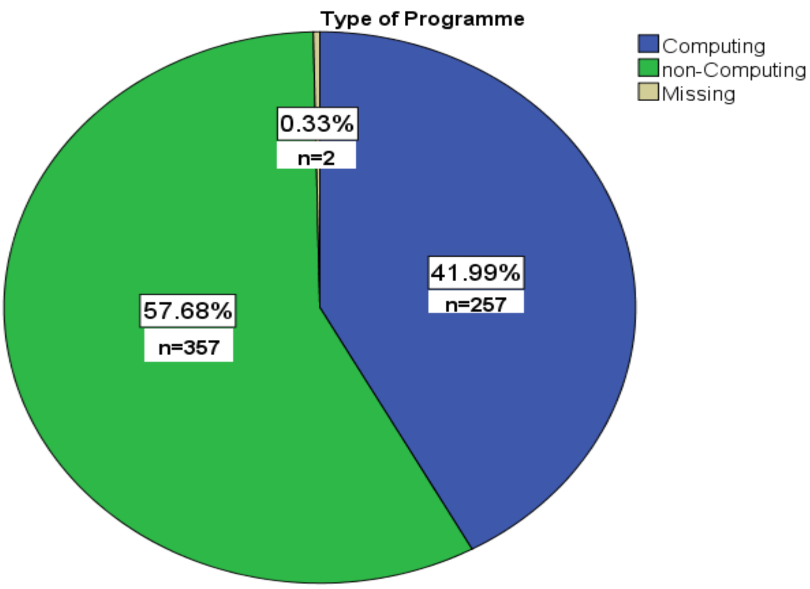

Figure 3.6: Percentage of Respondents According to Types of Degree Programmes

As described in Figure 3.6, it was observed that out of 612 respondents, about 42% (n=257) had enrolled for computing degree programmes e.g. Bachelor of Science in Computer Science (Bsc CS) and Bachelor of Science in Information Technology (Bsc IT). In addition, about 58% (n=357) of respondents had enrolled for non-computing degree programmes e.g. Bachelor of Arts, Bachelor of Commerce (Bcom) and Bachelor of Theology. Among the computing degree programmes, majority of the respondents had enrolled for Bachelor of Science in Information Technology (BScIT) (51.1%, n=129) followed by those who had enrolled for Bachelor Business and Information Technology (BBIT) (29%, n=73).

(ii) Learners with Mobile Devices

An M-Learning environment can also be described by existence of learners with mobile devices such as mobile phones (Muyinda et al., 2010). Results showed that approximately, 94% (n=546) of respondents owned mobile phones. Among these, 78.7% (n=317) owned Smartphones, 90.3% (n=353) owned ordinary phones (Dumb phones), and 72.2% (n=364) owned computers. This is illustrated in Table 3.5

Table 3.5: Percentages of Device Ownership

Groups	**Mobile phone**	**Ordinary phones**	**Smart phones**	**Computers**
Overall, n=612	94%,n=546	90.3%, n=353	78.7 % n=317	72.2%,n=410
Public universities	98% n=227	95%, n=159	47% n=110	66%,n=145
Private universities	91% n=319	87% n=194	58%,n=208	76%,n=265
KCAU	86.2%,n=50	84% n= 32	71%,n=29	68%,n=40

Results showed that approximately, 94% (n=546) of respondents owned mobile phones. Among these, 78.7% (n=317) owned Smartphones, 90.3% (n=353) owned ordinary phones (Dumb phones), and 72.2% (n=364) owned computers.

Among private universities, it was observed that United States International University (USIU) had the highest prevalence of both mobile phones ownership (95%, n=123) and smartphones ownership (89%, n=94) among private universities. With regard to computers, both USIU and Kenya Methodist University had the highest prevalence of computer ownership (83%). KCA University had the lowest prevalence of both mobile phone ownership (86%, n=50) and ordinary phones ownership (84%, n=32). Table 3.6 summarizes these results.

Table 3.6: Device Ownership in Private Universities

		Mobile phone	Smart phone	Ordinary phone	Computer
KCAU	Count	50	29	32	42
	% within Name of University	86.2%	70.7%	84.2%	67.7%
KEMU	Count	17	6	14	19
	% within Name of University	89.5%	66.7%	93.3%	82.6%
USIU	Count	123	94	59	109
	% within Name of University	95.3%	88.7%	85.5%	82.6%
ANU	Count	45	28	33	43
	% within Name of University	91.8%	82.4%	89.2%	81.1%
MKU	Count	60	32	42	42
	% within Name of University	88.2%	72.7%	89.4%	59.2%

Among public universities, results showed that Multi Media University (MMU) had the highest percentage of smartphones ownership (81%, n=21), ordinary phones ownership (96%, n=24) and computer ownership (91%, n=30). In addition, it was found that about 100% of respondents in Kenyatta University owned a mobile phone. Although University of Nairobi had a high percentage of mobile phone ownership (96%, n=107), the percentage of computer ownership was found to be relatively low (40%, n=46). Table 3.7 provides a summary of these results.

Table 3.7: Device ownership in Public Universities

		Mobile Phone	Smart phone	Ordinary phone	Computer
KU	Count	88	40	63	66
	% within Name of University	100.0%	80.0%	95.5%	69.5%
UON	Count	107	48	72	46
	% within Name of University	96.4%	70.6%	93.5%	40.0%
MMU	Count	32	21	24	30
	% within Name of University	97.0%	80.8%	96.0%	90.9%

These results were found to be comparable with results obtained by Muyinda et al.(2008), which indicated that 96% of research students at the Department of Distance Education in

Makerere University owned mobile phones. Majority of these had low-end phones (ordinary phones with limited or no access to internet).

Test of dependence was carried out to establish whether there was any relationship between ownership of mobile phones and types of mobile phones. Results indicated that there was a significant relationship between the two variables (Pearson chi-Square value =581.000, df=3, $p<0.05$).

(b) M-Learning propellers

M-Learning propellers are described as factors that motivate the growth or development of M-Learning (Muyinda et al., 2010). Results showed that prevalence of various types of mobile devices and availability of wireless network in the university are examples of M-Learning propellers.

(i) Types of Mobile Phones

It was observed that respondents owned different types of mobile phones across private and public universities. Out of 546 respondents who mentioned they owned a mobile phone, about 23% (n=123) of them owned more than one mobile phone. This is illustrated in Table 3.8.

Table 3.8 Types of Phones Across Types of Universities.

Mobile Type		**Category of University**		**Total**
		Public University	**Private University**	
Smartphones	Count	71	130	201
	% Within Mobile Type	35.3%	64.7%	100.0%
	% Within Category of University	30.2%	36.7%	34.1%
Ordinary Phones	Count	119	105	224
	% Within Mobile Type	53.1%	46.9%	100.0%
	% Within Category of University	50.6%	29.7%	38.0%
Both smart and ordinary phones	Count	39	84	123
	% Within Mobile Type	31.7%	68.3%	100.0%
	% Within Category of University	16.6%	23.7%	20.9%

As indicated in Table 3.8, it was found that within categories of universities, there was a higher percentage of students with smartphones only in private universities (37%, n=130) compared to public universities (30%, n=71). On the other hand, the percentage of students with ordinary phones only was found to be higher in public universities (51%, n=119) than in private universities (30%, n=105). Additionally, the percentage of students with both devices was slightly higher within private universities (24%, n=84) compared to public universities (17%, n=39).

A Pearson chi-square test revealed that there was a significant relationship between types of mobile phones owned by respondents across types of universities and the category of university (Pearson chi-Square value =32.451, df=3, p<0.001).

(ii) Wireless Network

Results showed that the availability of wireless network for internet connection was higher in private universities than in public universities. This is shown in Table 3.9.

Table 3.9: Availability of Wireless Network across University Categories

			Category of University		**Total**
			Public University	**Private University**	
Wireless network available	No	Count	54	33	87
		% Within Wireless network available	62.1%	37.9%	100.0%
		% Within Category of University	22.6%	9.1%	14.5%
	Yes	Count	185	328	513
		% Within Wireless network available	36.1%	63.9%	100.0%
		% Within Category of University	77.4%	90.9%	85.5%
Total		Count	239	361	600
		% Within Wireless network available	39.8%	60.2%	100.0%
		% Within Category of University	100.0%	100.0%	100.0%
		% of Total	39.8%	60.2%	100.0%

Table 3.9 shows that most respondents said that wireless network was available in their university (85.5%, n=600) compared to those who disagreed (14.5%, n=87). The availability was found to be slightly higher in private universities (91%, n=328) than in public universities (77.4%, n=185). The Chi-Square test conducted on the data showed that there was significant relationship between availability of the wireless network and the university category (Pearson chi-Square value = 20.992, df=1, p<0.05).

(c) M-Learning services

M-Learning services can be described as learning activities that are enabled by mobile devices. M-Learning services observed during the study are: information services, access to E-learning content and collaborative services.

(i) Access to E-learning content

It was found that most of the university students were not using their mobile phones to access E-learning content. This is shown in Table 3.10.

Table 3.10 Use of Mobile Phone for accessing E- learning content

		Mobile Type				**Total**
		Smart phones	**Ordinary Phones**	**Both smart and ordinary phones**	**None**	
No	Count	87	154	59	24	324
	% within use Mobile Phone	26.9	47.5	18.2	7.4	100
	% within Mobile Type	44.2	70.3	48.8	63.2	56.3
	% of Total	15.1	26.8	10.3	4.2	56.3
Yes	Count	110	65	62	14	251
	% within use Mobile Phone	43.8	25.9	24.7	5.6	100
	% within Mobile Type	55.8	29.7	51.2	36.8	43.7
	% of Total	19.1	11.3	10.8	2.4	43.7
Total	Count	197	219	121	38	575
	% within use Phone	34.7	38.1	21	6.6	100
	% within Mobile Type	100	100	100	100	100
	% of Total	34.3	38.1	21	6.6	100

As illustrated in Table 3.10, more than half of the respondents were found not to be using their phones for accessing E-learning (56.3%, n=324) in comparison to those who were doing so (43.7%, n=251). Among those with smartphones only (n=197), majority were using their smartphones to access E-learning content (55.8%, n=110). On the other hand, among those with ordinary mobile phones only (n=219), majority were not using their phones to access E-learning content (70.3%, n=154). These differences of access to E-learning content can be attributed to differences in capability to access internet between ordinary mobile phones and smartphones.

The test of independence showed that there was a significant relationship between types of mobile phones and the level of access to E-learning content (Pearson Chi square value = 32.821, df =3 p<0.001).

ii) Cloud-based Collaborative services

Observations revealed that there was high prevalence of access to cloud-based collaboration services through mobile phones. This shown Table 3.11.

Table 3.11 Percentage of Respondents Accessing Cloud-based services.

		Frequency	Percent	Valid Percent	Cumulative Percent
	Access Facebook	101	16.5	16.6	16.6
	Access Twitter	14	2.3	2.3	18.9
	Access Both Facebook and Twitter	343	56.0	56.2	75.1
	No	152	24.8	24.9	100.0
	Total	610	99.7	100.0	
Missing	System	2	0.3		
Total		612	100.0		

As illustrated in Table 3.11, out of the total number of respondents (n=612), approximately 75% (n=458) used mobile phones for access cloud-based collaboration services, namely Facebook and Twitter. Among these, majority were accessing Facebook (74%, n=450) compared to those who were accessing twitter (58%, n=352). Facebook was therefore found to be more popular than Twitter among the respondents. Additionally, more than half (56%, n=343) of all respondent were accessing both collaboration services (Facebook and Twitter) compared to those who were accessing Facebook only 16.5% (n=101) and those who were accessing Twitter only (2.3%, n=14) respectively.

Results showed that among those with smartphones only, majority (68.2%, n=137) were using their phones to access both Facebook and Twitter compared to those accessing Facebook only 12.4% (n=25) and Twitter only 2% (n=4). Although at a lower percentage level, similar pattern was also observed among respondents with ordinary phones. That is, access to both Facebook and Twitter was higher (41.1%, n=92) compared access to Facebook only (20%, n=44) and Twitter only (3.1%, n=7). A Pearson chi-square test indicated that there was a relationship between access to cloud-based collaboration services and types of mobile phones owned by the respondent (Chi square value = 30.850, df =3, $p < 0.001$).

iii) Information Services

Results showed that use of mobile phones for receiving administration updates was not very common among university students as shown in Table 3.12.

Table 3.12: Using phones to Access Information/Admin services.

	Frequency	**Percent**
No	418	69.4
Yes	184	30.6
Total	602	100

As indicated in Table 3.12, a relatively low percentage of respondents (30%, n=184), agreed that they were using phones to get administration updates such as reminders, notifications or consultation dates, compared those who disagreed (70%, n=418). These results were found to be comparable to observations made by Muyinda et al. (2010), which revealed that approximately 25% (n=107) of respondents used their mobile phones to receive administration messages from the University. Pearson Chi-Square test results indicated there was a significant relationship between information services and types of mobiles used to access such services (Chi square value = 25.161, df =3, $p < 0.01$).

(d) M-Learning Inhibitors

It was observed that there is a group of digitally marginalized students (36%, n=219), who were not using mobile phones to access E-learning content due to various reasons. The most common reasons were lack of access to internet- enabled mobile phones (10%, n=66) and lack of access to mobile phones that could access available formats of content (7.4%, n=45) such as power point and portable document formats (PDFs). Other limitations of mobile phones that were mentioned include: (i) Small screen (4.4%, n=27), which made accessed content to look small , (ii) Limited storage (1.6%, n=10) prevented mobile phones from holding large/heavy documents such as PDF and Power point documents, (iii) High cost (3.4%, n=21) made it expensive to buy data bundles for enabling internet access, (iv) poor network connectivity (4.7%, n=29) that was resulting to slow or no internet access, and (v) preference for using computers (10%, n=21) that made non- mobile learning students to prefer using a computer since they found it easier and comfortable to use it unlike a mobile phone. This is shown in Table 3.13.

Table 3.13 Reasons for not accessing E-learning content using phones.

M-Learning Inhibitors		**Frequency**	**Percent**
Mobile phone limitations	Small Screen	27	4.4
	Limited Storage	10	1.6
	Cost limitation	21	3.4
	Not internet Enabled	66	10.8
	Format limitation	45	7.4
Other limitations	Network Connection	29	4.7
	PC Preference	21	3.4
	Total	219	35.8
	Missing System	393	64.2
	Total	612	100

Standardized coefficients showed that there was a relationship between mobile types and reasons for not using mobile phones to access E-learning (Phi and Cramer's V value=0.347, $p<0.001$). Lack of access to internet enabled phones and limitations of accessing multimodal formats were attributed to students with ordinary phones, mainly because of their technical limitations.

It was also observed that majority of those who owned smartphones mentioned small screen (19%, n=16) and poor network connection as reasons for not using their handsets to access E-learning content. This was followed by preference for using computers (18%, n=15), content format limitation (16.7%, n=14), cost limitation (15.5%, n=13) and finally limited storage (2.4%, n=2). Table 3.14 provides a summary of these results.

Table 3.14: Reasons for not using Smartphones to Access E-learning Content

	Small Screen	Limited Storage	Cost Limitation	Network Connection	PC Preference	Not_internet Enabled	Format limitation	Total
Count	16	2	13	16	15	8	14	84
% Within Smart phone	19.0%	2.4%	15.5%	19.0%	17.9%	9.5%	16.7%	100.0%

3.3.7 Conclusion from Identifying Problems and Motivation Phase

Phase one of this study concluded that characteristics of M-Learning context for higher learning institutions can be described using four main features, which were found to be significantly related. These are M-Learning Environment, M-Learning propellers, M-Learning services and M-Learning inhibitors. Figure 3.7 illustrates how the four features are related.

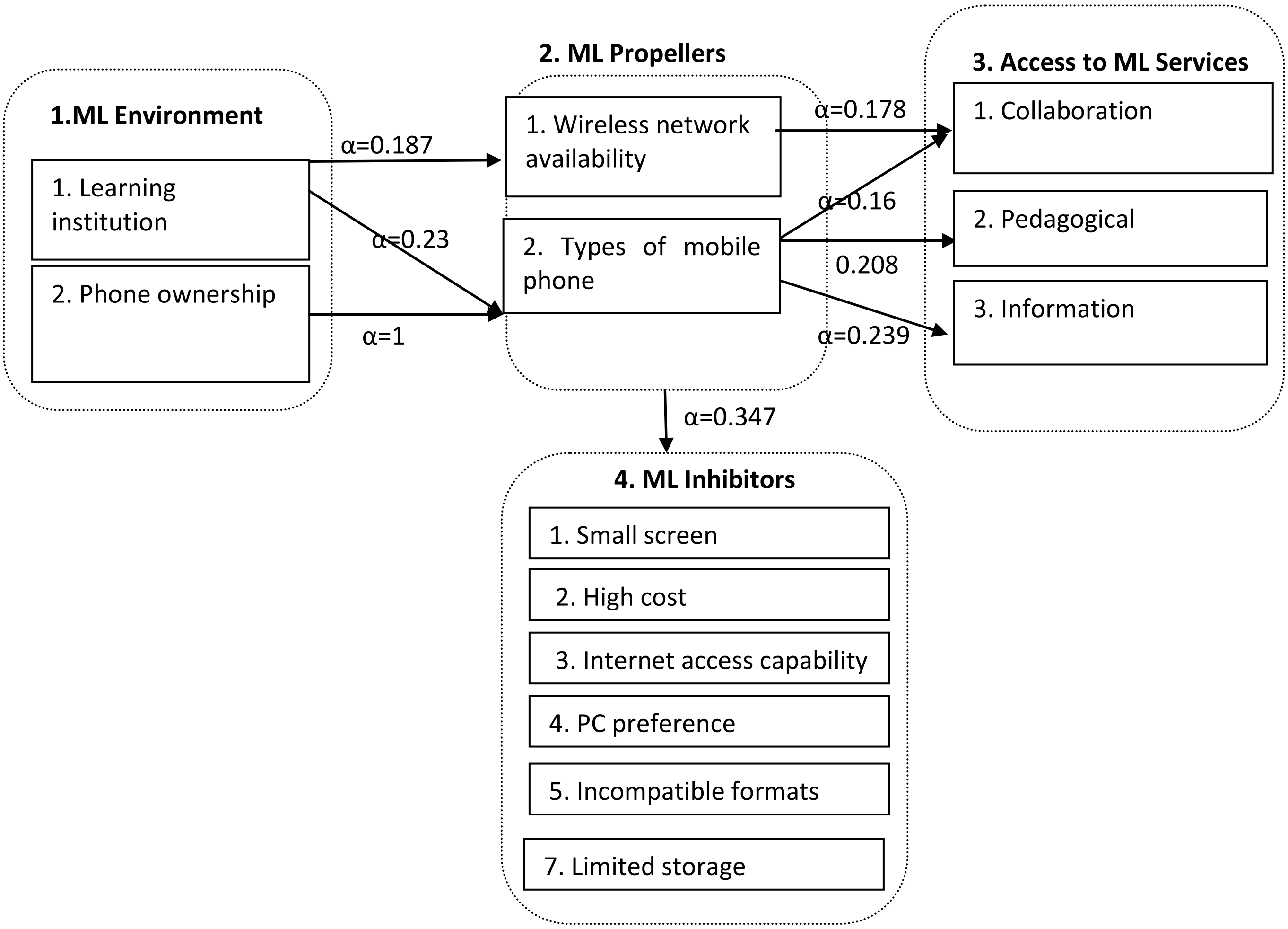

Figure 3.7: Associations between Features of M-Learning Context.
(Significant at the 0.05 level)

As described in Figure 3.7, the four features can be explained as follows:

(i) M-Learning environment contains information about settings where learning activities can take place. It contains two main sub-dimensions. These are: (a) higher learning institution such as private and public universities where learners are registered, and (b) learners with mobile phones that allow access to M-Learning services. For example, under graduate students enrolled for computing or non-computing degree programmes.

(ii) M-Learning Propellers include factors that encourage the growth of M-Learning. They can be categorized into two main sub-variables. First, availability of wireless network that connect mobile devices to M-Learning services. Examples are wireless fidelity (WIFI) and internet. Second, capability of mobile devices to access M-Learning services that are delivered over the internet. For example, high-end mobile phones such as smart phones and low-end mobile phones such as ordinary phones.

(iii) There are three M-Learning services that describe functions provided by M-Learning technologies. First, collaboration services such as messaging/chatting facilities offered by social media tools e.g. Facebook and Twitter using mobile phones. Second, pedagogical services that involves use of mobile devices to accessing digital study materials such as study documents and assessments. Third, information services, which refers to use of mobile devices to provide administrative information such as reminders and notifications of important learning events.

(iv) M-Learning Inhibitors, which refers to challenges that hinder development of M-Learning. Examples are small screen of mobile devices, high cost of accessing M-Learning services, poor access to internet-enabled mobile devices, limited or poor network connectivity, preference for personal computers, incompatibility of content format and limited memory of mobile devices.

As described in Figure 3.7, M-Learning environment influences the types of M-Learning propellers to be used, which in turn determines both inhibitors of M-Learning and M-Learning services. We therefore rejected the null hypothesis one (H01) that features of M-Learning context are not associated and failed to reject alternate hypothesis one (H11) that the two variables are related.

3.4 Defining Objectives Phase

The purpose of conducting cased based research was to study current mobile learning approaches that can be distinguished by their objectives. They include: single mode M-Learning, mixed mode M-Learning, context aware single mode M-Learning and ambient learning among other approaches. This was to facilitate definition of objectives of developing an ambient learning approach with a view to supporting flexible availability in the research project supervision process (Mwendia and Buchem, 2014).

The focus of case-based research was to explore an illustrative list of university-based M-Learning projects in African universities that could help to achieve the objective of our study. That is*, to study objectives of M-Learning projects that have adopted current forms of M-Learning with a view to enhancing flexible availability towards ambient learning.*

Case based research process comprised four sub-processes, namely, retrieving, Reusing, revising and retaining M-Learning cases (Fritz, 2008). This is shown in Figure 3.8

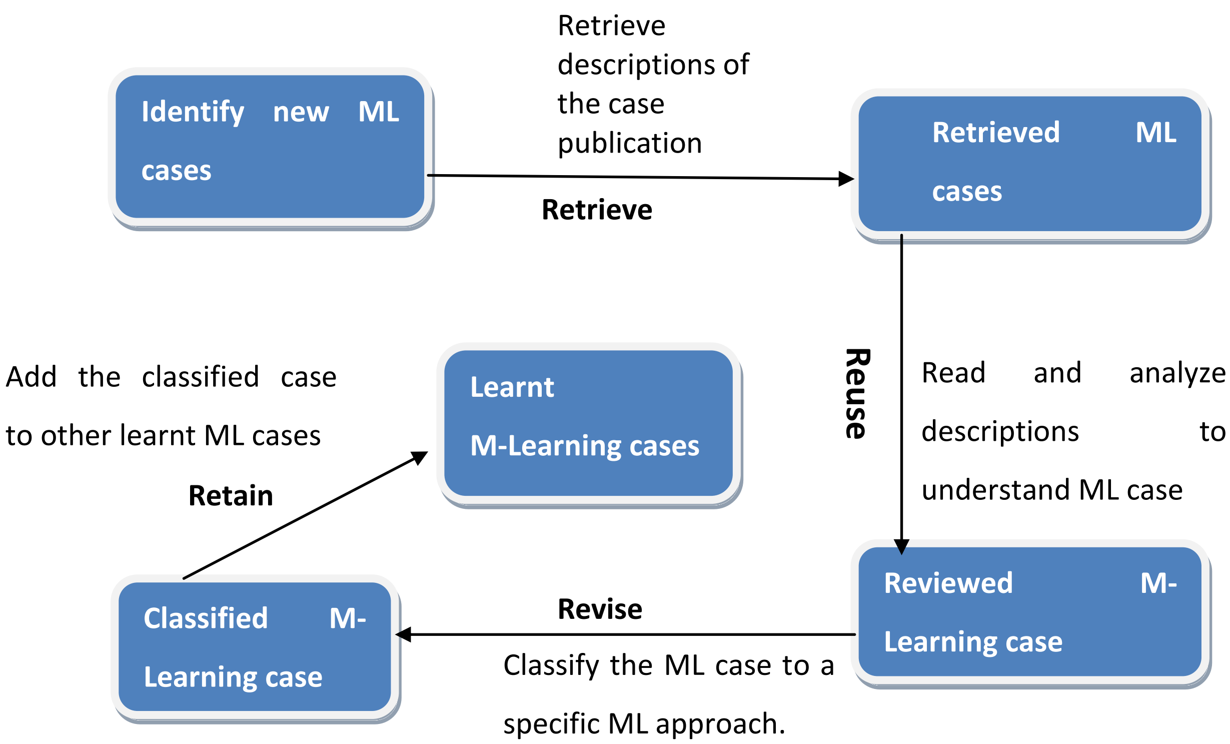

Figure 3.8: Case based Research Method

During case based research, M-Learning projects were used to represent previous cases and each case was identified by use of publications e.g. journal papers, conference papers, reports, among others. The study was limited to M-Learning cases initiated by African universities for supporting university level learning.

Using CBR cycle, one or more previous publications with information about a certain mobile learning case was *retrieved* from the source (internet) and the contained information was *reused* by the researcher (user) through reading to *learn* the type of M-Learning approach adopted by the M-Learning case in focus and the associated M-Learning context. Results obtained were then *retained* by use of both *textual* CBR and *structural* CBR approaches (Fritz, 2008).

3.4.1 Results from Defining Objectives Phase

The purpose of this section was to provide results for objective two and provide answers of to the following two research questions:

(i) Research Question Three: Are there cases of current M-Learning forms that focus on university level learning in African universities?

(ii) Research Question four: If cases exist, which M-Learning context features and objectives related to those cases?

Since this phase involved reviewing existing publications using case based research method, its findings were transferred to *2.3.3 Currents Forms of M-Learning Approaches* subsection in literature review chapter. In our study, cases were represented by various M-Learning projects initiated in African universities.

3.4.2 Communication of Results from Defining Objectives Phase

Communication of results obtained from this activity was made through two book chapters that were published by IGI global publishers. These are:

(i) A book chapter entitled '*Culture Aware M-Learning Classification Framework for African Countries" ,* which is published in a book entitled "Cross-Cultural Online Learning in Higher Education and Corporate Training". The chapter describes various M-Learning that have been launched in African countries and their associated cultural dimensions. Examples include Dunia moja and Agakhan M-Learning projects (Mwendia et al.,2014).

(ii) A book chapter entitled "*Ambient Learning Conceptual Framework for Bridging Digital Divide in Higher Education"*, which is published in a book entitled *"Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies*". The chapter describes ambient intelligence technologies that are used by ambient learning projects in African universities. For example, Digital Lecture Hall (DLH) Project (Mwendia et al., 2015).

3.4.3 Conclusions from Defining Objectives Phase

Based on results obtained from defining objectives phase, the following conclusions were made.

(i) Single mode learning is the most popular M-Learning approach in African universities. This is indicated by (50%, n=7) compared mixed representation learning (36%, n=5), context aware single mode by 7% (n=1) and ambient learning by 14% (n=2). This can be attributed to the fact that majority of the students owned low-end phones that could only support basic functions such as send SMS text messages and voice calls (Muyinda, et al., 2008). Consequently, such projects offered limited M-Learning services that can also include collaboration and information services.

(ii) Problems associated with single mode of representation include (a) low quality content that is exhibited by lack of multimodal representations such as text with video or text with audio presentations, (b) irrelevant content that is indicated by use of ‘one-fits-all' strategy, which entails broadcasting the same content to all learners irrespective of their different learning needs.

(iii) Propellers of SMR M-Learning include (a) high prevalence of ordinary mobile phones that have limited multimedia options and low or no capability for accessing internet, and (b) poor access to fixed ICT infrastructure in remote areas. For example, lack of wired computer networks and electricity.

(iv) The existence of high-end mobile devices like smartphones drives the growth of mixed mode of representation M-Learning projects in African universities.

(v) Collaboration between universities is one of the main propellers for ambient learning in African universities. For instance, the two reviewed ambient learning project were initiated by a collaboration of African universities and Germany universities. This is also means that there is limited capacity for ambient learning support in African universities. Therefore, there is need for African universities to initiate degree programmes that equip students with ambient intelligence computing knowledge to spur the growth of such projects.

(vi) There are no cases of ambient learning projects African universities that aim at supporting flexible availability of research supervision services through the use of M-AMI.

(vii) The existing cases of ambient learning in African countries are enabled by both ambient intelligence technologies and mobile technologies. However, there are several challenges associated with these cases. These challenges are: (a) fixed ambient intelligence technologies require high cost investment that may not be afforded by many institutions or individual students, and (b) Open Educational Resources (OER) have not yet been implemented. This means that ambient intelligence technologies are limited to supporting access to local learning resources only.

(viii) This means mobile learning is now being integrated to mainstream education as a compliment for traditional distance learning education. For instance, majority of M-Learning projects in African universities are supporting main stream courses.

(ix) The objectives of M-Learning projects in African countries can be summarised using Table 3.15.

Table 3.15: Objectives of M-Learning Projects in African universities

M-Learning category	**Main objectives**
SMR M-Learning	Use mobile technologies to support single mode representation of content for collaboration and information services at anywhere and anytime.
MMR M-Learning	Use mobile technologies for enabling access to collaboration services and delivery of locally stored multi-modal content at anywhere and anytime.
CSMR M-Learning	Utilizing mobile technologies for allowing access to unimodal collaboration services by considering M-Learner's context.
Ambient learning	Enabling access to collaboration services and delivery of locally stored, high quality and personalized content at anywhere, anytime and anyhow through fixed AMI and Mobile technologies.

3.5 Designing and Developing Ambient Learning Approach Phase

In order to design and develop the proposed ambient learning model, we adopted Creative process that was derived from Zeng et al. (2011) model. Enhancement was done to the model by incorporating communication component that described how results would be delivered to relevant audiences. This is shown in Figure 3.9.

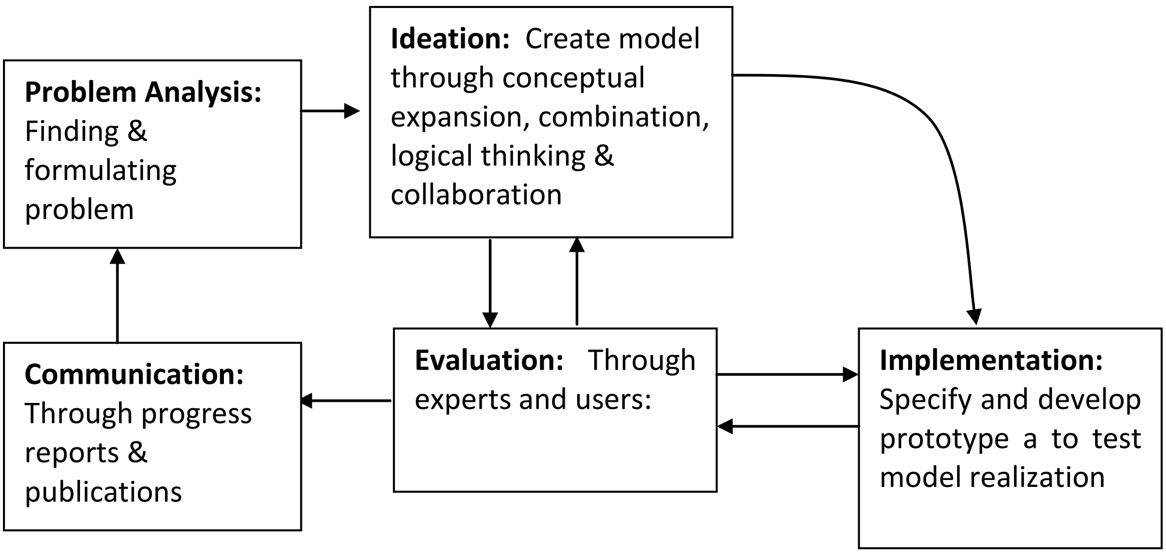

Figure 3.9: Creative Process for Designing and Developing Ambient Learning Approach

As illustrated in Figure 3.9, the process of designing and developing an ambient learning model comprised five main tasks, namely, problem analysis, ideation, implementation, evaluation and communication.

3.5.1 Problem Analysis Stage

Problem analysis stage involved looking for information that could facilitate understanding of the immediate problem to be addressed in order to accomplish the specified objectives (Zeng et al., 2011). This analysis comprised two activities, namely, problem finding and problem formulation.

(a) Problem Finding

Problem finding refers to the activity of deliberately discovering new opportunities and challenges that can lead to implementation of competitive service innovations (Zeng, Proctor, & Gavriel, 2009). In our study, several challenges and opportunities were identified from results obtained during previous research phases and literature review. They include the following:

(i) Back of access to personal computers for research support: Results from phase 1 and 2 research activities showed that although almost all university students own a mobile phone, some of them have poor access to personal computers. This calls for a technical solution for research support under the existing technical constraints (Muyinda, et al., 2008; Mwendia et al., 2014).

(ii) Content irrelevancy: The main challenge in the information-rich environment is not to deliver information at anytime and anywhere but to provide the right content (relevant) at the right time (when) in the right way (how) to the right person (e.g. learner) (El-Bishouty, Ogata, Rahman, and Yano, 2010).

(iii) Ambient learning limitations: Ambient Learning has not yet reached a state of common understanding and not widely implemented (Winkler et al., 2011).

(iv) Dependence on physical environment information by existing ambient learning approaches: According to Kofod-Petersen et al. (2008), ambient learning approaches use location dependent artefacts and/or mobile devices for delivering learning content according to individual learner's immediate physical environment (physical context) and available digital information (digital context). However, this view is associated with two limitations. First, some of the physical environments have low prevalence of location dependent technologies (such as 2D tags, embedded sensors, and computers) that can be used for capturing information about physical environment. For instance, in least connected countries (LCCs), less than 5% of households own a personal computer (computer-poor). Majority of these countries are situated in Africa (70%, n=29) (ITU, 2014). Second, not all immediate physical environments are relevant to current learning tasks. For example, learners may be accessing research materials from the internet using a mobile a device (such as smart phone), while waiting for public transport at a bus stop. In such a location, the immediate physical objects such as vehicles, newspapers on sale and other travelers may not be related to journal or conference papers required by the learner. This means that information about the immediate physical environment of the learner may not help in retrieving relevant study materials for research support at any location (anywhere). Therefore, there is need for ambient system models that utilize available devices including mobile devices to facilitate delivery of relevant study materials that may not be related to the immediate physical environment of the learner.

(v) Limitations of mobile phones: The development of learning approaches that use mobile devices for learning support is inhibited by limitations of mobile phones (Mwendia et al., 2014; UNESCO, 2014). These include limited storage capacity (Baek and Kim, 2007) that restricts storage scalability, small screens that makes it difficult to navigate and read between multiple pages of study materials (Lonsadel, Baber, Sharples, and Arvanitis, 2003) and cost of communication using mobile devices (e.g. airtime credit), which sometimes disrupts collaboration among research students (Muyinda, et al., 2008).

(b) Problem Formulation

Problem formulation refers to the activity of framing a vague problem in multiple meaningful and concrete ways that can suggest possible solutions (Zeng et al., 2009; Zeng et al., 2011). Requirement specifications is an example of a method used by researchers to formulate problems (Ken Peffers et al., 2008).

Based on these arguments, requirement specification tools were used for translating the identified challenges into meaningful user requirements. This translation helped to describe what the system was to attain and what restrictions are (Hertzum, 2003). The translation process involved four main steps of developing and scenarios. They are: (i) identification of main activities, (ii) description of user interface objects, (iii) identifying user roles, and (iv) developing of design scenarios (Oboko, Wagacha, Omwenga, and Libotton, 2012).

(i) Identification of Main Tasks

This activity involved identifying learning tasks to be enabled by the system so as to achieve the requirements of the system. Although these tasks may not be exhaustive, the represented the commonly known research supervision tasks. This is shown in Table 3.16.

Table 3.16: Identification of Main Tasks

Main task	**Sub-tasks**
Researching	Register for a research project
	Collaborate with peers and supervisor
	Access study materials for guiding research
	Access research assignment/task
	Submit progress report
	Access feedback
Supervising	Update repository study materials
	Provide research tasks/Assignments
	Collaborate with learners/research students
	Access submitted research progress report
	Provide Feedback

(ii) Description of User Interface Objects

The activity involved identifying objects for supporting interaction between the actors and the system. This is shown in Table 3.17.

Table 3.17: Descriptions of the Identified Objects

User Interface (UI) objects	**Purpose**
Command buttons	Triggering system actions when pressed by user
Images	Indicating the purpose of a certain object, e.g. command button
Text fields	Capturing user input. e.g. username and password.
Labels	Providing captions for UI objects
Text areas	Displaying retrieved learning content

(iii) Identifying User Roles

Delivering requirement specifications without an understandable reference to the kind of user that issued the requirement may result to problems in grouping and particularly prioritizing them. The identification of user roles is performed during the requirements analysis stage to allow identification of use cases, grouping of end users and unambiguously linking them to the requirement specifications (Oboko et al., 2012 ; Katifori and Schlatte, 2014). Based on this argument, two user roles were identified. These are: research student/learner and supervisor. This is shown in Table 3.18.

Table 3.18: Identification of User Roles

User Role	Sub-role	Criteria
Research Student/Learner	Research Beginner	Has not consulted supervisor previously
	Learner in progress	Has consulted previously and has successfully completed at least one research task/assignment
	Learner in final stage	Currently undertaking final research assignment/task.
Supervisor	Content administrator	Primary roles for supervisor
	Learner Administrator	Primary Roles for supervisor
	Collaborator	Primary roles for supervisor

(iv) Development of Design Scenario

It is viewed as an extended narrative forming a plausible storyline or vignette. Scenarios tend to be concrete, rich and specific, often full of gratuitous detail for realistic appearance (Constantine and LockWood, 2001). Examples of techniques for representing scenarios include: text, video, storyboards and other media that provide open ended descriptions of the tasks a user might perform while pursuing a specific concern, combined with details about the context in which the user is acting (Hertzum, 2003).

During problem analysis stage of this study, a scenario was created based on the components identified in earlier stages of the user requirement activity. These are user tasks, user interface objects, and user roles components. An example scenario was created through consultation with an expert from Beuth University of Applied Sciences, Berlin and was represented using story board technique as shown in the following Scenario example:

Tom is a university student that is currently undertaking research for the completion of bachelor degree. As a user of the proposed ambient learning system, Tom interacts with the system as follows:

Step1: When Tom logins to OMAL application (Figure 3.13a), it checks context database and recognizes that Tom is a beginner. Using accelerometer, it also recognizes that he is not moving as shown in Figure 3.13b.

Figure 3.10a: Login   Figure 3.10b: Bus Stop   Figure 3.10c UI Icons   Figure 3.13d Moving Bus

Figure 3.10: Scenario representation using Storyboard

Source: (Mwendia and Buchem, 2014).

Step2: The OMAL application then searches for relevant beginners' topics from the cloud-based repositories such as Google drive and Dropbox. A Screen with user interface icons appears so that Tom can choose his preferred format using tap gesture as shown in Figure 3.13c. However, Tom fails to choose within 30 seconds. Consequently, OMAL use previous context data obtained from other stationary users and recognizes that text format has majority downloads. It therefore downloads the most downloaded document and displays it on the screen for Tom to read.

Step3: Bus arrives and OMAL uses rotation vector sensor to detect rotation motion when Tom is putting the phone in his pocket. OMAL also uses accelerometer to recognize that Tom is moving at slow speed say when Tom is walking. A screen appears with user interface icon so that Tom can choose his preferred format using tap gesture (Figure 3.13c). However, Tom fails to choose within 30 seconds. OMAL therefore downloads the most downloaded MP3 file among walking beginners. Tom starts listening to the downloaded MP3 file while walking to the bus.

Step4: While in a moving bus (Figure 3.13d), OMAL also detects another rotation motion using vector sensor, when Tom is removing the phone from his pocket. Since the bus is moving, OMAL detects an accelerated change of locations using accelerometer. OMAL therefore recognizes that Tom is now a passenger holding his phone. Screen appears with user interface icons so that Tom can choose his preferred format using tap gesture. However, Tom fails to choose within 30 seconds. Using previous context data, OMAL therefore downloads most popular MP4 file among passengers at *beginners' stage. Meanwhile, OMAL looses internet connection as the bus moves to a remote area but the downloaded video continues to play.*

Step5: After 30 minutes of watching the video, internet connection is established again and OMAL application checks the duration video was played. By looking at the history of previous users from the context database, it anticipates that Tom is likely to stop the video since majority of previous users stopped the video after watching for 30 minutes. OMAL therefore stops the video. A screen appears with user interface icons so that Tom can choose his preferred content and format using tap gesture (Figure 3.13c). However, Tom fails to choose within 30 seconds.

Step6: OMAL therefore searches for a list of research groups at beginners' stage from cloud-based communication tools like Facebook and sends a request to join one group for discussion. Upon acceptance, Tom starts a discussion with current online members until he alight the bus.

3.5.2 Ideation Stage

Ideation task entailed creation of alternative ideas that could address the already identified problems. This activity comprises several cognitive sub-processes, namely, concept combination, concept expansion and analogical thinking (Zeng et al., 2009, 2011).

(a) Conceptual Expansion

According to Zeng et al. (2009), conceptual expansion involves generating novel examples of a certain conceptual category by extending the boundaries of the existing concept by combining with new concepts. This strategy helps to advance existing concepts as well as generating of new concepts from existing categories (Zeng et al., 2011). In our study, two classification frameworks were formulated based on observations from previous research activities. They are: (1) technological framework for classifying AMI technologies and (2) pedagogical framework for classifying ambient learning approach.

1. Technological Classification Framework of AMI Technologies

Technological classification framework describes two categories of AMI technologies based on mobility aspect. This is shown in Figure 3.11.

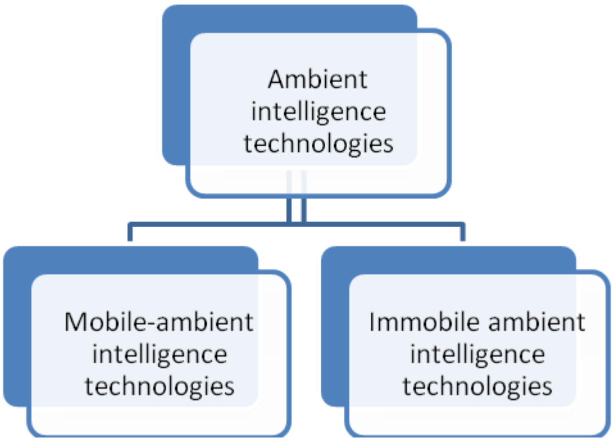

Figure 3.11: Technological Classfication Framework of AMI technologies.
(Mwendia et al., 2015).

In this study, we adopted, the definition of AMI technologies as technologies that aim at providing users with natural ways of interacting with the machines (natural interfaces) in ambient learning environments (Maheshwaree, 2008). Drawing from the idea of ambient spaces framework proposed by Winkler et al. (2011), we argue that AMI technologies can be divided into the following categories:

(i) Mobile AMI technologies (MAIT) that present context aware natural interfaces using mobile media like handheld, wearable, implanted devices, among others (Mwendia and Buchem, 2014; Mwendia et al., 2015). Examples of MAIT include, (a) Mobile phone centric (M-AMI technologies that use mobile phones to provide ambient intelligence services, and (b) Radio frequency identification (RFID) technologies that use mobile RFID readers (e.g. wearable and hand held) to interrogate RFID tags attached on physical objects in the neighbourhood. RFID readers extract information from the tags by sending radio waves to RFID tags, which are bounced back by the tags with relevant identification information (Maheshwaree, 2008).

(ii) Immobile AMI technologies (AIT) that are embedded on fixed (location dependent) media and provide context aware natural interfaces (Mwendia et al., 2014). Examples of IAT include, (a) smart interactive blackboard and smart desks, which support natural interaction through gestures and touch mechanisms (Margetis, Leonidis, Margherita, and Stephanidis, 2011), and (b) interactive walls that engage with users through audios, movies and images on a large window. Dementia people, who often experience the challenge of finding the way and being restless, can use such walls. The wall can be used to attract curious learners by presenting context aware interactive content to learners, thus reducing idle wandering which wastes time during learning (Kröse, Veenstra, Robben, and Kanis, 2012).

2. Pedagogical Classification Framework for Ambient Learning

Concept combination strategy was used to create three new categories of ambient learning approach based on characteristics of M-Learning technologies. They included Fixed Interface Ambient Learning (FIAL), Mobile Interface Ambient Learning (MIAL), and Hybrid Interface Ambient Learning (HIAL) (Mwendia et al., 2013). This is shown in Figure 3.12.

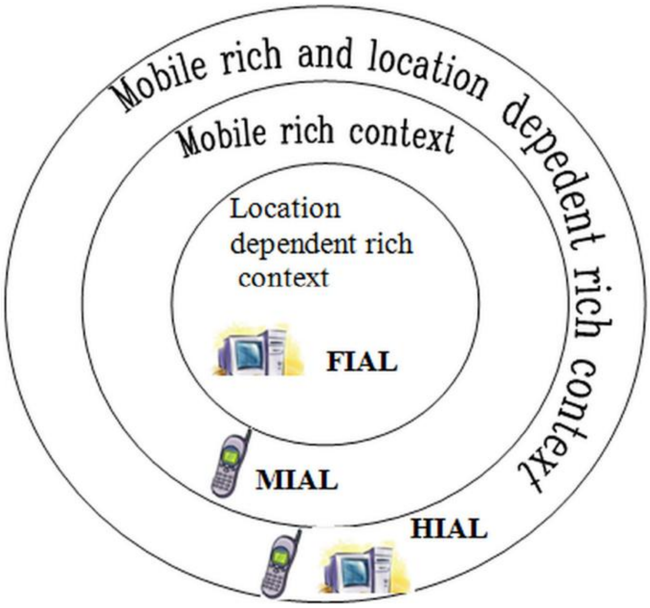

Figure 3.12 Categories of Ambient learning.

Source: (Mwendia et al., 2013).

The three ambient learning approaches were described as follows:

(i) Fixed Interface Ambient Learning (FIAL) enables learning to occur anywhere, any time and any how using location dependent devices (e.g. computers) that are embedded within physical environments surrounding the learner. This approach is suitable for learning contexts with high prevalence of fixed devices but low prevalence of mobile devices. A similar case of FIAL is smart classroom initiated by Laboratory of Pervasive Computing in Tsinghua University, which utilizes several location dependent devices embedded within the walls of a physical room. This includes an array of microphones and video cameras for recognizing human motion, gesture, and utterance (Shi, Qin, and Suo, 2010).

(ii) Mobile Interface Ambient Learning (MIAL) uses mobile devices only to support learning at anytime, anywhere and anyhow. This category is appropriate for mobile learning contexts with high proliferation mobile devices (‘mobile-rich’) but poor prevalence of location dependent devices ('computer - poor'). a similar case is (Min Chen, Chiang, and Yu, 2014) project, which uses smartphones to capture GPS location of a tree or a flower and the objectives of the learner supporting access to web pages with relevant information about trees or flowers that are in the immediate physical environment of the learner.

(iii) Hybrid Interface Ambient Learning (HIAL)- uses both location dependent devices(e.g. sensors embedded on the walls of classroom) and mobile devices (e.g. mobile phones) to enable context-aware situated learning, any time and any how using available location dependent (fixed) devices and mobile devices. HIAL can be applied in learning environments with adequate infrastructure such as developed countries, where there is prevalence of both location dependent devices and mobile devices. For example, ambient Learning project supported by a consortium comprised of 8 partners from Italy, Germany, UK/Ireland and Greece, utilizes a combination of location dependent and mobile devices for enabling access (Kolmel, 2006).

(b) Concepts Combination

Concepts Combination entailed integrating aspects ideas retrieved from pertinent information. The sources of this information included reviewed literature, phase 1 and 2 results as well as problem analysis results. In our study, combination of concepts strategy was used to create a new ambient learning approach named ‘Open Mobile Ambient Learning’ (OMAL) approach. This is shown in Figure 3.13.

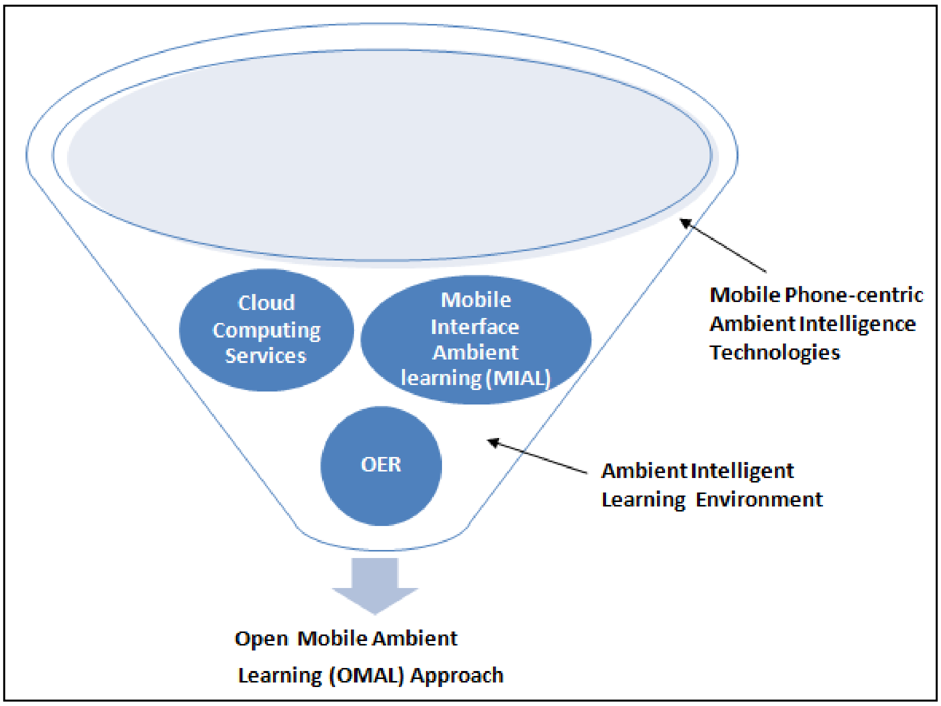

Figure 3.13: Open Mobile Ambient Learning (OMAL) Approach

Source: (Mwendia and Buchem, 2014).

Open Mobile Ambient learning (OMAL) was formed by integrating aspects ideas from four main concepts as indicated in Figure 3.16. They included the following:

(i) Cloud Computing Services (CCS) that assists in overcoming storage limitations of mobile devices (Jansen et al.2013). These are: (1) Cloud-based Repository Services (e.g. using drop box) to expand storage capacity for storing OER, (2) Cloud-based Communication Services (e.g. using Facebook chat and twitter) to offer cheaper means collaboration between learners and lecturer or supervisor, (3) Cloud-based Production Services (e.g. using Google docs) to allow cheaper means of creating online learning materials (such as online project supervision guides and progress appraisal forms).

(ii) Open Educational Resources (OER), which comprised freely available online learning materials such as text documents, audio and video clips stored in Cloud-based Repositories (Butcher, 2011).

(iii) Mobile phone-centric Ambient intelligence (M-AMI) technologies that used mobile phones to provide ambient intelligence services (Maheshwaree, 2008).

(iv) Mobile interface ambient learning (MIAL), which was a category of ambient learning approach that uses mobile devices only to support learning at anytime, anywhere and anyhow (Mwendia et al., 2013).

Additionally, OMAL approach was mainly driven by location independent context awareness learning theory, collaboration learning theory and cognitive learning theory that were discussed in literature review section (Naismith et al., 2004; Yau and Mike, 2010; Keskin and Metcalf, 2011).

3.5.3 Implementation of Ambient Learning Approach

The strategy of combining concepts was used to create several implementation models to facilitate instantiation of OMAL. These are:

(a) M-AMI System Model

(b) System architecture for M-AMI model

(c) Information retrieval algorithm

(d) Interface Implementation model

(e) Context Database Implementation model

(a) M-AMI System Model for OMAL

According to Heikki Ailisto et al. (2006), ambient intelligence should be 'mobile device-centric'. That is, instead of integrating sensors in the environment so that the environment can be made aware of the user, the personal mobile device (such as mobile phone) should be aware of intelligent affordances in the physical environment.

As an attempt to achieve this requirement, we proposed mobile phone-centric Ambient Intelligence system model that was derived from two concepts, namely, AMI System model (Augusto, 2010) and M-AMI applications concept (Maheshwaree, 2008) as illustrated in Figure 3.14.

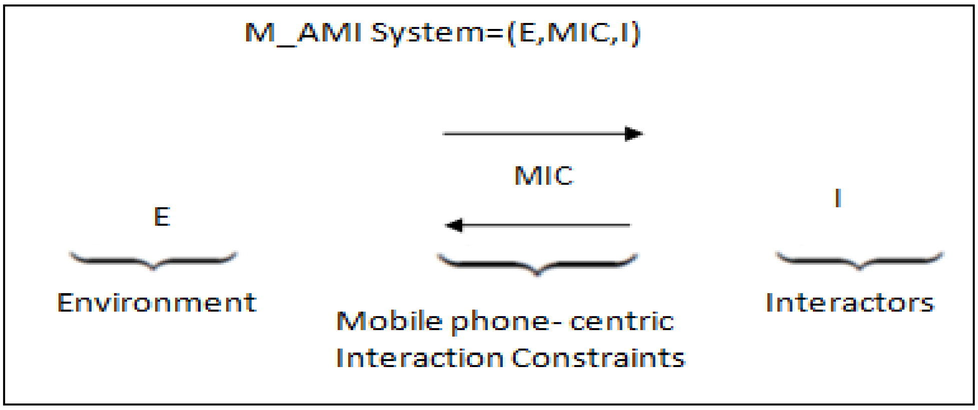

Figure 3.14: Mobile Phone-centric Ambient Intelligence (M-AMI) system model

The components of M-AMI include the following:

(i) Interactors (I) contains a set of elements that interact with the environment. In this case research students and their respective supervisors.

(ii) Environment (E) (Augusto, 2010) represented mobile learner's context that comprised natural human context, physical context and digital context . That is, MLC= {NHC, PC, DC}.

1. Physical context (PC) contained information about physical objects surrounding the learner (research project student), which were relevant to current learning activities (Soylu, Causmaecker, Desmet, and Leuven, 2009). For instance, physical infrastructure information such as mobile network and devices used by the learner, interaction environment such as class room, university library or conference room, and physical conditions information such as time of the day, month or year (Schmidt et al.,1998 as cited in (Kolari et al., 2004)).

2. Natural human context (NHC) (Kolari et al., 2004) that contained information regarding natural situation of individual learners. These are: (i) User information such as user id and preferences, among others, (ii) Social environment such as research groups in the area of interest and collaborating members, and (iii) Task information such as current research task or assignment.

3. Digital context (DC) contained the following two main components:

   (a) Cloud computing services to assist in overcoming storage limitations of mobile devices (Jansen et al., 2013). They were three of them: Cloud-based repository services, cloud-based communication services, and cloud-based production services.

(b) Open educational resources (OER) (Butcher, 2011) comprised freely available study materials stored in Cloud-based Repositories. They included text documents and video clips.

(iii) Mobile Phone -centric Interaction Constraints (MIC) Mobile phone -centric Interaction constraints (MIC): contained various components that use mobile phone as the central device to facilitate interactions between elements of Interactors (I) and Environment (I). This is described in the following model:

MIC = {MS, MA, MCI, IR, MM, CB}

Where:

MS: A set of mobile phone-embedded sensors for providing contextual information from the environment (E). They are also known context providers (Anand Ranganathan and Roy H. Campbell, 2003) . Examples are: ambient intelligent mobile application, camera, motion sensors, accelerometer, and touch screen, among others.

M*A*: Mobile phone-embedded actuators for acting and influencing environment. Examples are: ambient intelligent mobile application and SMS messaging application.

MCI: Stands for mobile phone-embedded contexts of interest that differentiate situations in the environment to be acted upon. For example, icons or buttons on the interface of ambient intelligent application can be used to capture details for distinguishing leaner's context of interest (preferences) for determining what content will be presented to the learner.

IR: Stands for collection of interaction rules that establishes the protocol (algorithm) for combining all the previous elements (Interactors (I), environment (E) and Interaction Constraints elements (MIC)) together to make decisions and trigger actions. In this project, interaction rules were used for capturing, evaluating and storing learners' context in the context database. Examples of context include learner's identity, education level, and preferences, among others. The interaction rules were implemented using two components, (i) ambient intelligent mobile application, which was running on android-based smartphones, and (ii) context manager that was running on a web server established in a local computer for confidentiality reasons (Mwendia et al., 2014).

(b) System Architecture for M-AMI model

Various researchers have defined system architecture differently. For the purpose of our study, we view system architecture as a description of system structure in terms of components, connections, and constraints (Maier and Rechtin, 2002). This is shown in Figure 3.15.

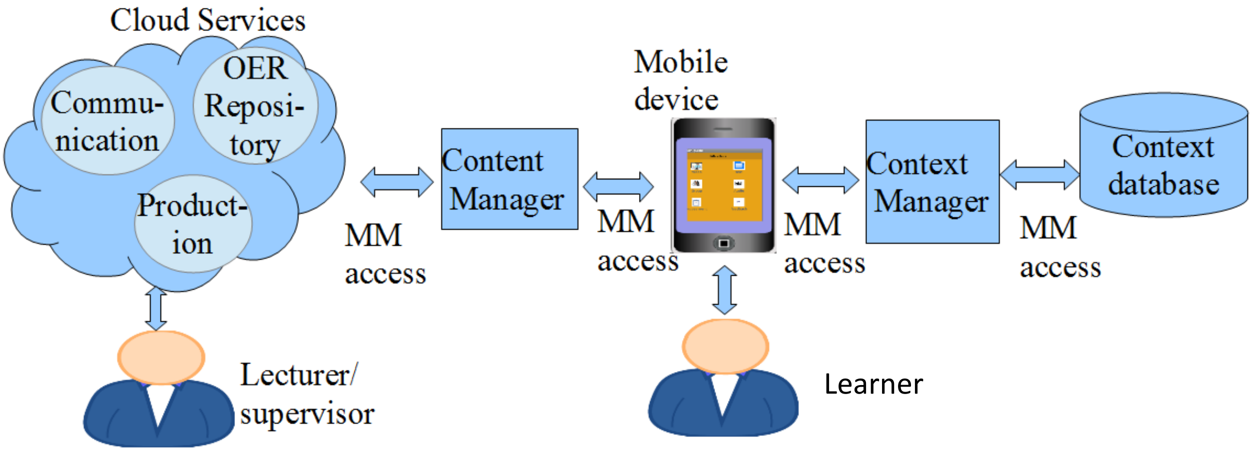

Figure 3.15: System architecture for M-AMI Model

Source: (Mwendia et al., 2014).

As illustrated in Figure 3.18, the system architecture for M-AMI model contains several components that are interconnected. These are (Mwendia et al., 2014):

(i) Cloud computing services used for storing OERs and supporting collaboration services.

(ii) Multimodal mobile (MM) Broadband Access facilitated internet access through mobile phones.

(iii) Mobile phone was used for running ambient intelligent application. The application was used for implementing intelligent user interface.

(iv) Content manager was used for integrating OERs to Cloud based repositories. It provided services such as uploading, downloading and customizing available OERs.

(v) Context manager was connected to both context database and mobile phone. The component was adopted for integrating M-Learner's context to facilitate context awareness

(vi) Context database (CB) was used for storing Mlearners' context (MLC). That is, natural human context, physical context, and digital context. It was connected to context manager module, which implements interaction rules (IR) for managing context.

(c) Information Retrieval Algorithm for OMAL

The Information retrieval algorithm for implementing OMAL approach was derived by combining two mechanisms of implementing intelligent interfaces. That is, semantic searching approach and greedy best search technique.

i) **Semantic searching approach** required users to indicate their preferences by pressing MCIs represented using images embedded on the intelligent user interface of mobile application. The preferences and other M-Learner's context were then used as ontology for dynamically recognizing and adapting learning services. This approach was used because sometimes the user does not know about the documentation before searching. (Guha, Rob, and Eric, 2003; Soulah-Alila, Nicolle, and Mendes, 2013). The approach adopted the following information retrieval algorithm:

1. *Start*
2. *Perform Dynamic Greedy best-first search to generate query*
3. *Perform random file access using hash function to retrieve web address of a particular OER.*
4. *Use the web address to retrieve the OER from the Cloud-based repository.*
5. *End.*

ii) **Dynamic Heuristics - Greedy Search Algorithm** was used for generating user queries. The technique was derived from Greedy Best -first search method (Elaine Rich, Knight, & Shivashankar B Nair, 2009) that uses an evaluation function to determine the most promising option among available alternative. Greedy Best - first search method was enhanced by formulating an evaluation function that uses dynamic heuristics to generate the most promising user query among available alternatives. The following pseudo code was used to represent Dynamic Heuristics - Greedy Search Algorithm:

1. *Start by creating Queue with initial* ***OPEN*** *node*
2. ***WHILE*** *(query has not been generated and*
3. *Queue is not empty)*
4. ***DO***
    a) *{Remove the first path from the Queue*
    b) *Create new paths to all the successor nodes*
    c) *Reject the new paths with loops*
    d) *Add the new paths to the front or back of the queue*

e) Compute heuristics of all OPEN nodes in the queue

f) Sort the queue according to heuristics (H) }

5. ***UNTIL** query is complete or no existing open nodes*
6. ***IF** query is generated **THEN** success,*
7. ***ELSE** Failure.*

(d) User Interface Implementation Model

User interface was designed to facilitate interaction between the user and the system. The design specified the look and feel of the system, which included: main menu, content view design, color code and others. The interface design was divided into two categories, namely, i) Learner's user interface design and, ii) Lecturer/Supervisor user interface design

i) Learner's User interface Model

Student user interface design included a mobile application interface that contained several views : main menu, study content view and feedback view. This is shown in Figure 3.16.

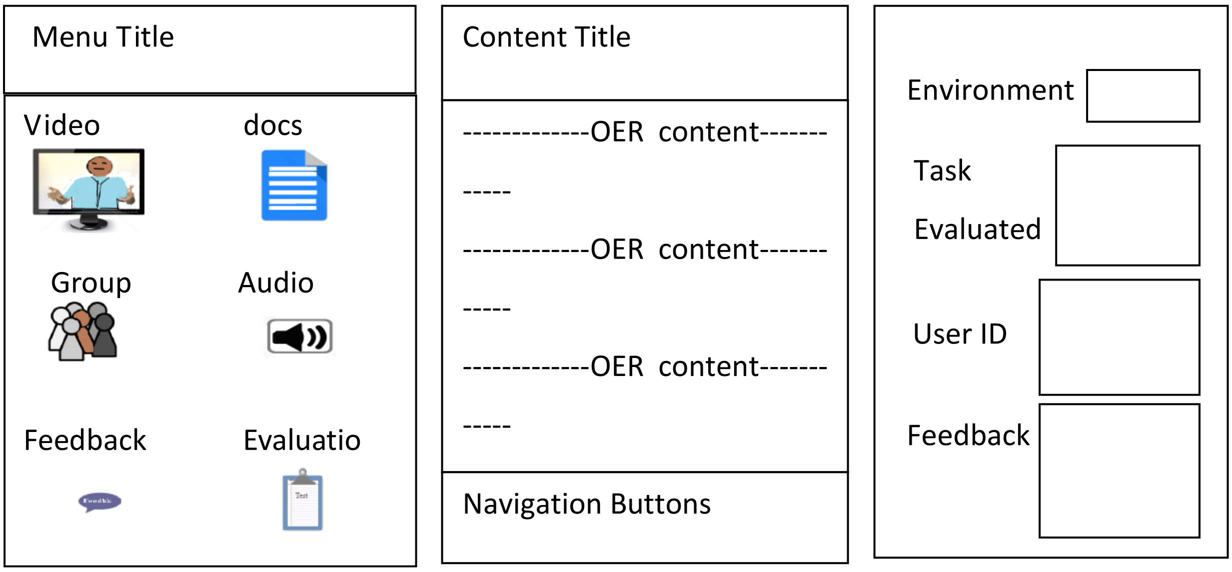

Figure 3.16a: Main Menu   Figure 3.16b: Content View   Figure 3.16c: Feedback View

Figure 3.16: Learner's User Interface

As described in the above Figure 3.16a, main menu design contained labeled images for representing mobile phone-embedded contexts of interest (MCI). These are regions that can be pressed by the learner to indicate his/her preference. Figure 3.16b shows the content view design, which contains display area for presenting retrieved study materials to the learner. The Feedback design view in Figure 3.16c aims at providing a view for allowing learners to view feedback posted by their respective supervisors.

ii) Supervisor's User Interface Model

The design for lecturer's user interface was used for specifying how submitted research deliverables will be presented to the supervisors for evaluation purposes. This is shown in Figure 3.17.

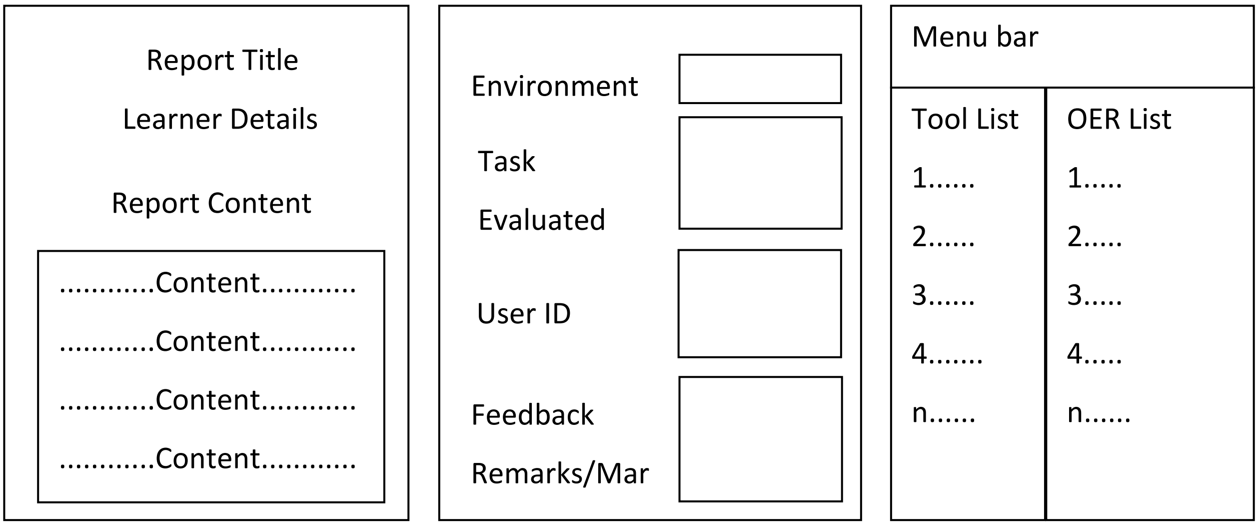

Figure 3.17a: Progress Report   Figure 3.17b: Feedback UI   Figure 3.17c: Content Manager UI

Figure 3.17: Supervisor's User interface.

Figure 3.17 shows three supervisor's user interface designs for different purposes. In Figure 3.17a, Progress report (UI) design specified the layout of a view that presents progress report submitted by learners. In Figure 3.17b, Feedback user interface (UI) design described the layout of feedback form that can be used by the supervisor to post feedback after evaluating submitted progress reports whilst in Figure 3.17c, Content Manager User Interface (UI) describes the layout of user interface (UI) that can be used by the supervisor to manage open educational resources (OER) by sharing, adding, creating or customizing the content.

(e) Context Database Implementation Model

For the purpose of this study, context attention metadata (CAM) framework was adopted for guiding the process of designing context database. According to Schmitz, Wolpers, Kirschenmann, and Niemann (2011), Contextual attention metadata (CAM) refers to observations about users' foci of attention and activities that can be analyzed to provide statistical information on interests and activities of learners over time. The data can then be used to generate individual learner profile for personalizing learning services. Based on these views, contextualized attention metadata (CAM) schema was designed to capture data on how learners use cloud computing services and mobile learning tools to access open education resources (OERs). This is shown in Figure 3.18.

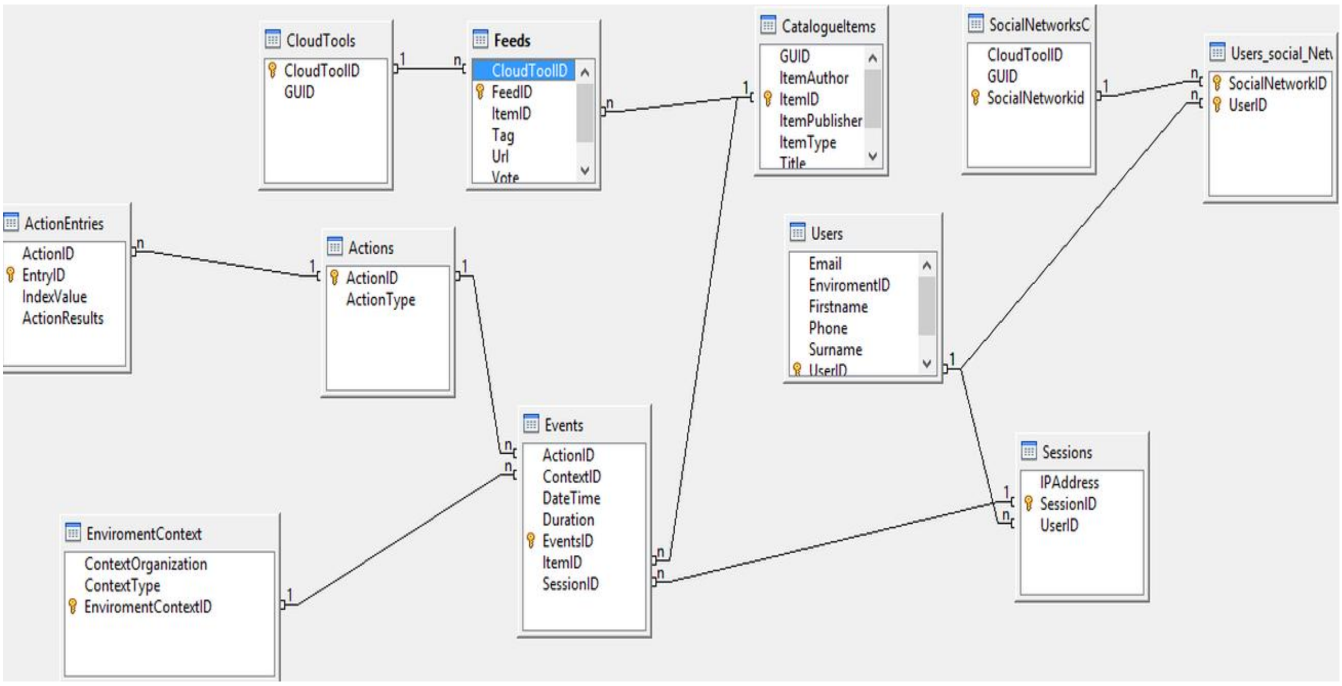

Figure 3.18: Context Database Model

As described in Figure 3.18, context database design described entity relation (ER) schema that contained several related entities and their respective attributes. These attributes are:

(i) Environment context element which captures information about the environments the user may interact with. Examples: course information such as course id, course title (i.e. item value), discipline (item type), faculty and university (organization context) where the course is offered.

(ii) Preferences element which describes information about choices made by the learner during learning. For example, the learner could choose audio, video or text modes.

(iii) Events element which holds references to activities performed by users of the system. Each record contained a link to other elements such as environment context, preferences, actions and sessions. It also collects information on the date and time when the event occurred.

(iv) Action element which contained information about actions that can be performed on an item. They include type of action and action identifier.

(v) Items element which described information about OER items that can be accessed in cloud repository. Examples: Item identifier, Global unique identifier (GUI), title and type of the item (i.e. audio, video, document).

(vi) Feeds element which was used for capturing information about user activities in Cloud Computing tools such as Facebook, Dropbox and googledocs. Each feed describes properties of one or more items. These include: FeedId, ItemID, global identifier (GUID), tags and voting data.

(vii) Users element which stores information about individual users and user groups. Examples: userID, names, groupID, contacts (e.g. phone, email) and their education performance.

(viii) Sessions which stores information for identifying the working session. Examples: session ID, IPAddress and User id.

(ix) Social networks context which described information about user groups (i.e. social networks). Examples: social network ID and network title.

(x) Action element holds metadata about actions performed on individual items. Examples are reading text documents, collaborating, watching study videos, uploading items, among others.

3.5.4 Evaluating Validity of OMAL Approach Model

The validity of the ambient model was evaluated through consultations with experts in Kenya and Germany universities. In Kenya, the researcher consulted the two supervisors allocated to him by the University of Nairobi. During a research visit to Germany between September 2013 and May 2014, the researcher discussed ambient learning approach with academic advisors. That is, one professor of media and diversity at Beuth University of Applied Sciences, Berlin and one professor of computer science at Collide lab in University of Duisburg, Essen. The feedback information obtained from all the experts was then used to make necessary modification as recommended by Zeng et al. (2009).

Peer review process was also used to evaluate the OMAL approach. This was effected through publishing two conference papers (Mwendia and Buchem, 2014; Mwendia et al.,

2014) and one book chapter (Mwendia et al., 2015). These were accepted following a successful peer review process.

3.5.5 Communication of design and development results

Results communication was the final task for design and development activity. The objectives of communicating results was to provide an opportunity for relevant audience to benefit from the product of creative process and to help obtaining further feedback for possible adjustment of the model (Truman, 2011). Several methods were used to carry out the communication task. They include the following:

i. Writing several progress reports submitted to University of Nairobi through supervisors.

ii. Published, used case scenario, OMAL approach proposal and system implementation model, through three conference papers (Mwendia et al., 2013; Mwendia and Buchem, 2014; Mwendia et al., 2015).

iii. Publishing demonstration of technological framework through one book chapter (Mwendia et al., 2015).

iv. Presentations that included the following:

   1. Paper presented during proceedings of IST-Africa 2013 Conference Proceedings. Nairobi, Kenya.
   2. Paper presentation at UNESCO Mobile Learning Week 2014, Paris-France.
   3. Paper presentation at the 22nd ICCE2014 Conference, Nara, Japan on 3rd December 2014.
   4. Guest lecture presentation at Beuth University of Applied sciences, Berlin in Germany on 31st January 2014.
   5. Presentation at Collide Lab in University of Duisburg, Essen in Germany.

3.6 Demonstration of Ambient learning approach Phase

Demonstration was the final phase for development in CODSRM and its aim was to help in achieving the following objective and research question:

Objective iv: *To demonstrate ambient learning approach*

Research Question vi: *How can ambient learning approach be used to support search supervision services?*

During this phase use case scenario method (Peffers et al., 2008) was applied to demonstrate two OMAL artefacts that were created during the design and development stage. These are (i) OMAL Mobile Application, and (ii) Dynamic Heuristics - Greedy Search Algorithm (Mwendia and Buchem, 2014; Mwendia et al., 2014).

3.6.1 Demonstrating OMAL Mobile Application

Use case scenario was used to provide narrative descriptions of how OMAL can be adopted in a typical university context. These descriptions contained important demonstration elements such as time, location, actors, and actions with definite starting and end points (Mannio and Nikula, 2001). In this case, an example of a typical research student in KCA University was used to show he can use his mobile phone to access feedback and OER study materials through Cloud-based services and how a typical supervisor can interact with the system to access submitted progress reports and post feedback (Mwendia et al., 2014). The example was described as follows:

Peter is a university student with a smart phone but has no personal computer at home. He has just registered for the research project unit through his phone and would like to start the learning process while busy cleaning his house, say on Saturday morning.

Upon login, the mobile application in his smart phone checks the context database and notices that no feedback has been posted so far. The application determines that Peter is a beginner and anticipates that the next learning material is the proposal guide. Multi modal access screen is then presented (Figure 3.19a) so that Peter can choose his mode of access .That is, video, text or audio. Peter chooses audio mode, which will allow him to listen through headphones while he is cleaning the house. The application retrieves an mp3 file from OER repository (as shown in Figure 3.19b) and Peter presses download button so that the audio file can play from his phone, even when there is no internet connection (offline).

After listening for 30 minutes, Peter decides to do a test for evaluating his proposal idea. He stops the audio and the Multi-modal access screen appears as shown in Figure 3.19c, where he chooses assessment option. The application then presents Progress Appraisal forms, which has diagnostic questions for identifying knowledge gaps and reflective questions for helping the student to evaluate himself. The appraisal assumes that the current user is working on his project idea. Peter answers all the questions and submits them by pressing submission button.

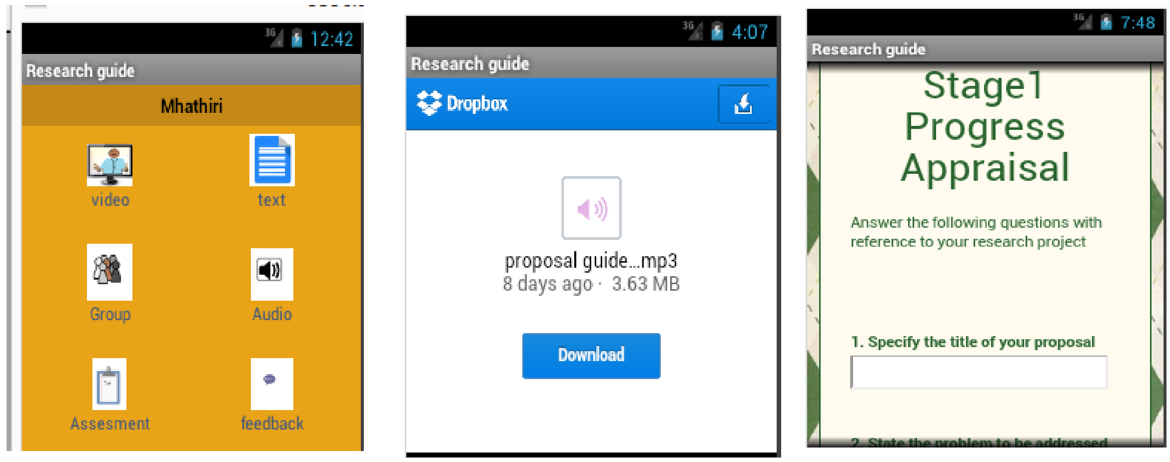

Figure 3.19a: Menu Figure 3.19b: Content Figure 3.19c: Appraisal

Figure 3.19: Research Study Activities

Before closing the application, Peter presses Group button in Figure 3.19a, which displays Facebook page as shown in Figure 3.20b. He then writes a message to notify his supervisor that he has submitted stage1 progress appraisal. On receiving notification, the supervisor uses his tablet to download the appraisal document in pdf format as shown in Figure 3.20b. He evaluates submitted work and posts feedback (marks and remarks) using his tablet as shown in figure 3.20c.

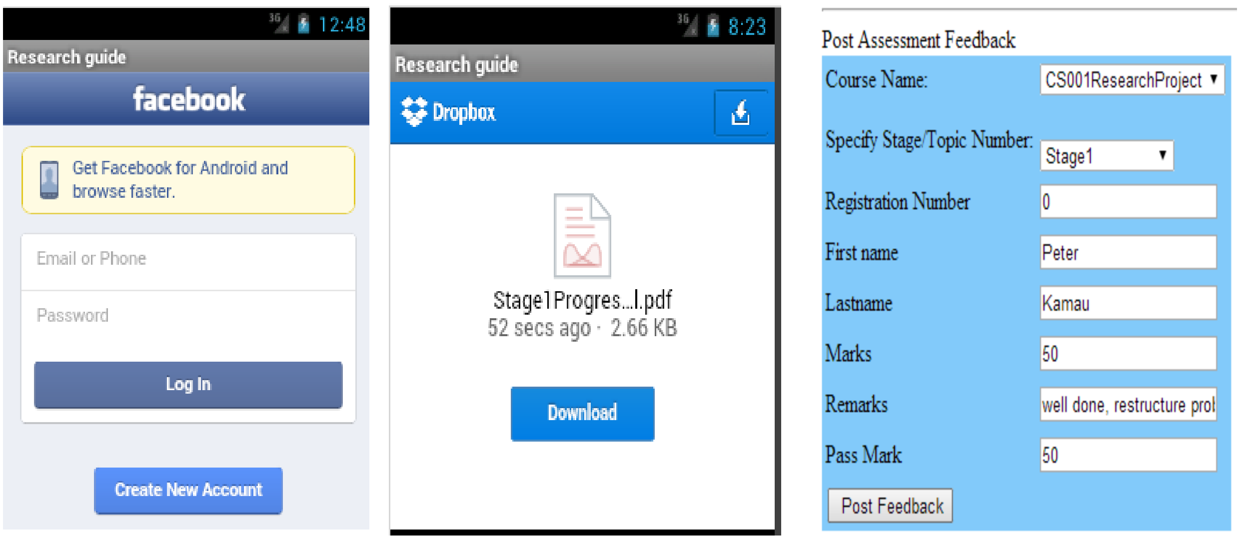

Figure 3.20a: Facebook page Figure 3.20b: Downloading Figure 3.20c: Posting

Figure 3.20: Evaluation of Stage1 Research activities

On Saturday evening, Peter decides to check feedback of stage1 evaluation. He therefore logs in and presses Feedback button at the bottom of multi-modal access screen in Figure 3.21a. The mobile application retrieves feedback from the database, and presents feedback as shown in Figure 3.20c below. Peter therefore decides to continue learning by pressing text *button in Figure 3.19a. Since the feedback of Stage1 is above the threshold (50%), the application anticipates that Peter is now interested in accessing Stage2 learning material. The system requirement specification (SRS) document is then retrieved from Google Docs and displayed as shown in Figure 3.21b.*

Finally, Peter decides to attempt Stage2 assessment (Progress appraisal) by pressing the assessment button in Figure 3.19a. The application retrieves SRS progress assessment from Google docs and presents it as shown in Figure 3.21c. This process continues for several days until Peter completes all the required learning stages as per the university standards.

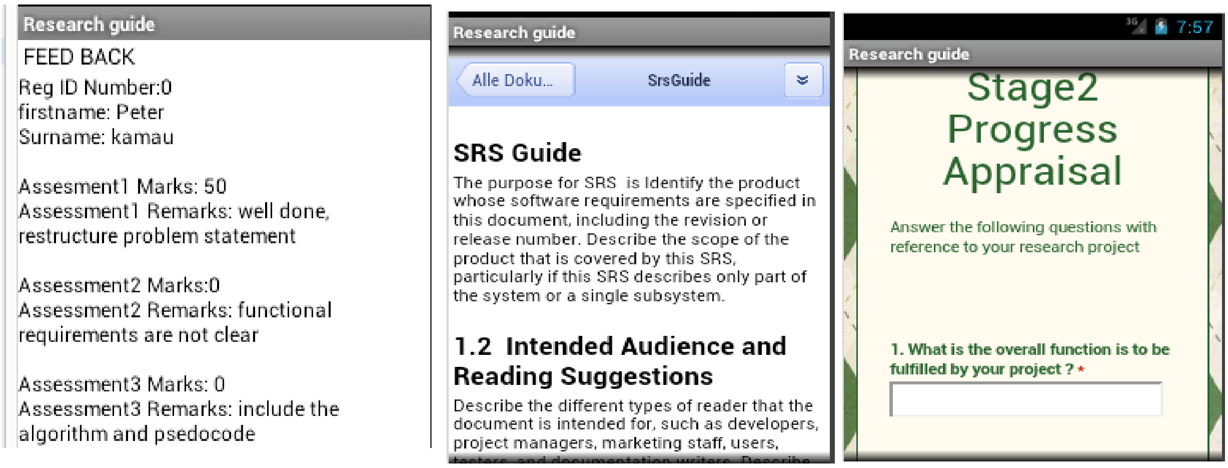

Figure.21a: Stage1Feedback   Figure 3.21b: Stage2 Content   Figure 3.21c: Stage2 Appraisal

Figure 3.21: Accessing Stage1 Feedback and Progressing to Stage2 Activities.

3.6.2 Demonstrating Dynamic Heuristics - Greedy Search Algorithm

For the purpose of achieving objective four and research question six, use case scenario method (Mannio and Nikula, 2001) was adopted to demonstrate how the proposed Greedy search algorithm can be applied to retrieve relevant Open Education Resources (OER) from cloud-based repositories like Dropbox or Google Drive. This is explained using the following example:

As described in Figure 3.25, the system records learner identity (L) during login and computes its heuristic (L=6). A list of paths to existing learning stages are created and their heuristics computed (LS_1=5 LS_2=5 LS_3=5 LS_4=5, $S_{i=}$5).Then the system checks the current learning stage of the learner in the context database (e.g.Stage1) and reduces the heuristics of the identified learning stage by one unit (S_1=5-1=4). The entire queue is then sorted based on the new heuristic values (LS_1=4, LS_2=5, LS_3=5, LS_4 = 5 .... LS_i=5).

During iteration two, the system creates paths to all available representation formats in the current learning stage (S_1) and computes their heuristics ($LS_1T=3$ $LS_1A=3$, LS_1V3.....$LS_1I=3$). All the available representation formats are presented to the user so that s/he can choose one of them. This is shown in Figure 3.22

Figure 3.22: Available Representation Formats.

When the user selects one option (e.g. Audio), the system reduces heuristics of the path with audio node by one unit ($LS_1A=3-1=2$). At this point, the entire queue is sorted according to the new heuristics ($LS_1A=2$, $LS_1T=3$ $LS_1V=3$...). During iteration three, the system creates paths to all the potential learning goals associated with audio (A) representation format and computes their heuristics ($LS_1AR=1$, $LS_1AJ=1$). For example, paths for accessing existing course units like research project, probability and statistics or java programming units. A list of available course units is then presented to the user so that he can choose one of them. This is shown in Figure 3.23.

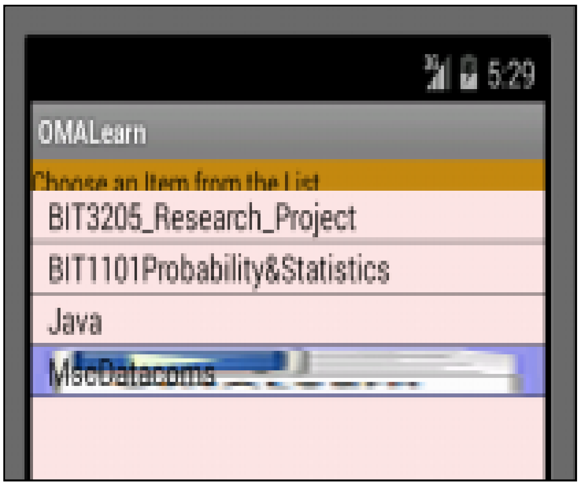

Figure 3.23: List of Learning Goals.

Upon selection of one learning goal (e.g. Research Project), the system reduces its heuristic by one value (R=1-1=). The entire queue is then sorted according to the new heuristics (LS_1AR=0, LS_1AJ=1, LS_1T=3 LS_1V=3, LS_2=5, LS_3=5, $LS_{4.}$= 5).

Finally, the system returns the first path (LS_1AR=0) in the queue as the keyword generated from the user context, which can be interpreted as follows:

- *Current Learner ID=L_i,*
- *Current learning stage= Stage1(S_l),*
- *Selected representation format = Audio (A),*
- *Selected Learning Goal=Research Project (R)*

The interpreted keyword is then mapped to a web address of a relevant OER or cloud computing service using the following hash function:

***IF** Learnid= L_i **AND** Learning stage=S_i **AND** Representation format =R_i **AND** Research Goal=Gi **Then** URL =Ui.*

The following is an example of how the hash function can be used to map interpreted keywords into a typical web address:

***IF** Learnid= KCA56 (A student registration number) **AND** Learning stage=Stage1 **AND** Representation format = Audio **AND** Research Goal=Research Project unit **Then** URL = Https://www.dropbox.com/research.....*

3.7 Generalization Evaluation Phase

The main purpose of this phase was to assess the generalization of OMAL approach model. The activities of this phase were carried out using creative process derived from Zeng et al. (2011) model as illustrated in Figure 3.24.

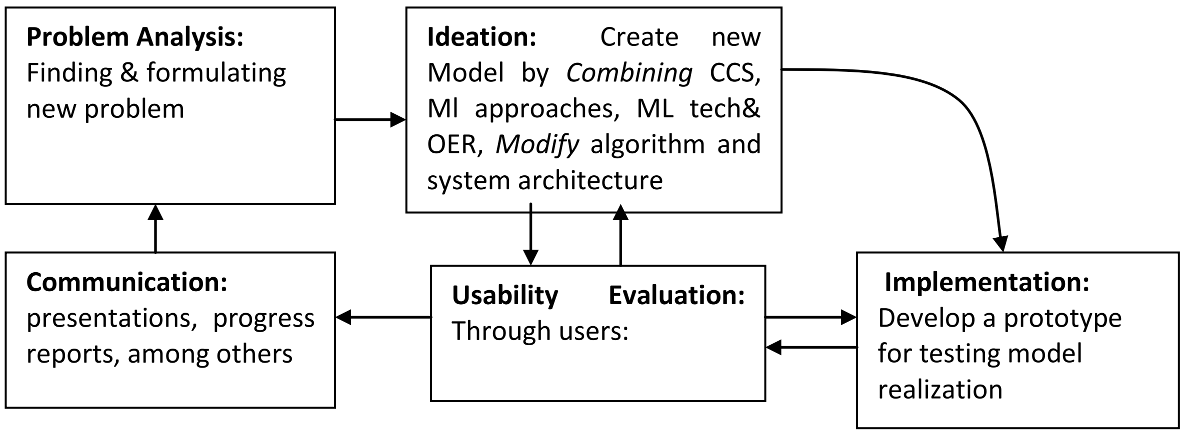

Figure 3.24: Creative Process for Evaluating Generalization of OMAL Model

Figure 3.24 shows five tasks of creative process that were carried out during generalization evaluation phase. They include (1) problem analysis, (2) ideation, (3) implementation, usability evaluation, and (4) communication.

3.7.1 Problem Analysis

According to Zeng et al.(2011), problem analysis entailed looking for information to help with problem understanding and framing it in a meaningful and concrete way that could suggest possible solutions. For the purpose of this phase, one main challenge was identified. That is, it is difficult to generalize artefacts when using design and development research since the method adopts longitudinal research approach (Saltuk and Kosan, 2014).

3.7.2 Ideation of M-Learning Variants

To address this limitation, Inverted-T adoption approach derived from phased implementation model (Craig et al., 2008) was to used guide execution of Ideation task. This shown in Figure 3.25

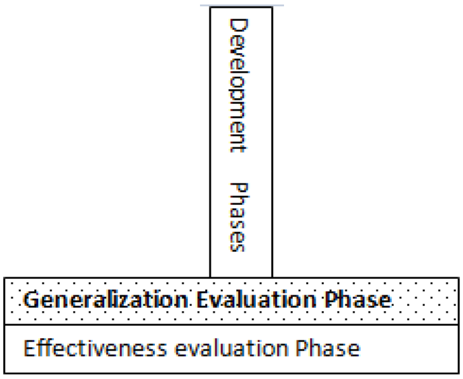

Figure 3.25: Evaluation Phases in inverted-T Adoption approach of CODSRM.

The Inverted-T Adoption approach involved repeating one of the development phases to assess its output. In our study, this involved repeating design and development phase to ideate three variants of existing mobile learning approaches that are similar to OMAL approach. They include, (a) Open Single mode of Representation (OSMR), (b) Open Mixed Mode of representation (OMMR), and (c) Open Context aware Single Mode of representation (OCSMR).

3.7.3 Implementation of M-Learning Variants

Implementation of the three M-Learning variants was done by creating one prototype for each of the three approaches. That is, open single mode representation (OSMR) prototype, open mixed modes representation (OMMR) prototype, and open context aware single mode representation (OCSMR) prototype. This section therefore describes two implementation models that were used to guide implementation of each prototype. They include (a) information retrieval algorithm that illustrated the logical flow of each mobile M-Learning prototype, and (b) system architecture that was used to describe components of each prototype.

(a) Implementation of OSMR M-Learning system

i) System architecture of OSMR M-Learning Approach illustrated how components of OSMR application are interconnected. This is shown in Figure 3.26.

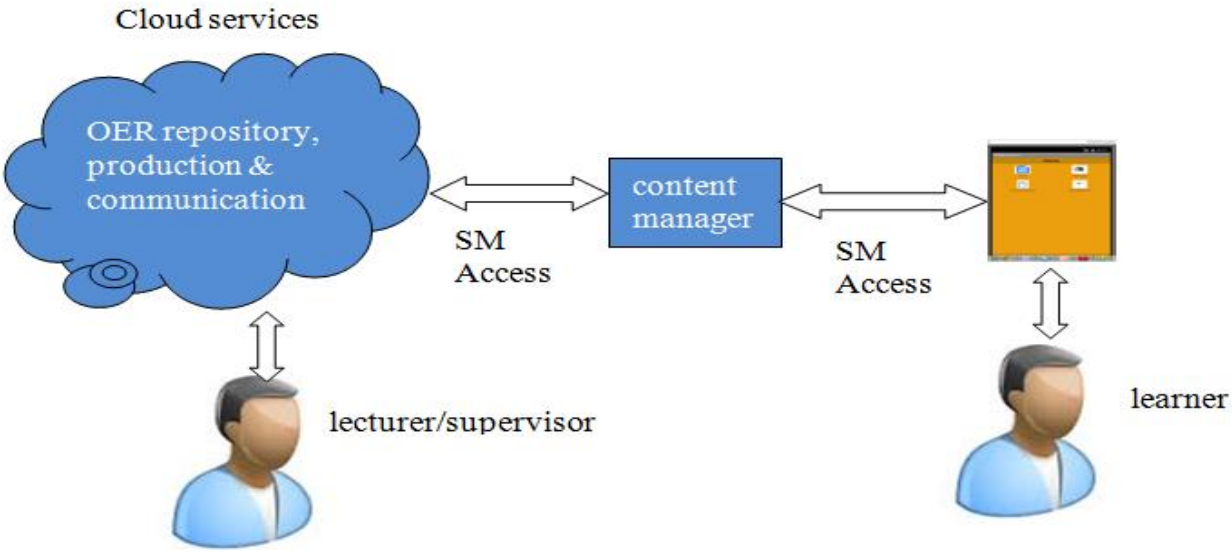

Figure 3.26: System Architecture for OSMR M-Learning System.

As illustrated in Figure 3.26, the architecture for OSMR M-Learning System contained similar components those of OMAL system, namely, cloud-based services, content manager, mobile devices, OER repository and users (supervisor and learners). Nevertheless, it lacked context manager and multimodal access. This means that the OSMR M-Learning system could not allow learners to access personalized multimodal content.

(ii) Information Retrieval Algorithm for OSMR M-Learning contained the following execution steps:

1. *Start*
2. *Capture topical details (identity and preferences)*
3. *Retrieve all the available OERs that are in single mode of representation from cloud-based repository.*
4. *End.*

The OSMR algorithm was then converted to the following pseudo code:

1. *Start*
2. *Capture topical details (Topic or Task)*
3. *For (index=initial; index <=maximum Index; ++Index)*
   { While (Topical details = Single mode OER index)
   a. {Retrieve single mode OER from cloud-based repository}
   }
4. *End.*

(b) Implementation of OMMR M-Learning System

Similarly, implementation of OMMR M-Learning system was described using system architecture and the associated information retrieval algorithm.

(i) System Architecture for OMMR M-Learning system is shown in Figure 3.27.

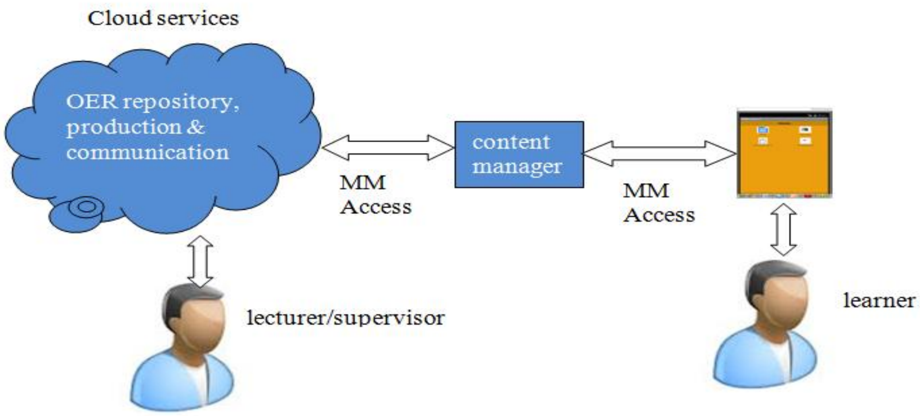

Figure 3.27: System Architecture for OMMR M-Learning system.

As illustrated in Figure 3.30, OMMR system contained components that were similar to those of OSMR M-Learning system. That is, cloud-based services, OER repository, content manager mobile devices and users (supervisor and learners). However, it was distinguished from OSMR by use of multimodal (MM) access for delivering mixture of text documents and video or audio clips.

(ii) Information retrieval Algorithm for OMMR System contained the following steps:

1. *Start*
2. *Capture topical details (identity and preferences).*
3. *Retrieve all the available collection of Multi-modal OERs (e.g. both text documents and video formats) from cloud-based repository.*
4. *End.*

The pseudo code for OMMR information retrieval algorithm was described as follows:

1. Start by capturing topical details (Topic or Task)

2. For (index=initial; index <=Maximum Index; ++Index)

{ While (Topical details = multimodal OER index)

{ Retrieve multimodal OER from cloud-based repository } }

3. End.

(c) Implementation of OCSMR M-Learning System

Finally, implementation of OCSMR was also illustrated using system architecture and associated information retrieval algorithm.

(i) System Architecture for OCSMR M-Learning is shown in Figure 3.28.

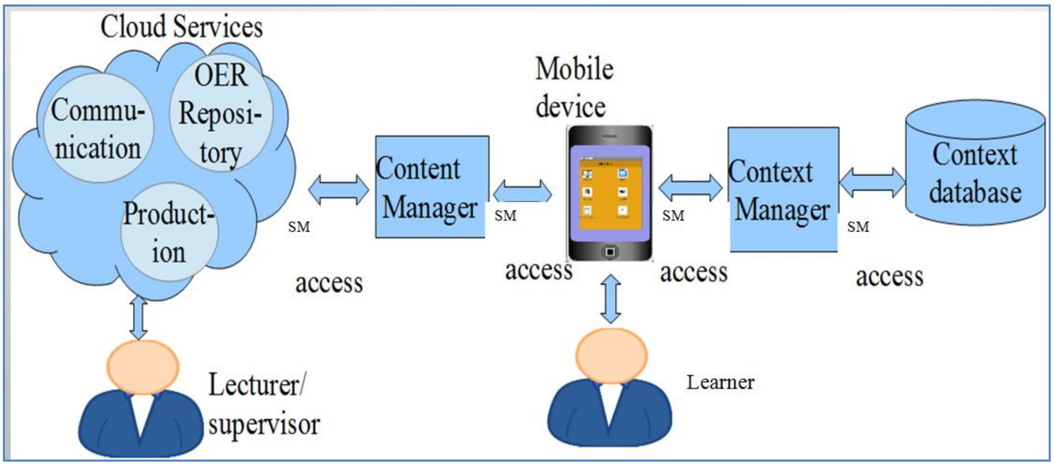

Figure 3.28: System Architecture for OCSMR M-Learning Approach.

As described in Figure 3.28, system architecture for OCSMR M-Learning approach described context manager in addition to all the components of OSMR M-Learning approach. The purpose of context manager was to evaluate and store the learners' context in the context database. Examples of context are: learner's education level, identity, preferences and others (Mwendia et al., 2014).

However, users of OCSMR system could only access OERs materials that were represented in single mode (unimodal) format e.g. using instant messaging tools or short message service (SMS) only.

ii) Information Retrieval Algorithm for OCSMR M-Learning System was adopted to illustrate the logic flow of OCSMR system execution. It contained the following steps:

1. *Start*
2. *Perform Greedy best-first search based on dynamic heuristics to find a solution*
3. *Translate the solution to a query*
4. *Perform random file access using hash function to retrieve web address of relevant single mode OER material.*

5. *Use the web address to retrieve single mode OER materials from the cloud-based repository.*
6. *End.*

The above OCSMR information retrieval algorithm was then converted to the flowing pseudo code:

1. *Start by creating Queue with Learner ID (L) as a root.*
2. *While (query has not been generated and Queue is not empty)*
3. *Do*
4. *{ Remove the first path from the Queue*
    a. *Create new paths to all the children*
    b. *Compute Heuristics (H)*
    c. *Add the new paths to the front of the queue*
    d. *Sort the queue according to heuristics (H) }*
5. *While (Path ≠ CompletePath)*
6. *Translate solution to a query using mobile actuator*
7. *Map the query to web address (URL) of relevant single mode OER material*
8. *Use the web address (URL) to search for single mode OER material*
9. *End*

3.7.4 Evaluating Variants of M-Learning Approaches

According to Zeng et al. (2009), ideation evaluation entails logical analyses of ideas generated during ideation activity. The output of this evaluation include making accurate and unbiased judgments regarding the advantages of the proposed ideas in a particular problem context artefact

In our study, the novelty of the three developed M-Learning approaches (OSMR, OCSMR, and OMMR) was carried out by identifying new features that were added to the existing M-Learning approaches.

(a) Evaluating OSMR M-Learning Approach

Open Single Mode of representation (OSMR) M-Learning was found to be a novel type single mode of representation (SMR) M-Learning since it included use of Cloud-based computing services and open education resources (OER).This is shown in Table 3.19.

Table 3.19: Comparing OSMR M-Learning with other SMR M-Learning projects

	Index	Project Name	Technological Features	ML-Services
	Variant of SMR M-Learning	*OSMR M-Learning approach*	*Cloud-based services & OER*	*Collaboration Information Pedagogical*
1	Onguko (2010)	Agakhan m-l project	SMS	Collaboration Information
2	Muyinda, et al. (2008)	M-Research Supervision Initiative	SMS	Collaboration
3	UNESCO (2012)	M-Learning at Centro de Ensino à Distância(CED) in Catholic University of Mozambique	SMS	Information
4	Bon et al. (2012) Aluko (2012); Brown (2005); Brown (2005)	Pretoria University SMS project	SMS	Information Collaboration
5	UNESCO(2012);(Mostert, n.d.)	Stellenbosch Varsity blended Programme	SMS	Information Pedagogy, Collaboration
6	Hodgkinson-Williams & Ng'ambi (2009)	DFAQ at university of cape town	WAP SMS	Information, Pedagogy Collaboration

Looking at Table 3.19, it can be seen that OSMR M-Learning approach is the only type of Single Mode of M-Learning (SMR) approach that incorporates Cloud-based computing and open education resources (OER). The other six reviewed SMR projects were using short messaging service (SMSs) and/or wireless application protocol (WAP) that have technological constraints of supporting heavy content such as power point and portable document formats (PDFs) (Brown, 2005; Bon et al., 2012).

(b) Evaluating Novelty of OMMR Approach

A comparison of OMMR M-Learning with other MMR M-Learning approaches was also carried out. This is shown in Table 3.20.

Table 3.20: Comparing OMMR M-Learning Approach with other MMR approaches.

Sn	Index	Project Name	Features
1.	*Variant of MMR Approaches.*	*OMMR M-Learning*	*- Cloud-based repository services* *- OERs*
2.	Adedoja et al.(2012)	University of Ibandan Initiative	- Locally hosted repository of study materials.
3.	BCcampus and COL, (2008).`	Dunia Moja	- Central repository of study materials among Partners
4.	Bon et al. (2012).	BlackBoard learn	- Locally hosted repository
5.	Boyinbode et al.(2012)	Opencast Mobile learning	- OER tool. - Locally hosted repository
6.	Ikarambu (2011)	(ILU) M-learning Project	- Locally hosted repository of study materials.

As illustrated in Table 3.20, OMMR M-Learning approach is differentiated from the five studied MMR M-Learning approaches by the use of cloud-based repository services such as Google drive and drop box. The adoption of freely available cloud-based repositories reduces the cost of providing storage infrastructure.

(c) Evaluating OCSMR M-Learning Approach

Finally, comparison of OCSMR M-Learning was also made with similar CSMR M-Learning project. This is shown in Table 3.21.

Table 3.21: Comparing OCSMR M-Learning with Similar CSMR M-Learning Project

Sn	Index	Project name	Features
1	*Variant of CSMR*	*OCSMR*	*- OERs* *- Cloud based Computing Services*
2	Kekwaletswe (2007); Kekwaletswe and Ng'ambi (2006)	M-Learning project at CET, University of Cape Town (UCT)	- Locally based Computing services (instant message tool) - Locally hosted repository services

As indicated in Table 3.21, incorporation of both OERs and Cloud-based computing services in OCSMR M-Learning approach distinguished it from M-Learning project at CET in University of Cape Town. This difference makes OCSMR M-Learning approach to be viewed as novel type context aware single mode of representation (CSMR) M-Learning among the studied projects in African based universities.

3.8 Evaluating Effectiveness of Ambient Learning Approach - Experimental Design

Effectiveness of open mobile ambient learning (OMAL) was evaluated in terms of enabling flexible availability by conducting an experiment in KCA University. The activity entailed distributing the four developed mobile applications to four different groups of undergraduate students, who had enrolled for course units that required undertaking of research based assignments as part of course work assessment.

Several resources were needed for carrying out the experiment. They include the following:

(i) Participants with smartphones for accessing OERs through Cloud Computing Services

(ii) Customized OERs that can be accessed through developed M-Learning applications

(iii) A mobile learning application for each of the four developed mobile learning approaches (OMAL, OSMR, OMMR, OCSMR), which implement proposed information searching algorithm and system architecture of respective mobile learning approaches

(iv) Dropbox and Google drive for providing Cloud-based repository services that can allow management (storing, deleting, sharing, modifying) of OERs recommended by respective supervisors (lecturers of specific course units). Both tools were selected mainly because they are freely accessible.

(v) Turnitin.com, which is an example of Cloud-based repository, to support submission of research assignments so that they can be accessed by respective lecturers for marking

(vi) MYSQL database management system was used to manage context database.

(vii) WAMP server that contained hash functions (Interaction rules) for mapping generated queries to web addresses of relevant OERs.

3.8.1 Design Considerations for the Experiment

Before the experiment was carried out, the following two design considerations were taken into account:

(i) Other Approaches: Since mobile application was running on android based phones, students who did not have android based phone could use other approaches to access study materials like email from friends and Facebook.

(ii) Content development: Each lecturer was supposed to design study guides and assessments for his/her course unit according to curriculum requirements.

3.8.2 Experiment Assumptions

The experiment was conducted based on the several assumptions. These are:

(i) Coursework representation: The four tasks represented 2 assignments. That is, one assignment was represented by two tasks.

(ii) Content exclusion: Course topics assessed through the experiment were not taught in class until the experiment was over.

(iii) Make up assignments: In case some students did not perform well during experiment, an individual lecturer was required to give them make-up assignment after the experiment.

(iv) Content development: Each lecturer was supposed to prepare study guides and assessments for his/her course unit according to curriculum requirements.

3.8.7 Preparation of Materials for the Experiment

In order to prepare for the experiment lecturers were required to Customize learning content (OERs and research assignments) and uploading them to Cloud - based repository (drop box or Google drive). This is shown in Figure 3.29.

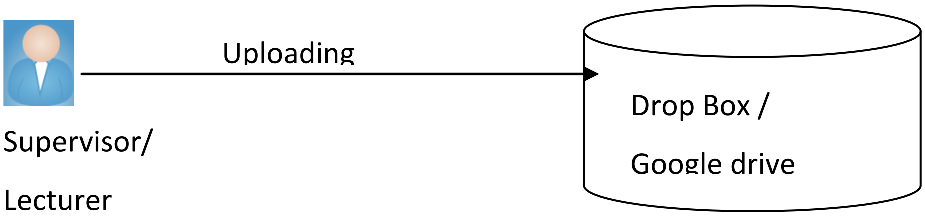

Figure 3.29: Customizing and uploading learning content

In addition, lecturers/supervisors were required to submit a list of potential participants to the experiment coordinator. This is shown in Figure 3.30.

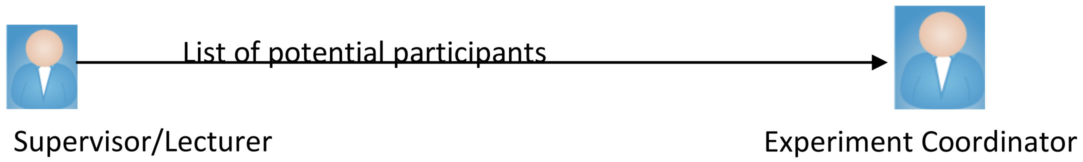

Figure 3.30: Submitting list of Potential Participants.

Table 3.22 shows a list of names given to default OERs and assessments, which were customized by individual lecturers according to their course units.

Table 3.22: Tasks and Assessments Details

Tasks	**Default open education resources (OERs)**	**Default research assignments**	
		Tasks assignments	**Deliverable**
Task1	Concept paper guide	Writing a concept paper.	Concept paper
Task2	Research proposal guide	Writing a proposal	Proposal document
Task3	System requirements specification (SRS) guide	Writing a system specification (SRS)	System requirement specification document
Task4	System design specification (SDS) Guide	Writing a system design document	System design document

As described in Table 3.22, there were four tasks to be undertaken by individual participants. In each task a participant was required to access respective OER guide(s) and a description of task assignment through one of the developed mobile applications installed in his/her smart phone. After conducting research according to guidelines contained in downloaded guide, each participant was expected to submit a deliverable through turnitin.com tool for evaluation.

3.8.7 Experiment Procedure

The procedure for conducting the experiment can be summarized as follows:

Step 1: Coordinator administer pre-experiment questionnaires to sampled participants as shown in Figure 3.31

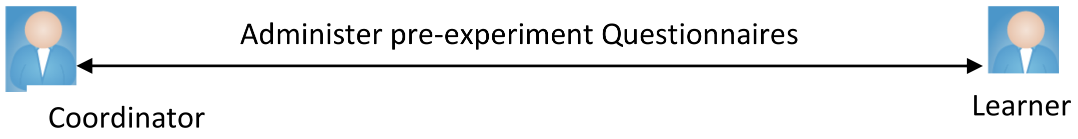

Figure 3.31: Sampling Process.

Step 2: Participants start accessing content and submitting task appraisals using their phones as well as submitting deliverables through turnitin.com at the end of each week. This is shown in Figure 3.32.

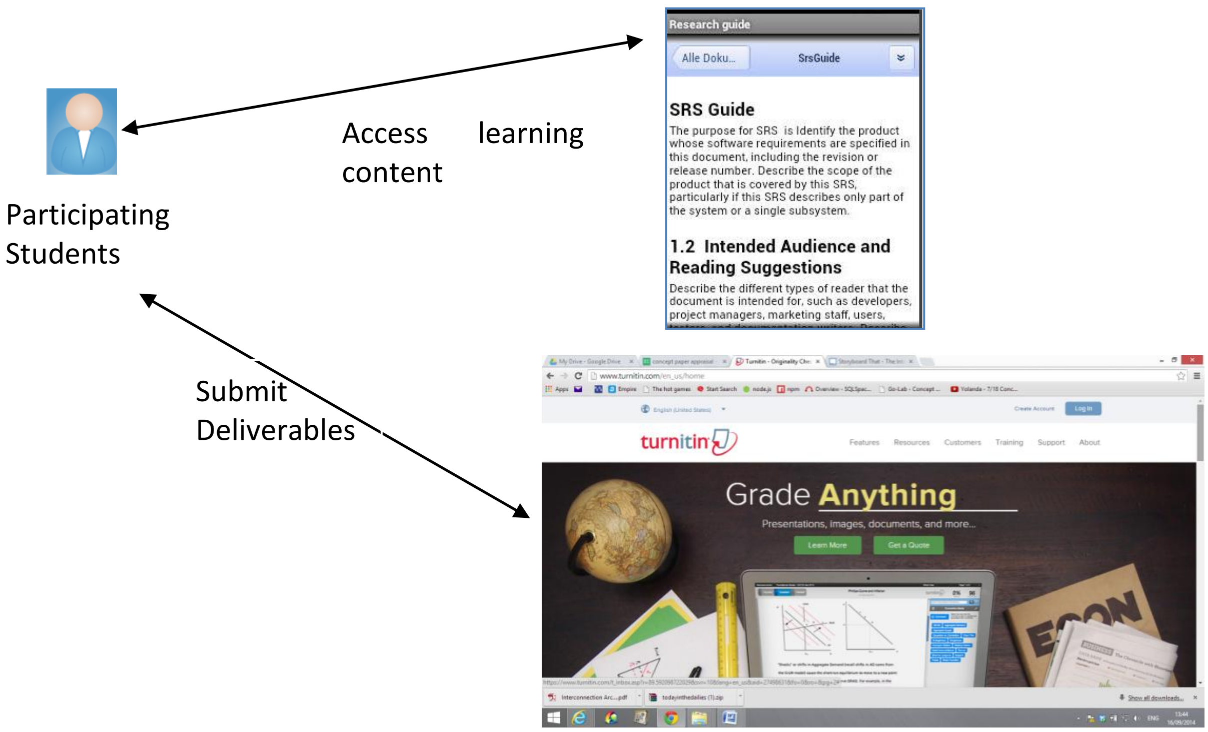

Figure 3.32: Tasks Performed by Students

Step 5: Lecturers assesses submitted task deliverables on weekly basis at his/her convenient time and posts feedback (both marks and comments) to the system through a computer. This is shown in Figure 3.33.

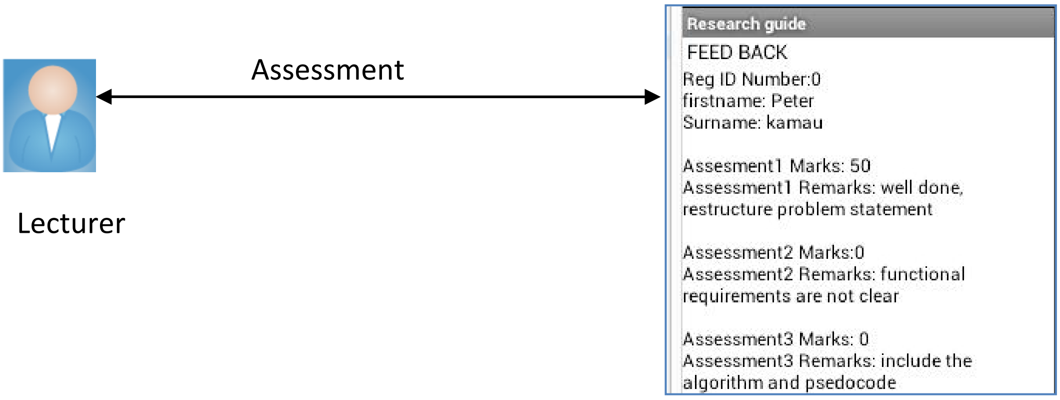

Figure 3.33: Posting Feedback

Step 6: Participating students access results through their phones once the lecturer has posted marks and comments. This is shown in Figure 3.34.

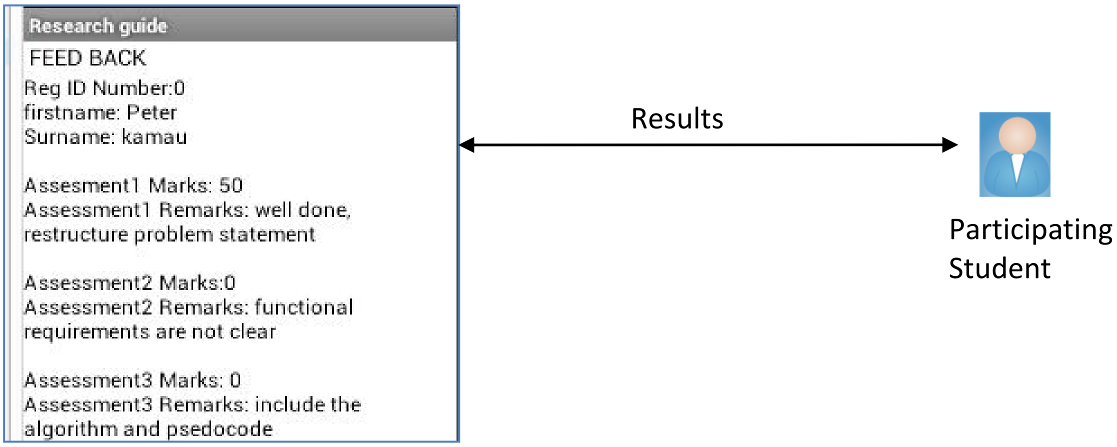

Figure 3.34: Accessing Feedback

Step 7: After 4 weeks of accessing content and submitting assessments, the coordinator administered post -experiment questionnaires to participating students. This is shown in Figure 3.35.

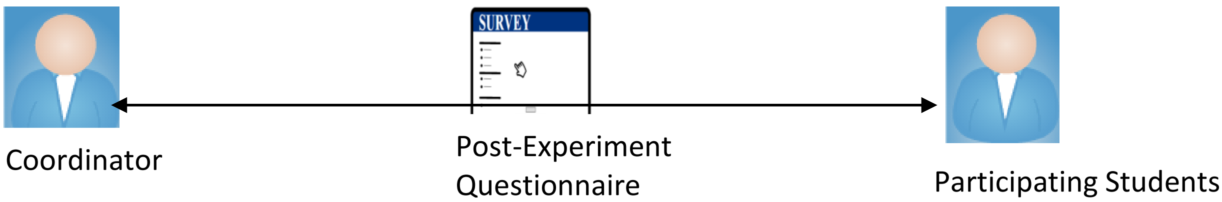

Figure 3.35: Administering Post-experiment Questionnaire.

Step 8: Initial results obtained from the experiment were presented during proceedings of KCA University Faculty Colluquium that was held on 20th March 2015. The aim of the presentation was to furnish the KCA University community with results obtained from the study since the university participated in the evaluation activity (Mwendia et al., 2014).

3.8.1 Experiment Timeline

A schedule was adopted when conducting the experiment. It is shown in Table 3.23

Table 3.23: Experiment Schedule

S/n	Task/ Dates	Sept 15/2014 3/10/2014	3/10/2014 15/11/2014	16/11/2014 21/11/2014
1.	Administer Pre-Experiment Questionnaire			
2.	M-Learning activities			
3.	Distribute Post-experiment Questionnaire			

As indicated in Table 3.23, the experiment involved four main activities that were performed in a sequence. They included distributing pre-experiment questionnaire, M-Learning activities, and distributing post-experiment questionnaire.

3.8.2 Target Group

The target group for experimental study was undergraduate students in KCA University. The students included both computing and non-computing students to ensure wide representation of views across degree programmes. Both categories included students that had enrolled for units that had been purposively selected. Selected computing course units included Principles of Artificial Intelligence, Research Skills and Design and Java Programming.

3.8.3 Sampling Design

Sampling design activity was divided into tasks, namely, determining sampling method and determining sample size.

(a) Determining Sampling Method

Stratified sampling method was used to divide participants into two main groups to enhance distribution of representation. However, due to high number of students in non-computing course units, only one non-computing course unit was selected. That course unit is Management of Mathematics 11 (MMII). Factors considered in selecting course units are:

(i) Willingness of concerned lecturer to participate in experiment

(ii) Accessibility of participating learners

Systematic random sampling was used to select individual participants. The objective was to ensure all M-Learning applications were distributed across all sampled course units.

(b) Determining Appropriate Sample Size

According to Lederman and Abell (2014), a sample size of 20 students per combination of grouping variables is generally considered as minimum and a sample size of 40 students is typically recommended. If two different treatments are to be compared under controlled environment (e.g. experiment), a group of 20 students is required per treatment. Warner (2008) as cited in (Corder and Foreman, 2009), recommended n>20 as minimum and n> 10 per group as an absolute minimum. Based on these views, we divided target participants into four groups, namely, one experimental group and three control groups. The experimental group was required to use OMAL application while each of the three control groups was required to use one of the three developed mobile applications (OSMR, OCSMR and OMMR). The required minimum number of participants per group was 20. Therefore, the minimum total number of all participants was 20 x 4= 80. To ensure the number does not reduce below 80 participants during the course of experiment, a higher number of 213 participants were purposively selected to participate in the experiment as illustrated in Table 3.24. Among these, 197 agreed to fill pre-experiment questionnaire at the beginning of the experiment whilst 139 of them filled post-experiment questionnaire at the end of experiment. Several reasons were attributed to high dropout rate. These are: (a) Some of the participants did not own smartphones that use android platform, (b) the high internet cost for down loading video lectures discouraged some of the participants from using the developed mobile applications, therefore they preferred to receive study materials from peers, (c) technical limitations of smartphones like memory and small screen were making it difficult to use smartphones, and (d) some students preferred to use computers that had larger screens in comparison to smartphones.

During data entry stage, 8 questionnaires were discarded due to high number of missing values. In addition, among 139 post-experiment filled questionnaires, 7 of them were discarded because there were no corresponding questionnaires among pre-experiment questionnaires. For the purpose of comparing pre-experiment and post-experiment results, the analysis activity was therefore conducted on 132 cases that appeared. This is shown in Table 3.24

Table 3.24: Sample Size per group

	Initial Sample (N)	Dropped Out of the group	Final Sample(N)
OMMR	54 (25%)	32 (59%)	22 (17%)
OSMR	53 (25%)	29 (55%)	24 (18%)
OCSMR	53 (25%)	19 (36%)	34 (26%)
OMAL	53 (25%)	31 (58%)	22 (17%)
Other Learning Approaches	0(0%))	0 (0%)	30 (23%)
Total	213 (100%)	111 (52%)	132 (48%)

3.8.4 Validating Questionnaire

The accuracy of experiment questionnaire for evaluating the effectiveness of the proposed Open Ambient Learning (OMAL) model was validated by experts in the field of Technology Enhanced Learning (TEL). The purpose of validation was to ensure the accuracy and meaningfulness of the instrument (Mugenda and Mugenda, 2003).

Between September 16th 2013 and February 28th 2014, the research questionnaire was validated by a professor in the field of mobile learning and media diversity, in Beuth University of Applied sciences, Berlin. The expert reviewed the questionnaire four times using triangulation method. Based on the advice from the expert, an online version of the questionnaire was piloted by broadcasting it to Masters and bachelor students in Berlin universities. The universities included Beuth University of Applied Sciences-Berlin, Technical University-Berlin, Berlin School of Economics and Law and Humboltz University-Berlin. As a way of improving the quality of the questionnaire, it was further validated by experts in University of Duisburg- Essen. These included a professor and his PhD students in the field of Cooperative Learning in Intelligent Distributed Environments (COLLIDE). A sample of the feedback obtained during this activity is included in Appendix 3.

Finally, the experiment questionnaire was validated by two research supervisors from School of Computing (SCI) in University of Nairobi. Validation was carried out through a discussion meeting that was held on June 5th 2014. Comments made during the meeting include the following:

1. Consider dividing questionnaire into sections such as introduction section and profile information section, M-Learning approach section and other approaches sections
2. Consider starting with current learning approach followed by new approaches such as M-Learning approaches

3. Demonstrate or explain to respondents how to fill the questionnaire
4. Consider removing 'undecided' attribute in likert scale questions.
5. Consider adding the following question: "Do you have access to learning materials through E-learning system"
6. Pilot the questionnaire in one Kenyan university
7. Evaluate concentration span e.g. 15 minutes.

3.8.5 Evaluating Reliability of Questionnaire.

In order to test reliability, the questionnaire was revised based on the feedback from experts and piloted again among the 48 students that had enrolled in Berlin and Germany universities. Results obtained from reliability tests showed that there was high was level of consistency (Cronbach's alpha=0.827667) among responses from respondents. A sample of these results is attached in Appendix 4.

A second pilot was later carried out in Kenya during the month of July 2014 to test reliability of the questionnaire in Kenyan universities context. The questionnaire was administered to a group of 18 undergraduate students in KCA University. The students included those that had enrolled for Bachelor of Science in Information Technology (Bsc IT) or Bachelor of Business and Information Technology (BBIT). The outcomes of the second piloting activity included the following:

(i) The average consistency level was satisfactory (Cronbach alpha= 0.723).

(ii) Some of non-computing students don't use cloud based collaborative tools such as Twitter or Facebook.

(iii) Some questions are repeated.

(iv) Digital study materials, which are represented in texts format, were found to be the most popular (90%, n=43), followed by video formats (67%, n=32). However only (19%, n=9) of respondents prefer audio formats.

(v) Majority owned smartphones (89%, 43), followed by those who owned laptops (63%, n=30), then those who owned tablets (60%, n=29) and finally those who owned ordinary phones (56%, n=27).

(vi) All the participants agreed that a wireless network is available in their university (100%, n=48).

3.8.9 Data Analysis

Data analysis activity comprised three main tasks. That is, (a) pre-experiment data analysis, (b) post experiment data analysis and finally, (c) comparison of pre-experiment and post-experiment results. Experiment results and associated discussions were therefore organized according to the three data analysis tasks on both pre-experiment and post- experiment data.

3.8.6 Usability Evaluation of All Developed M-Learning approaches.

During the month of August 2014, all the four prototypes developed were piloted to support research activities in KCA University. They included OSMR, OMMR, OCSMR and OMAL prototype. The aim of this activity was to assess usability of the application and obtain feedback from end users for the purpose of making improvements (Zeng et al., 2009).

The target piloting group was post graduate students undertaking a research project. All of them had enrolled for Masters of Science degree in data communications (Msc Datacoms). All the four mobile applications were distributed to four different cohorts of users through the electronic mail (E-mail) communication method. This is shown in Table 3.25.

Table 3.25: Usability Evaluation of M-Learning applications

Developed M-Learning approach	**Target Users**
Open mobile ambient learning approach (OMAL)	Msc Data communications May 2012 Cohort
Open Context aware single Mode (OCSMR) M-Learning	Msc Data communications Jan 2012 Cohort
Open Single mode Representation (OSMR) M-Learning.	Msc Data communications JAN 2013 Cohort
Open Mixed Mode representation (OMMR) M-Learning.	Msc Data communications SEPT2012 Cohort

The four prototypes were used to access research guides (e.g. presentation and thesis guidelines) provided by faculty of computing and information management (FOCIM). Most of the feedback obtained from users was related to technical issues. These issues include: (a) queries on how to reset password, (b) the missing command buttons, and (c) issues relating to downloading.

During usability evaluation, data was also collected automatically by the system. Results indicated that all the four developed mobile applications (OMMR, OSMR and OMMR) were sharing the same log file, hence making it difficult to analyze logged data separately. This is shown in Table 3.26.

Table 3.26: Usability Evaluation Results

			Cohort					**Total**
			Sept-2011	**Jan-2012**	**May-2012**	**Sept-2012**	**Jan-2013**	
M-L Application	OCSMR	Count	0	9	0	0	0	9
		% within Cohort	0.0%	64.3%	0.0%	0.0%	0.0%	22.5%
	OMAL	Count	0	4	10	0	1	15
		% within Cohort	0.0%	28.6%	100.0%	0.0%	20.0%	37.5%
	OMMR	Count	1	1	0	9	0	11
		% within Cohort	50.0%	7.1%	0.0%	100.0%	0.0%	27.5%
	OSMR	Count	1	0	0	0	4	5
		% within Cohort	50.0%	0.0%	0.0%	0.0%	80.0%	12.5%
Total		Count	2	14	10	9	5	40
		% within Cohort	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	5.0%	35.0%	25.0%	22.5%	12.5%	100.0%

As indicated in Table 3.26, OMAL application was piloted with 15 users (37.5%), OMMR application with 11 users (27.5%), OCSMR with 9 users (22.5%) and finally OSMR with 5 users (12.5%). These differences were attributed to unequal number of users within the targeted cohorts as indicated in Table 3.27.

Table 3.27: Number of Research Students Per Cohort

	Cohorts				
	Sep-12 Intake	**Jan-13 Intake**	**May-12 Intake**	**Jan-12 Intake**	**Total**
Number of students	15	9	12	10	46
Percentage	33%	20%	27%	22%	100

As described in Table 3.27, January 2013 cohort had the smallest percentage of research students (20%, n=9), while September 2012 cohort had the highest percentage of research students (33%, n=15), followed closely by May-2012 cohort (27%, n=12). This pattern was found be more or less similar to the percentage of users within each cohort (see Table 3.24). The existent of outliers in the data was attributed to study leave and repeat cases. Examples are: one student in September 2011 cohort was using OSMR application and another one in January 2013 was using OMAL application.

It was also observed that Dropbox and Facebook tools can be used to support Cloud-based Services. As described in Table 3.28, Dropbox received 131 requests (22.5%). Additionally, Facebook was used to provide cloud-based communication services and it received 61 requests (10.5%). The system reported 6 request errors (1.0%) and 12 cases of missing results (2.1%).

Table 3.28: The Adoption of Cloud-based Services

Tools	**Service**	**Frequency**	**Percent**
Dropbox	Cloud-based Repository	131	22.5
Error	None	6	1.0
Facebook	Cloud-based Communication service	61	10.5
Local Web Server	Data Storage	370	63.5
Missing	None	12	2.1
Total		580	100.0

The four developed application supported different M-Learning services (activities). Table 3.28 shows that a total of 583 M-Learning activities were performed through the four developed M-Learning applications. Most of the users were accessing feedback from supervisors/assessors (66%, n=385), followed by reading text documents for guiding research process (13.4%, n=78), then collaboration activities through Facebook (9.9%, n=58), followed by watching study Videos (5.5%, n=32) and finally accessing sample deliverables (5.1%, n=30) as illustrated in Table 3.29.

Table 3.29: M-Learning Services across the Four Developed Applications

	M-Learning Services (Activities)					**Total**
	Samples Access	**Feedback Access**	**Facebook Access**	**Read Text**	**Watch Video**	
Count	8	48	11	13	0	80
%Within OCSMR	10.0%	60.0%	13.8%	16.2%	0.0%	100.0%
Count	22	153	25	40	28	268
% Within OMAL	8.2%	57.1%	9.3%	14.9%	10.4%	100.0%
Count	0	119	15	21	4	159
% Within OMMR	0.0%	74.8%	9.4%	13.2%	2.5%	100.0%
Count	0	65	7	4	0	76
% Within OSMR	0.0%	85.5%	9.2%	5.3%	0.0%	100.0%
Total Count	30	385	58	78	32	583
% of Total	5.1%	66.0%	9.9%	13.4%	5.5%	100.0%

M-Learning inhibitors are described as factors that inhibit the development of M-Learning (Muyinda et al., 2010). During piloting stage, several M-Learning inhibitors were encountered. They included technical issues such as authentication failures because of forgotten passwords and failure to retrieve documents or feedback results due to poor network connectivity. The following statements show two errors that were caused by using undeclared variables in context manager.

*"
Notice: Undefined index: Stage1VideoAdress in E: wamp www androidmlearn studentsearch_videoAddre"*

*"
Notice: Undefined index: stage1audioaddress in <b> E: wamp www androidmlearn studentsearch_AudioAddr"*

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents findings and discussions of experimental design study. The purpose of this activity was to achieve the following objective and two associated research questions:

Objective 5: *To compare the developed ambient learning approach with other forms of M-Learning in terms of flexible availability*

Research Question 7: *Is there any relationship between forms of M-Learning approaches and flexible availability and if it exists, can it be moderated by age, gender and experience?*

Research Question 8: *What is the level of flexible availability that ambient learning can afford in comparison to other forms of M-Learning?*

Flexible availability was measured using three main indicators, namely, *anyhow access, anywhere access* and *anytime access*. The other forms of M-Learning were represented by the three developed M-Learning approaches. These are Open Single Mode of Representation M-Learning (OSMR), Open Mixed Mode of Representation (OMMR) and Open Context Aware Single Mode (OCSMR) M-Learning approaches.

The chapter is organized according to the activities conducted during the study, namely, demographic analysis, pre-experimental analysis, post experimental analysis and pre-post experimental analysis.

4.2. Demographic information of participants

Demographic analysis activity was conducted to facilitate the understanding of participants of the study. For the purpose of this study, the following attributes were analyzed:

(i) Distribution of degree programmes: Out of 132 participants whose data was analyzed, most of them were computing students (61%, n=79), of which majority had enrolled for Bachelor of Science in Information technology (Bsc IT) degree programme (85.0%, n=67) and Bachelor of Business and information Technology (BBIT) (15%, n=12). All non - computing students (100%, n=53) had enrolled for Bachelor of commerce (Bcom) (100%, n=53). Within degree programmes, Management of mathematics 11 (MM11) had the highest percentage of participants (40.2%, n=53), followed by Java programming (27.3%, n=36), then principles of Artificial Intelligence (20.5%, n=27) and finally Research skills and design (12.1%, n=16). The high percentage of computing students was as a result of purposive sampling. That is, selection of degree courses that was easily accessible to the researcher.

(ii) Gender: Most of the participants were male (64.4%, n=85) compared to female (35.6%, n=47) out of the number of participants (n=132). This can be attributed to the fact that majority of them had enrolled for computing degree courses (60.8%).

(iii) Age: The predominant age category was 20 -25 years (62.1%, n=82) followed by 26-35 (13.6%, n=18) by a big margin. This distribution can be explained by the fact that most of the participants were fulltime students (69.5%, n=66) in comparison to part time students (43.2%, n=16), who are usually young adults from secondary school.

(iv) Academic level: Majority of the participants were second year students (53%, n=71), followed by third year students (32.6%, n=43) and 1st year students (13.6%, n=18) respectively. Purposive sampling of easily accessible courses was the main contributing factor to this distribution.

4.2 Pre-experiment results

The purpose of conducting pre-experiment was to obtain flexible availability results that could be compared with post-experiment results in order to achieve objective five. The results in this section are divided into two main sections. The first section contains results for addressing research question seven whilst the second section contains the results for addressing research question eight.

(a) Relationships Between Flexible Availability and M-Learning Approaches

Pre-experiment results showed that there was no significant relationship between flexible availability variable and M-Learning approaches (OMAL, OMMR, CSMR and OSMR) without consideration of moderators. This is shown in Table 4.1

Table 4.1: Relationship between M-Learning approaches and Flexible availability

ML Approaches without Moderators	Test of Independence	Flexible Availability Variables				
		Personalized access	Anyhow Access		Any where Access	Any time Access
			Text Access	Video Access		
	Chramer's V	0.564	0.451	0.395	0.358	0.521
	Asymp. Sig.	0.86	0.346	0.629	0.825	0.179

As described in Table 4.1, it was found that the association between the four groups of participating learners and flexible availability indicators was not statistically significant ($p>0.05$). This means that flexible availability was at the same level across the four M-Learning groups.

(b) Pre-experiment Results of Moderators' Effects

Moderators refer to variables that strengthen or weaken a relationship between independent and dependent variable. Examples of such variables include: age, gender and experience (Venkatesh et al., 2003). Pre-experiment results for each of these variables are presented as follows:

(i) Gender Distribution Results showed that a very high percentage of participants (85.2%, n=109) were not using mobile application to access study materials from the supervisor/lecturer, of which most of them were male (86.0%, n=74) compared to female (83.3.0%, n=35). On the hand, among mobile application users to accessing research study materials (14.8%, n=19), the highest percentage was within female (16.7%, n=7) compared to male (14.0%, n=12).

(ii) Age Distribution Results showed that majority of mobile application users were within 20-25 years age group (61%, n=11) followed by 20 years and below group (33%, n=6). Only one mobile application user was within 31-35 years age group.

(iii) Experience Results revealed that majority of mobile application users had only used mobile application to access study materials for one semester (52.6%, n=10) followed by those who had used it more than two semesters (36.8%, n=7). However, these percentages were relatively low compared to non-mobile application users that had used other methods for more than two semesters (39.4%, n=41). This means that mobile application usage in research support is relatively new in comparison to other non-mobile methods such as E-Learning.

After combining M-Learning approaches with each of the three moderating variables (Experience, Gender, Age), the relationship was found not significant as shown in Table 4.2.

Table 4.2: Pre-experiment Results of Moderators' effects

M-Learning With Moderators	Test of Independence	Personalized Access	Anyhow Access		Any where Access	Any time Access
			Text-based Access	Video Access		
ML With Experience	Chramer's V	0.581	0.530	0.523	0.607	0.570
	Asymp. Sig.	0.303	0.421	0.519	0.518	0.353
ML With Gender	Chramer's V	0.250	0.262	0.255	0.231	0.247
	Asymp. Sig.	0.617	0.464	0.559	0.749	0.612
ML with Age	Cramer's V	0.600	0.421	0.609	0.505	0.549
	Asymp. Sig.	0.125	0.534	0.196	0.849	0.525

As described in Table 4.2, there were no significant relationships between the four groups of M-Learning approaches with moderators and the indicators of flexible availability ($p>0.05$). This means that the effect of moderating variables was not significantly strengthening or weakening on the relationship between existing learning approaches and flexible availability variables.

(c) Pre-Experiment Results of Flexibility Availability Level

During pre-experiment evaluation, the flexible availability variable was assessed with the aim of comparing the results with post experiment results. Three indicators of flexible availability were measured as described in the proposed conceptual framework. They include anywhere access, anytime access and anyhow access. Results obtained from each indicator are explained as follows:

Anyhow access Results

Anyhow access is viewed as provision of different strategies for supporting access to digital study materials. In our study, anyhow access aspect was measured using two sub-variables. First, anyhow representation that describes access to multi-modal content (e.g. mixture of video and text) digital. Second, anyhow adaptation that describes access to different digital study materials that are relevant to the current task of the learner. During pre-experiment evaluation activity, the following observations were made with regard to the two sub-variables, namely video access and text access.

Results showed that most participants were not accessing multimodal learning content through mobile application. A higher percentage of both groups strongly disagreed that they could access video format in within mobile application users (21%, n=4) compared to those who strongly agreed (10.5%, n=2). With regard to text access, many mobile application users (15.8%, n=3) strongly agreed that they could access text documents compared to those who strongly disagreed 0% (n=0) respectively. This means that the existing digital learning approaches were enabling access to text formats but support for video access was limited.

Kruskal-Wallis test results showed that the mean ranks with the four groups were less than 15. Among these, the mean rank of OMMR group was the highest (12.21) followed by OCSMR (9.55), OSMR (8.9) and OMAL (6.65). The low mean ranks were attributed to lower percentage of those who agreed that they accessed study materials represented in video formats.

Personalized (Adapted) Access Results

It was observed that only mobile application users (11.1.6%, n=2) were accessing study materials for current task. This is in comparison to a higher percentage of those who disagreed (66.7%, n=12). The observations were viewed as an important pointer that existing learning approaches were not enabling personalized access in terms current research task. In order to test the flexible availability level among mobile application users, Kruskal-Wallis test was conducted. This is shown in Table 4.3

Table 4.3: Anyhow Access in Pre-Experiment Results

M-Learning approaches	**Mean Ranks for Personalized (Adapted) Access**
OMAL	9
OMMR	7.83
OCSMR	6.2
OSMR	13.2
Average Mean Rank	9.0575

As illustrated in Table 4.3, it was observed that the mean ranks of the four targeted groups were less than fifteen. The low level of mean ranks was attributed to limited number of mobile application users (17%, n=16) compared to non-mobile users (83%, n=80).

Anywhere Access Results

Anywhere access results described the degree of freedom to choose location for accessing digital study materials. It was revealed that majority mobile application users strongly agreed that they were accessing study materials at anywhere (21.1%, n=4) compared to those who strongly disagreed (10.5%, n=2). Similarly, most non-mobile application users agreed that they were accessing study materials at anywhere (48%, n=48) compared to those who disagreed within the same group (32.1%, n=34). These observations were interpreted to mean that the existing learning support approaches were enabling anywhere access, which needs to be measured by comparing with other new learning support methods. Table 4.4 shows the level of anywhere access among the four groups targeted to use mobile applications.

Table 4.4: Pre-experiment Results for Anywhere Access

	M-Learning Approach	**Pre-experiment N**	**Mean Rank**
I access study materials in any place through mobile learning application	OSMR	5	9.30
	OMMR	6	8.83
	OMAL	1	6.00
	OCSMR	6	10.92
	Total	18	

As illustrated in Table 4.4, the mean ranks for the four groups were less than eleven. The limited number of mobile application users (n=18) contributed to low mean ranks of anywhere access.

Anytime Access Results

Any time access results described the degree of freedom to choose time for accessing digital study materials. Pre-experiment results showed that within mobile application users, majority disagreed that they could access study materials at any time (41.2%, n=7) followed by those who agreed (35.3%, n=6) and strongly agreed (17.6%, n=3). Table 4.5 shows Kruskal-Wallis test results for anytime access in terms of mean ranks.

Table 4.5: Pre-experiment Results for Anytime Access

	M-Learning Approaches	Pre-experiment N	Mean Rank
	OMMR	6	6.33
	OSMR	5	10.80
I Access at any time through mobile learning application	OCSMR	5	11.40
	OMAL	2	11.00
	Total	18	39.53
	Average	4.5	9.8825

As illustrated in Table 4.5, the average mean rank among the four groups of target participants was less than 10. The limited number of mobile application users (n=18) and high number of participants that disagreed contributed to low level of anytime access.

4.4 Post experiment Results

Post-experiment results showed observations made after conducting experiment. The same variables analyzed during pre-experiment evaluation were also analyzed during post-experiment evaluation. These are M-Learning approaches, moderators and flexible availability. Therefore, this section presents post-experiment results of the three variables according to the two research questions.

(a) Relationships between Flexible Availability and M-Learning Approaches

Post experiment results showed that without incorporation of moderating variables, the four M-Learning approaches (OMAL,OMMR,OSMR and OCSMR) were significantly related in terms of *Personalized Access* and *Video Access* ($P<0.05$). However, it was found that there was no significant relationship between the four M-Learning approaches and three sub-variables of flexible availability ($p>0.05$) in terms of *Anywhere Access*, *Anytime Access* and *Text Access*. These results are shown in Table 4.6.

Table 4.6: Relationships between Flexible Availability and M-Learning Approaches

	Test of Independence	Personalized Access	Anyhow Access		Anywhere Access	Anytime Access
			Text Access	Video Access		
M-Learning Without Moderators	Chramer's V	0.532	0.183	0.400	0.128	0.170
	Asymp. Sig.	0.001	0.444	0.001	0.897	0.615

The results pointed out that all the four mobile applications were enabling *Anywhere access, Anytime access* and *Text Access*. However, not all the applications were enabling *Video Access* and *Personalized Access.*

(b) Results of Moderators' Effects

Post-experiment results showed that a combination of M-Learning approaches and moderators (experience, age and gender) was significantly related to *Personalized Access* and *Video Access* (P<0.05). However, the same combination of M-Learning approaches and moderating variables was not significantly related to *Anywhere Access*, *Anytime Access* and *Text Access* variables (p>0.05). Table 4.7 summarizes these results.

Table 4.7: Post experiment results of Moderators' Effects

M-Learning and Moderators	Measurements	Personalized Access	Anyhow		Any where	Any time
			Text Access	Video Access		
M-Learning and Experience	Chramer's V	0.523	0.233	0.442	0.267	0.285
	Asymp. Sig.	0.001	0.525	0.001	0.459	0.522
M-Learning and Gender	Chramer's V	0.439	0.154	0.367	0.155	0.162
	Asymp. Sig.	0.001	0.699	0.001	0.897	0.644
M-Learning and Age	Cramer's V	0.460	0.353	0.502	0.339	0.341
	Asymp. Sig.	0.009	0.343	0.001	0.349	0.520

Comparing the results in Table 4.6 and Table 4.7, it was found that significance of relationships did not change after including the three moderators. It can therefore be argued that, there was no significant effect of the three moderating variables on the relationship between M-Learning approaches and flexible availability variables.

(c) Flexible Availability Level Results

Normality test showed that flexible availability data was not normally distributed. That is, the significance value of the Shapiro-Wilk test was less than 0.05. Therefore, Kruskal-Wallis test (an example of non-parametric test) was conducted to evaluate the effectiveness of open mobile ambient learning approach (OMAL) in terms of enabling flexible availability. The aim of obtaining these results was to address research question eight. They are summarized as follows:

(a) Personalized (Adapted) Access Results

It was found that a higher percentage of OMAL group (57.9%, n=11) and OCSMR group (57.1%, n=16) agreed that they could only access OER materials for the current research task in comparison to those who disagreed in both groups OMAL (0.0%) and OCSMR (3.8%, n=1). On the other hand, none agreed within OMMR group (0%) and only one agreed in OSMR group (4.8%, n=1) with respect to accessing OER materials for current task only. The test of independence showed that there was significant relationship between developed M-Learning approaches and accessing materials for current access only (Cramer's V =0.532, p= 0.01). A kruskal-Wallis test results indicated these differences were significant (Chi-Square value= 56.986, DF=3, p=0.001). Table 4.8 shows the mean rank for each participating group.

Table 4.8: Mean Ranks for Personalized (Adapted) Access

	M-Learning approach	**N**	**Mean Rank**
In every login session mobile learning application allows access to study materials for current assignment task only	OMAL	19	65.97
	OCSMR	28	59.07
	OSMR	21	23.40
	OMMR	19	22.58
	Total	87	

As described in Table 4.8, the mean rank of OMAL group (65.97, n=19) was the highest among the four M-Learning groups followed by OCSMR (59.07, n=28). However, both OSMR and OMMR had very low means of (23.40, n=21) and (22.58, n=19) respectively. These differences can be explained by the context awareness functionality implemented in both OCSMR and OMAL applications but was missing in OMMR and OSMR applications.

(b)Anyhow Access Results

These results described how mobile applications were enabling access to different formats of study materials e.g. video and text (Kolmel, 2006). The results revealed that the highest percentage of those who strongly agreed that they accessed video files was within OMAL group (26.3%, n=5) followed by those in OMMR group (21.1%, n=4). On the other hand the highest percentage of those who strongly disagreed was within OSMR group (33.3%, n=7) followed by OCSMR group (28%, n=8). Kruskal Wallis Test observations showed that there was a statistically significant difference in accessing video formats between the different M-Learning approaches (Chi-Square value= 36.158, DF=3, p=0.001). Table 4.9 shows the mean rank of video access for each participating group.

Table 4.9: Mean Ranks for Access to Video Formats (Video Access)

	M-Learning Approach	**N**	**Mean Rank**
I access study videos (mp4 files) through mobile learning application	OMMR	19	61.63
	OMAL	19	60.71
	OCSMR	28	33.82
	OSMR	21	26.50
	Total	87	

As illustrated in Table 4.9, the mean rank of OMMR group was the highest (61.63) followed closely by OMAL group (60.71). These mean ranks were twice as high as that OCSMR group (33.82) and OSMR group (26.50) respectively. The results pointed out that access to video formats was mainly supported OMAL and OMMR applications.

With regard to accessing text-based formats (*Text Access*), it was also found that about 63.2% (n=55) of the participants strongly agreed that they could access text documents. That is, presentation format documents, portable document format (pdf) and word processed documents. The highest percentage of those who strongly agreed was within OMMR (47%, n=9) followed by OSMR (42%, n=9), OMAL (36.8%, n=7) and OCSMR (21.4%, n=6) groups respectively. In order to evaluate whether these differences were significant, Krushkal-Wallis test was conducted. This is shown in Table 4.10.

Table 4.10: Mean ranks for Access to Text Formats (Text Access)

	M-Learning approach	N	Mean Rank
I access study texts (pdf/power point/msword) documents for assignments through mobile learning application	OMMR	19	49.37
	OSMR	21	47.43
	OMAL	19	44.84
	OCSMR	28	37.21
	Total	87	

Table 4.10 shows that the mean rank for OMMR (49.37) was the highest, followed by OSMR (47.43), OMAL (44.84) and OCMR (37.21). Krushkal-Wallis test showed the differences among the four groups were not significant (Chi-Square value=4.681, df=3 p=0.197). This means that all the four M-Learning applications were enabling access to text formats.

The overall results for *Anyhow Access* were obtained by combining results for *Video Access* and *Text Access*. This was done by computing the average of both sub-variables as shown in Table 4.11

Table 4.11: Mean Ranks for Anyhow Access

Rank	Developed M-Learning approaches	N	Text Access Mean Ranks	Video Access Mean Ranks	Anyhow access = Average of both Mean Ranks
1	OMMR	19	49.37	61.63	55.5
2	OMAL	19	44.84	60.71	52.775
3	OSMR	19	47.43	26.50	36.965
4	OCSMR	28	37.21	33.82	35.515

As described in Table 4.11, it was observed that OMMR group had the highest mean of 55.5, followed by OMAL group with a mean of 52.78, then OSMR with a mean rank of 36.97 and finally OCSMR with a mean rank of 35.515.

Anywhere Access Results

It was observed that most of the participants strongly agreed that they can access study materials at anywhere using mobile (35.7%, n=30) compared to those who strongly disagreed (2.4%, n=2). Among those who strongly agreed, OSMR group had the highest percentage of 47.4% (n=10) followed by both OMAL (27.8%, n=5) and OMMR groups

(31.6%, n=6). The Kruskal Wallis Test was also applied to compare *Anywhere Access* level for M-Learning approaches. Results obtained from the test are shown in Table 4.12.

Table 4.12: Mean Ranks for Anywhere Access

	M-Learning Approaches	**N**	**Mean Rank**
I access study materials in any place through mobile learning application	OSMR	21	48.64
	OMMR	19	42.71
	OCSMR	27	42.30
	OMAL	18	37.78
	Total	85	

Table 4.12 show that the mean rank for OSMR group (48.64) was the highest followed by that of OMMR (42.71), then OCSMR (42.30) and finally OMAL (37.78). However, Kruskal-Wallis test showed that these differences were not significantly different (Chi-Square value =2.255, 3 =3, p=0.521). The insignificant differences mean that all the four developed M-Learning applications were allowing the same level of anywhere access flexibility.

Any Time Access Results

It was found that participants who strongly agreed that they could access study materials at any time (33.7%, n=28) were more than those who strongly disagreed (2.4%, n=2). In addition, results also showed that none strongly disagreed within both OMMR (0%) and OSMR (0%) groups. The two participants who strongly disagreed in OMAL (n=1) and OSMR (n=1) groups, were viewed as outliers. In order to evaluate whether these differences were significant, Krushkal-Wallis test was conducted. Table 4.13 summarizes these results.

Table 4.13: Mean Ranks for Any Time Access.

	M-Learning Approaches	**N**	**Mean Rank**
I access study materials at any time through mobile learning application	OSMR	21	44.64
	OMMR	19	42.61
	OCSMR	26	40.87
	OMAL	17	39.79
	Total	83	

Looking at Table 4.13, it was observed that OSMR group had the highest mean rank value of 44.64, followed by 42.61 of OMMR group, then 40.87 of OCSMR group, and finally 39.79 of

OMAL group. However, Kruskal-Wallis test results showed that these differences were not statistically significant (Chi-Square=0.533, df=3, p=0.912). Therefore, it was interpreted that all the four developed M-Learning applications were allowing the same level of anytime access flexibility.

Overall flexible Availability Level Results

In order to determine the overall level flexible availability afforded by each the four developed M-Learning approaches, the average of all the mean ranks as indicated in Table 4.14.

Table 4.14: Comparing Means of all Mean Ranks for all flexible availability indicators

Rank	**Developed M-Learning approaches**	**Flexible availability Mean Ranks**					
		Anyhow Access					
		Text Access	**Video Access**	**Personalized Access**	**Anywhere Access**	**Any time Access**	**AVG**
1	OMAL	44.84	60.71	65.14	37.78	39.79	49.65
2	OMMR	49.37	61.63	22.40	42.71	42.61	43.74
3	OCSMR	37.21	33.82	57.50	42.30	40.87	42.34
4	OSMR	47.43	26.50	22.63	48.64	44.64	37.97
	Average	44.71	45.67	41.92	42.86	41.98	**43.43**

Key: AVG : Average

As indicated in Table 4.14, it was observed that the average mean rank value 43.43. Among the four M-Learning groups, the average mean rank of OMAL group (49.65) the highest. This was followed closely by the other three M-Learning groups. That is, OMMR=43.744, OCSMR=42.34, and OSMR=37.97 respectively. A shapiro-wilk test of normality was carried out to assess whether this data was normally distributed. Table 4.13 summarizes these results.

Table 4.15: Normality Distribution of Mean ranks

	M-Learning Approach	Shapiro-Wilk Test Statistic	Df	Sig.
Mean ranks	OMAL	.873	5	.278
	OMMR	.916	5	.503
	OCSMR	.825	5	.128
	OSMR	.854	5	.208

As indicated in Table 4.15, results showed that all sets of mean ranks were normally distributed (p>0.05). Consequently, one-way ANOVA test was conducted to find out whether all the mean ranks were significantly different.

Results showed that there was no significant difference among the mean ranks of the four M-Learning approaches (P> 0.05). This can be explained by the fact that all the four developed M-Learning approaches were tested using the same combination of technologies apart from M-AMI technologies. This is illustrated in Table 4.16

Table 4.16: Multiple Comparisons of all Mean Ranks for Flexible Availability Variables

(I) M-Learning Approach	(J) M-Learning Approach	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
OMAL Mean=48.6940	OMMR	5.25800	7.36103	**.890**	-15.8020	26.3180
	OCSMR	11.43800	7.36103	**.431**	-9.6220	32.4980
	OSMR	6.86200	7.36103	**.788**	-14.1980	27.9220
OMMR Mean= 43.4360	OMAL	-5.25800	7.36103	**.890**	-26.3180	15.8020
	OCSMR	6.18000	7.36103	**.835**	-14.8800	27.2400
	OSMR	1.60400	7.36103	**.996**	-19.4560	22.6640
OCSMR Mean=37.2560	OMAL	-11.43800	7.36103	**.431**	-32.4980	9.6220
	OMMR	-6.18000	7.36103	**.835**	-27.2400	14.8800
	OSMR	-4.57600	7.36103	**.924**	-25.6360	16.4840
OSMR Mean=41.8320	OMAL	-6.86200	7.36103	**.788**	-27.9220	14.1980
	OMMR	-1.60400	7.36103	**.996**	-22.6640	19.4560
	OCSMR	4.57600	7.36103	**.924**	-16.4840	25.6360

As described in Table 4.16, all the P values for indicating the level of significance were more than 0.05. This means that the four M-Learning approaches were statistically providing the same level of flexible availability.

4.5 Comparison Analysis of Pre-experiment and Post Experiment results

(a) Comparison of Relationships Between Flexible Availability and M-Learning Approaches

Comparison analysis of pre-experiment results and post-experiment results showed that there was a change of relationships after conducting the experiment as shown in Table 4.17.

Table 4.17 Comparison Analysis for M-Learning and Flexible Availability Relationships

		Existence of Relationship	
Variables		**Pre-experiment**	**Post-experiment**
Anyhow Access	Text Access	No	No
	Personalized Access	No	Yes
	Video Access	No	Yes
Anywhere Access		No	No
Any time Access		No	No

As illustrated in Table 4.17, it was found that there was significant change of relationships between the four M-Learning approaches and two variables, namely, *Personalized Access* and *Video Access*. However, there was no significant change of relationships with respect to T*ext Access, Anywhere Access* and A*nytime Access*. This means that mobile applications that were previously used by participants to access study materials (e.g. email applications) does not determine access to documents anywhere and anytime. This is the same case for the four developed mobile applications (OMAL, OMMR, OSMR and OCSMR). However, the type of the four developed mobile applications used by individual participants determined whether they could access video clips and whether they could access relevant study materials based on the current task (*Personalized Access).*

(b) Comparison Results for Moderators' Effects

The results for moderators' effects from both pre-experiment and post-experiment evaluation were also compared. This is shown in Table 4.18

Table 4.18: Comparison Results for Moderators' Effects

	Existence of Moderating effect on relationship with Anyhow, Anywhere and Anyhow Access	
	Pre-experiment	**Post-experiment**
M-Learning and Experience	None	None
M-Learning and Gender	None	None
M-Learning and Age	None	None

As illustrated in Table 4.18, results from both pre-experiment and post-experiment evaluation showed that age, gender and experience did not have any moderating effect on the relationship between M-Learning approaches and flexible availability variables. This means that differences in age, gender and experience does not affect flexible availability provided by different mobile learning approaches.

(c) Comparison Results for Flexible Availability

A comparison analysis was conducted to determine whether there was any significant change between pre-experiment and post-experiment results in terms of flexible availability level. The purpose of this activity was to help in answering question eight of our study. Similar to results for both pre-experiment and post-experiment results, comparison results for flexible availability level was divided into *five* main categories. They include *Anyhow Access comparison results, Personalized Access comparison results, Anywhere Access comparison results, Anytime Access comparison results* and *Overall Flexible Availability comparison results.*

(i) Anyhow Access Comparison Results

These results describe the significance of differences of anyhow access between pre-experiment results and post-experiment results. They described the differences between pre-experiment and post-experiment results in terms of two aspects, namely, access to video formats and access to text formats.

Comparison results for *access to video formats (Video Access)* revealed that all the mean ranks of video access increased after conducting the experiment with an average of 58.21. As illustrated in Table 4.19, the average mean rank of the four M-Learning groups increased from 14.86 in pre-experiment results to 73 in post-experiment results. A paired sample t-test results showed that these differences were significant (t=3.964, DF = 3, p=0.05). Among the four groups of participants, the highest increase of mean rank was in OMAL group (53.91) followed closely by OMMR (50.21). However, it was observed that the mean rank increase of both OCSMR (23.9) and OSMR (17.5) groups was not as high as those of OMAL and OMMR groups. This can be explained the fact that both OSMR and OCSMR applications were not designed to allow *Video Access.*

Table 4.19: Mean Ranks differences of Access to Video Formats (Video Access)

		Pre-experiment		Post-experiment		Mean Rank Differences
	M-Learning Approaches	**N**	**Mean Rank**	**N**	**Mean Rank**	
I access study videos (mp4 files) through mobile learning application	OMMR	6	11.42	19	61.63	50.21
	OMAL	1	6.80	19	60.71	53.91
	OCSMR	6	9.92	28	33.82	23.9
	OSMR	5	9.00	19	26.50	17.5
	Total	18	37.14	87	182.66	145.52
	Average	7	14.86	34.4	73	58.21

Comparison results for *access to text formats (Text Access)* indicated that the average mean rank increased from 9.17 in pre-experiment results to 37.21 in post-experiment results. The highest increase was within OSMR group (38.63) followed by OMAL (38.34), OMMR (36.37) and finally OCSMR (28.04). Paired-Samples T-Test results showed that the mean rank differences between pre-experiment and post-experiment in terms of text a*ccess* were significant (t=14.216, DF=3, p=001). Table 4.20 shows these results.

Table 4.20: Comparison of Mean Rank Results for Access to Text Formats (Text Access)

		Pre-Experiment		Post-Experiment		Mean Rank Differences
	M-Learning Approaches	**N**	**Mean Rank**	**N**	**Mean Rank**	
I access study texts documents for assignments through mobile learning application	OMMR	6	13.00	19	49.37	36.37
	OSMR	5	8.80	21	47.43	38.63
	OMAL	2	6.50	19	44.84	38.34
	OCSMR	6	9.17	28	37.21	28.04
	Total	19	37.47	87	179	141.38
	Average	6	9.17	28	37.21	28.04

The overall comparison results for A*nyhow Access* was obtained by comparing the average mean rank values of O*verall Anyhow* Access in pre-experiment results and the corresponding average mean rank values of *Overall Anyhow Access* in post-experiment results. The average mean rank values in both results were computed using the following equation:

$$\textit{Overall Average Anyhow Access} = \frac{\textit{Video Access mean rank} + \textit{Text-based Access mean rank}}{2}$$

Equation 5.1

Results showed that the average mean rank of *anyhow Access* increased from 9.32 in pre-experiment results to 45.1 in post-experiment results. Table 4.21 summarizes these results.

Table 4.21: Comparison of Anyhow Access Results

		Pre-experiment		Post-experiment		Overall increase of *Mean Ranks*
Rank	**Developed M-Learning approaches**	**N**	**Average Anyhow Access of Mean Ranks**	**N**	**Average Anyhow Access of Mean Ranks**	
1	OMAL	2	6.65	19	52.775	46.125
2	OMMR	6	12.21	19	55.5	43.29
3	OSMR	5	8.9	19	36.965	28.065
4	OCSMR	6	9.545	28	35.515	25.97
	Average		9.32	21.25	45.1	35.86

As illustrated in Table 4.21, the average overall increase of mean ranks was 35.86. Among the four M-Learning groups, the highest increase was within OMAL group (46.125) followed closely by OMMR group (43.29). However, there was relatively low increase of mean rank values within OSMR group (28.07) and OCSMR group (25.97). This can be explained by the fact that both OSMR and OCSMR applications were not enabling video access. Results obtained from Paired Samples T-test indicated that the differences of *Anyhow Access* between pre-experiment and post-experiment results were significant (t=6.954, DF=3, p=0.006).

(ii) Comparison Results for Personalized Access

These results were obtained by comparing the mean ranks of *Personalized Access* in pre-experiment results and the corresponding mean ranks in post-experiment results. Table 4.22 shows these results.

Table 4.22: Mean Ranks for Personalized Access

		Pre - experiment		Post- Experiment		Differences of Mean ranks
	M-Learning Approach	**N**	**Mean Rank**	**N**	**Mean Rank**	
In every login session M-Learning application allows access to study materials for current assignment task only	OMAL	1	9	19	65.97	56.97
	OCSMR	5	6.2	28	59.07	52.87
	OSMR	5	13.2	21	23.40	10.2
	OMMR	6	7.83	19	22.58	14.75
	Total	17	36.23	87	171	134.8
	Average	4	9	22	42.76	33.70

As illustrated in table 4.22, the average mean rank of *Personalized Access* increased from 9 in pre-experiment results to 42.76. The highest increase was within OMAL group (56.97) followed by OCSMR group (52.87). However, the Paired T-test results showed that differences of mean ranks for *Personalized Access* between pre-experiment results and post-experiment results were not significant (t=2.736, DF=3, p=0.072).

(ii) Anywhere Access Comparison Results

These results described the difference between pre and post-experiment results in terms of access at anywhere. It was found that the entire mean ranks of *Anywhere Access* in pre-experiment results were found to be lower than the corresponding mean ranks in post-experiment results. As illustrated in Table 4.23, the average mean rank valued increased from 8.76 in pre-experiment results to 42.86 in post-experiment results. The biggest increase was within OSMR group (39.34) followed by OMMR (33.38), then OMAL (31.78), and finally OCSMR (31.38).

Table 4.23: Comparison of Mean Ranks for Anywhere Access

	M-Learning approach	Pre-experiment N	Pre-experiment Mean Rank	Post-experiment N	Post-experiment Mean Rank	Mean Rank Differences
I access study materials in any place through mobile learning application	OSMR	5	9.30	21	48.64	39.34
	OMMR	6	8.83	19	42.71	33.88
	OMAL	1	6.00	18	37.78	31.78
	OCSMR	6	10.92	27	42.30	31.38
	Total	18	35.05	85	171.43	136.38
	Average	4.5	8.76	21.25	42.86	34.10

A Paired Samples T-test results showed that this increase in mean ranks was significant (Paired-Samples T value=-18.608, DF=3, p=0.001).

(iii) Anytime Access Comparison Results

Analysis was also conducted to determine mean rank differences in terms of accessing study materials at any time between pre-experiment and post-experiment as shown in Table 5.24.

Table 4.24: Comparison of Mean Ranks for Anytime Access

	M-Learning Approaches	Pre-experiment N	Pre-experiment Mean Rank	Post Experiment N	Post Experiment Mean Rank	Differences Of Mean Ranks
I Access at any time through mobile learning application	OMMR	6	6.33	19	42.61	36.28
	OSMR	5	10.80	21	44.64	33.84
	OCSMR	5	11.40	26	40.87	29.47
	OMAL	2	11.00	17	39.79	28.79
	Total	18	39.53	83	167.91	128.38
	Average	5	9.8825	21	42.00	32.10

Looking at Table 4.24, all the mean ranks of post- experiment results were found to be higher than those pre-experiment results. The average mean rank value increased from 9.88 in pre-experiment results to 42.00 in post experiment results. The biggest increase was within OMMR group (Diff=36.28) whilst OMAL had the lowest increase (Diff=28.79). Results obtained from Paired-Samples T-test showed that this increase in mean rank values was significant (t=-17.948, DF=3, p=0.001).

4.6 Summary of Experiment Results

Results obtained from experimental design study can be summarized with two main concluding assertions that can be used two answer research question seven and eight respectively. First, the four developed mobile learning approaches were found to be significantly related with flexible availability in terms of *Anyhow Access* and *Personalized Access*. Additionally, the three moderating variables (Experience, Gender and Age) did not significantly affect this relationship. Figure 4.1 summarizes these results.

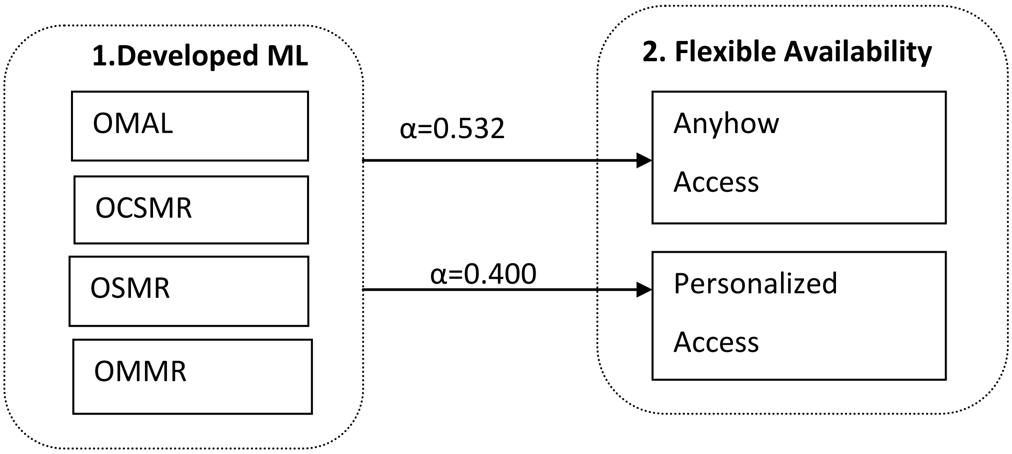

Figure 4.1: Relationships between M-Learning approaches and Flexible Availability

Second, flexible availability level of accessing OERs and cloud-based services increased significantly ($P<0.05$) after using the four developed M-Learning applications (OMAL, OMMR, OSMR and OCMR). As indicated in table 4.25, the average increase of mean ranks among the four developed M-Learning approaches was 36.30. The highest was within OMAL group (44.16) followed by OMMR 35.57, OCSMR (35.41) and finally OSMR (30.06). Paired Sample T-test results revealed that there was significant difference in terms of *Video Access* ($p=0.032$), *text access* ($p=0.01$), *Anywhere Access* ($p=0.001$) and *Anytime Access* ($P=0.001$). However, it was surprising to find that there was no significant difference in terms *Personalized Access* ($p=0.072$). Table 4.25 summarizes these differences.

Table 4.25: Differences of Mean Ranks between pre and post experiment results

Rank	ML Approach	Differences of Mean Ranks between pre and post experiment results					
		Anyhow Access					
		Text Access	Video Access	Personalized Access Diff	Any where Access Diff	Any Time Access Diff	Average Differences
1	OMAL	38.34	53.91	56.97	31.78	39.79	44.16
2	OMMR	36.37	50.21	14.75	33.88	42.61	35.57
3	OCSMR	28.04	23.9	52.87	31.38	40.87	35.41
4	OSMR	38.63	17.5	10.2	39.34	44.64	30.06
	Average	35.35	36.38	33.70	34.10	41.98	36.30

Key: Diff = Differences

4.7. Discussion of Results

The purpose of this section is to discuss results obtained during the study. The section is organized according to research questions and hypotheses of the study. They include the following:

RQ1: What are the challenges and motivations, among other features that can be used to describe of M-Learning context?

Results from this study showed the following features that are suitable for describing M-Learning context:

(i) M-Learning propellers (motivations), which are viewed as factors that encourage M-Learning growth in university learning. Our study identified three main M-Learning motivations. First, high penetration of mobile phones (>90%) among learners, which include both ordinary mobile phones and smartphones as indicated in Tables 3.5, 3.6 3.7. These results are comparable to observations made by other similar studies conducted in African universities as shown in Table 4.26.

Table 4.26: Results from previous studies in African based universities

University	Own Mobile Phones	smart phones
University of Cape town (CED,2010 as cited in (Rambe Patient 2013)	98%	x
Makerere university (P. Muyinda et al., 2010)	97%	x
A South Africa University (Uys et al. 2012)	x	60%
Catholic university of Mozambique (Henzinger Gerald 2011)	99%	x
50 Kenyan (Kashorda and Waema 2014)	x	53%

Key x: Data is not Available

Second, potential capability associated with some types of mobile phones. For instance, it was found that majority of learners with smartphones only were using their handsets to access E-learning content (55.8%, n=110). However, most of those who owned ordinary phones only were not using their phones to access E-learning content (70.3%, n=154) as described in Table 3.10. Third, adequate availability of wireless network in public and private universities (85.5%, n=600), which provides an enabling environment for using mobile phones to access digital study materials such as study guides. Table 3.9 shows these results.

(ii) M-Learning inhibitors refer to factors that hinder the growth of M-Learning in a typical M-Learning context like universities. It was observed that there are several M-learning inhibitors in Kenyan universities. These are small screen of mobile devices, high cost for accessing M-Learning services, poor access to internet-enabled mobile devices, poor network connectivity, preference of using personal computers, incompatibility of content format, and, limited memory of mobile devices. These results are summarized in Tables 3.13 and 3.14.

(iii) M-Learning services are described as learning activities provided through mobile devices. The study found that there are three main M-Learning services within the M-Learning context of Kenyan universities. They include, (a) collaboration services that consist of messaging and chatting facilities provided by cloud computing tools such as Facebook and Twitter as shown Tables 3.11, (b) pedagogical services that entails using mobile devices to accessing E-learning materials such as study documents and assessments as indicated in Table 3.10, and, (c) information services, which provide administrative information such as reminders and notifications of important events such as exam dates and assignment deadlines as described in Table 3.12.

RQ2: Are features of M-Learning context related to each other?

From the results obtained through survey research, there were significant relationships between features of M-Learning context. These can be explained as follows:

(i) *M-Learning environment* was found to influence *motivations of M-Learning*. For example, results showed there was higher percentage of students with smartphones only in private universities (37%, n=130) than in public universities (30%, n=71) as described in Table 3.8. It was also observed that private universities are characterized by high availability of wireless network (WIFI) compared to public universities as indicated in Table 3.9. The higher availability of wireless network and smartphones in Kenyan private universities is an indication that they are more M-Learning ready than Kenyan public universities.

(ii) Motivations of M-Learning determine both *M-Learning inhibitors* and *M-Learning services*. Most students with smartphones were accessing pedagogical services while those with ordinary phones were mostly using them to access information services (Table 3.12). The observed relations can be attributed to internet access capability of smartphones and technical limitations ordinary phones (low-end) phones.

Based on these on observations, we reject the first null hypothesis and fail to reject the corresponding alternative hypothesis that features of M-Learning context are related to each other. However, this assertion could not be compared with the reviewed studies since none of them was found to have investigated how features of M-Learning context are inter-related. Therefore, there is need for future research that can compare results from our study with results obtained from other similar M-Learning contexts.

RQ3: Are there cases of current M-Learning forms that focus on university level learning in African universities?

In the results obtained using case-based research during defining objectives phase, single mode representation (SMR) learning was most popular M-Learning approach in African universities (43%, n=6). All of them were using SMS technology to support information services and many of them were in South Africa. The popularity of SMR M-Learning approach can be attributed to high prevalence of low-end mobile devices (dumb mobile phones or ordinary phones) among learners that can only support basic functions such as send SMS text messages and voice calls. These results are consistent with UNESCO (2012) report, which notes that majority of M-Learning projects in Africa use lower-end mobile handsets and rely on text-based communication to support interaction, learning, and teaching. Text-based communication includes the utilization of SMS and mobile instant messaging.

Case based research results also indicated that there were only two cases (13%, n=2) of ambient learning out of all reviewed M-Learning cases (n=14). Therefore, it can be argued that ambient learning is not prevalently adopted in African universities. The main contributing factors could be lack of adequate ICT infrastructure in African universities that includes east African universities (Kashorda and Waema 2009, 2014). These results confirm observations by Bick et al.(2007) that ambient is not widely adopted.

RQ4: If cases exist, which M-Learning context features and objectives are related to those cases?

From the results of case based research, it is clear that the four categories of M-Learning projects can be distinguished by their main objectives and associated features as follows:

(i) *SMR M-Learning projects* aim at using mobile technologies to support single mode represented collaboration and information services at anywhere and anytime. This objective could have contributed to high prevalence of SMR M-learning projects in African universities. This is because delivery of single mode formats can be enabled by low-end phones, which are owned by majority of learners in African based universities (Muyinda et al,. 2010; Uys et al. 2012).

(ii) *Context aware single mode of representation (CSMR) M-Learning projects* aim at allowing access to unimodal collaboration services at anywhere and anytime by considering M-Learner's context through mobile technologies. The complexity of implementing context awareness in M-Learning systems could have contributed to low adoption of CSMR projects in African universities (7%, n=1).

(iii) *Mixed modes of representation (MMR) M-Learning* projects aims at supporting access to multi-modal content at anywhere and anytime through mobile technologies. The main M-Learning services afforded by MMR M-Learning are collaborative and content delivery. The high prevalence of MMR M-Learning projects can be attributed to the increasing need for use of high end phones for enhancing learning environment through multi-modal support (Mwendia and Buchem 2014). However, this category of M-Learning approaches fails to consider the context of the learner for enabling personalization of learning content. Therefore, some of the delivered M-Learning services may be irrelevant to needs of learners.

(iv) *Ambient Learning* projects aim at enabling access to collaboration services and delivery of locally stored, high quality and personalized content at anywhere, anytime and anyhow through immobile ambient intelligence technologies (AMI) and Mobile technologies. However, Immobile AMI technologies require high cost investments that may not be afforded by individual learners to allow learning away from university establishments. Therefore, it is difficult to implement existing ambient learning projects in 'computer-poor' contexts where location dependent technologies are not readily available, e.g. remote areas of the less connected countries (LCC). This limitation of immobile - AMI can be used to explain low adoption of ambient learning projects in Africa (14%, n=2). In order to realize the goal of ambient learning, there is need for innovative ambient learning approaches like OMAL that use readily available technologies like mobile phones. Such approaches can reduce the need to use immobile AMI technologies, which are more expensive and complex to install.

Results for research question four are comparable to UNESCO (2012) report, which identifies three main features M-Learning projects. First, M-Learning goals, that are categorized according to the Education for all Goals (EFA). Second, challenges of M-Learning that include limited-phone based educational content and applications, anti-mobile phone sentiments in communities and technical limitations of mobile phones. Third, motivations of M-Learning that include exponential growth of mobile phones, systematic failures in traditional education delivery, potential in enabling open distance learning and new methods that youth are using with mobile phones. However, observations described by UNESCO (2012) report are not exhaustive. For example, the ambient learning cases in African universities e.g. DLH and IClass have not been reviewed.

RQ5: Which is the appropriate model that can be used to describe ambient learning approach for enhancing flexibility availability of research supervision services in the identified learning context?

Findings from design and development phase indicate that development of an ambient learning entails specification of the following development artefacts:

(i) Requirement specifications that translate identified problems to user requirements. This can be realized using an example of learning scenario (Mwendia and Buchem, 2014).

(ii) Technological classification framework for describing type of ambient intelligent technology that is appropriate for the identified M-Learning context (Mwendia, Wagacha, and Oboko 2015).

(iii) Pedagogical classification framework that describes type of ambient learning that is appropriate for the approach to be developed (Mwendia, Waiganjo, and Oboko 2013).

(iv) System architecture for describing components of ambient learning system to be developed (Mwendia et al., 2014).

(v) Information Retrieval algorithm, which explains the logical flow of the ambient learning system to be developed.

(vi) Mobile application that implements all the designed artifacts to enhance flexible availability of research supervision services.

During creative process, results from two sub-processes were used to validate and improve the proposed artefacts. First, consultations with supervisors and experts in the field Technology Enhanced Learning (TEL) as described in section 3.5.4. Second, communicating the artefacts to relevant audience through book chapters and conference publications as described in section 3.5.5.

Observations from design and development processes are comparable to other previous studies as shown in Table 4.27.

Table 4.27: Design and Development Models from Similar Studies

Author	Derived Aspects
Liro(2012)	: Mobile-phone-centric system architecture for Ambient Intelligence services (M-AMI)
Bick et al.(2007)	: Ambient learning framework
Augusto (2010).	: Ambient Intelligence (AMI) System Model.
Mikulecký (2012)	: Properties of smart environment for learning
Maheshwaree (2008)	: Mobile-phone-centric ambient intelligence services
ALCAÑIZ, and REY(2005)	: Categories of Ambient Intelligence technologies
Elaine Rich, Knight, and Shivashankar B Nair (2009)	: Greed best first search that use static heuristics
Soulah-Alila, Nicolle, and Mendes(2013)	: Semantic search approach

RQ6: How can ambient learning approach be used to support research supervision services?

Findings from the demonstration phase indicate that *use case scenario* method can use a hypothetical example to demonstrate artefacts of ambient learning approach. The phase demonstrated two artefacts as a representative of the developed artefacts. First, demonstration of how a typical research student can use OMAL application to collaborate with the supervisor when undertaking a research project. Second, demonstration of how proposed information retrieval algorithm can be used by OMAL application to retrieve relevant OERs from cloud-based repositories.

Both artefacts were validated through writing conference papers that were accepted after a competitive peer review process (Mwendia and Buchem 2014; Mwendia et al,.2014, 2016) . This is a key indicator that the two artefacts are novel and contribute to body of knowledge.

RQ7: Is there any relationship between current forms of M-Learning approaches and flexible availability of M-Learning relationships and if it exists, can it be moderated by age, gender and experience?

Observations from experimental design study showed that there was no significant relationship between types of M-Learning approaches and flexible availability variables before the experiment was conducted as illustrated in Table 4.1. After carrying out the experiment, results showed that the developed M-Learning approaches were significantly related to *Personalized Access* and *Video Access* variables (P<0.05). However, the M-Learning approaches were not significantly related to *Anywhere Access, Anytime Access* and *Text Access* variables (p>0.05) as indicated in Table 4.6. Since there was a significant change of relationships between pre-experiment results and post-experiment results, we reject the null hypothesis one (H01) and fail to reject alternate hypothesis one (H11). Therefore, we conclude that the type of M-Learning approach adopted determines the level of flexible availability afforded.

After combining M-Learning approaches with each of the moderating variables (Experience, Gender and Age), significance of all relationships did not change in both pre-experiment results and post experiment results. This is shown in Table 4.2 and Table 4.7 respectively. Therefore we fail to reject the second null hypothesis (H02) and reject the alternate hypothesis (H12). This means that experience, gender and age do not moderate the relationship between current forms M-Learning approaches and flexible availability.

Table 4.28 summarizes observations made by other similar studies

Table 4.28: Moderation Effects Results from other Studies

Author	**Derived aspects**	**Results from previous studies**
McElroy and et al.(2007)	Age, Gender	: Moderation by ages is not significant
Yaneli, Imed, and Said (2014)	Experience	:Moderating effect for effort expectancy and social influence on performance expectancy is not significant

RQ 8: What is the level of flexible availability that ambient learning can afford in comparison to other current forms of M-Learning?

From the findings of experimental design method indicated that the overall Flexible availability mean rank for OMAL (49.652) was the highest in comparison to mean ranks of the other three developed M-Learning approaches. However, one way ANOVA test results, it was observed that there was no significant difference among the mean ranks of the four developed M-Learning approaches (P> 0.05). We therefore fail to reject null hypothesis one (H03) and reject alternate hypothesis one (H13) that flexible availability afforded by OMAL is different from the one afforded by variants of M-Learning approaches. These findings can be explained by the fact that all the four M-Learning approaches were tested under similar M-Learning context and using similar combination of technologies apart from mobile phone-centric ambient intelligence technologies.

From the comparison of pre and post experiment results, the average increase of mean rank was 36.299 among the four M-Learning approaches as described in Table 4.25. Observation from a *paired samples test* indicated that this difference was significant (p=001). Since the highest difference was within OMAL group (Diff=158), we reject our null hypothesis four (Ho4) and fail to reject the alternate hypothesis four (H14) that flexible availability afforded by ambient learning differs from that of existing M-Learning approaches.

4.8 Summary of Study Findings

The results of our study can be generalized using the resulting framework from the conceptual framework. This is shown in Figure 4.2

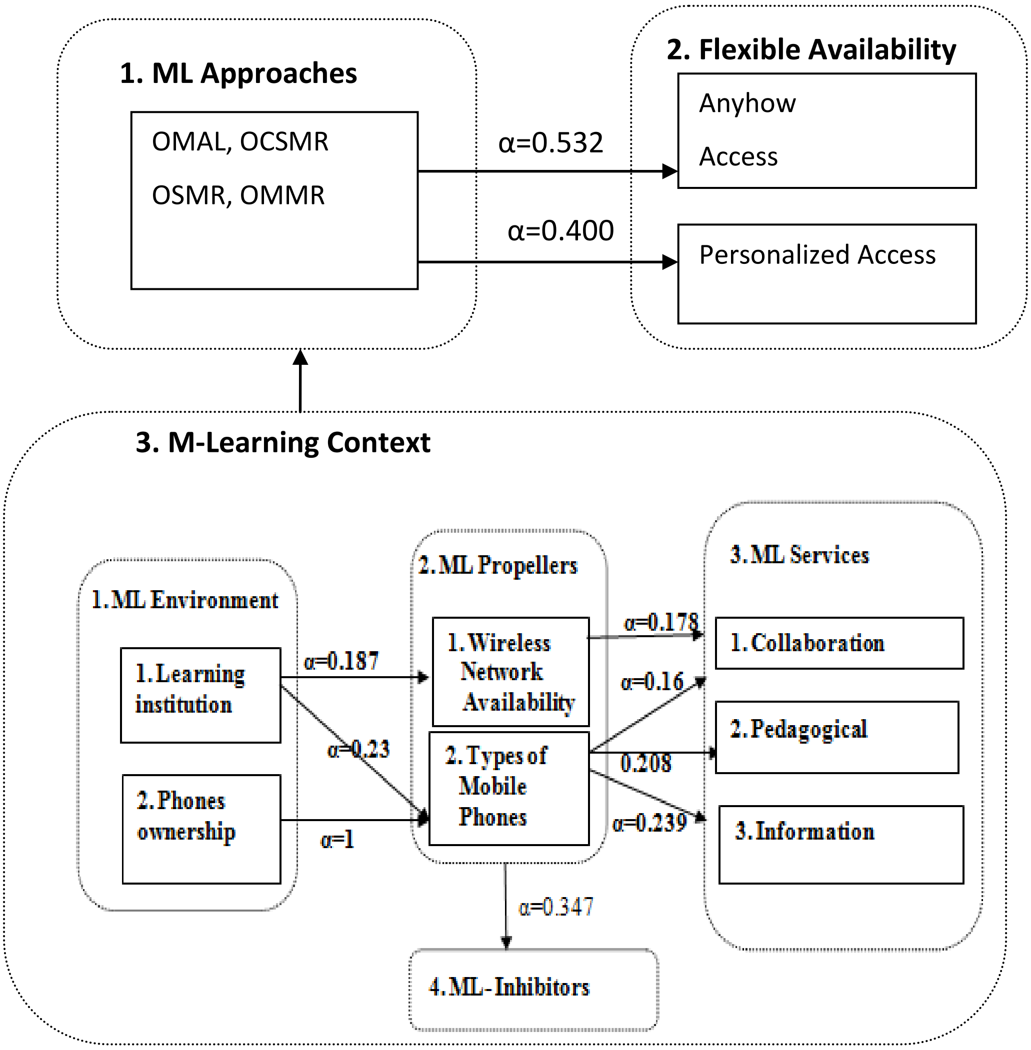

Figure 4.2: Resulting Framework from Conceptual Framework

As illustrated in Figure 4.2, the relations between evaluated variables can be summarized with three main assertions. First, features of M-Learning context are related. That is, *M-Learning Environment* influences *M-Learning Propellers* that in turn determine M-Learning services and M-Learning. Second, M-Learning approaches are significantly related to flexible availability in terms of *Anyhow Access* and *Personalized Access*. Thirdly, such a relationship may not be moderated by age, gender and experience.

The study also revealed that ambient learning is not widely adopted in East African universities. Therefore, there is need for innovative ambient learning approaches like OMAL that use features of M-Learning context such as 'mobile rich' but 'computer-poor'-'contexts. The development of such approaches requires taking advantage of readily available technologies like mobile phones and specification of conceptual models like OMAL approach model. In order to implement the model, there is need to specify a supporting implementation model like a pedagogical classification framework, technological classification framework, system architecture and information retrieval algorithm.

Observations from experimental design study suggests that implementation of ambient learning can significantly increase flexible availability of research supervision services. This is in comparison to other existing M-Learning approaches that do not support representation anyhow and adaptation anyhow.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses opinions of the researcher that were derived from the results of the study. It is organized into four main sections, namely, overview of the findings, contributions, limitations and recommendations for other research activities to be undertaken in future.

5.2 Overview of the Findings

The first objective of our study *was to establish the features such as challenges and motivations that can be used to describe characteristics of the mobile learning context.* From the results of this objective, it can be concluded that there are four main features of M-Learning context. First, M-Learning propellers encourage the development of M-Learning. They include high penetration of mobile devices and adequate availability of wireless networks. Second, M-Learning inhibitors hinder the development of M-Learning. They include limitations of mobile devices (e.g. small screen and limited storage), high cost of using mobile devices (e.g. the price of buying bundles), limited internet connectivity, preference to use computers and limited multi-media capability (e.g. unable to download video). Third, M-Learning environment refers to learning settings where both M-Learning propellers and M-Learning inhibitors are located. Examples are private and public universities where learners with mobile phones are enrolled. Fourth, M-Learning services refer to functions for supporting learning activities through mobile devices. These can be categorized into the following categories:

(i) Information services that enable delivery of administration information such reminders of consultation and examination dates.

(ii) Pedagogical services that allow delivery of course content such as research guides that may be in single format or multi-modal format.

(iii) Collaboration services that support interaction among learners and with their supervisors (or instructors). They involve using chatting through social media tools such as Facebook and twitter, among others.

The second specific objective was *to study objectives of M-Learning projects that have adopted current forms of M-Learning with a view of enhancing flexible availability towards* *ambient learning.* From the results of this objective, it can be concluded that majority of mobile learning projects in African universities aim at allowing single mode of representation M-Learning. This is largely attributed to the view that there is high prevalence of low-end mobile phones among learners in these universities. In addition, it can be argued that ambient learning is not prevalent among African universities. One of the contributing factors is the requirement to use immobile AMI technologies which are usually expensive and complicated to implement. Examples of such technologies are smart boards and sensors that are embedding on everyday objects like furniture (desks, chairs and tables) and classroom walls.

The third specific objective was *to design an ambient learning approach that enhances flexible availability of research supervision services*. From the findings of this objective, it can be concluded that combining M-Learning approaches with other concepts can help to address limitations of mobile devices. There are three examples of such concepts. First, cloud computing services are suitable for enlarging storage capacity of mobile phones through provision of cloud-based repository services. Second, open education resources (OER) reduces the effort required to author study materials for research support and the cost of using mobile devices. Third, mobile phone-centric ambient intelligence technologies are appropriate for enabling delivery of personalized OER at anytime, anywhere and anyhow (e.g. different representation formats).

The fourth third specific objective was *to demonstrate application of ambient learning approach.* From the observations of this objective, it evident that use case scenario method is an appropriate method demonstrating how proposed ambient learning models can be used. This requires use a hypothetical example for showing a sequence of activities that can be enabled by the model. In this study, the method was used to demonstrate two artefacts of implementing OMAL model, namely, OMAL mobile application and information retrieval algorithm.

The last specific objective of our study was to compare the developed ambient learning approach with other forms of M-Learning in terms of flexible availability. From the findings of this objective, we can make two conclusions. First, M-Learning approaches are significantly related to flexible availability variable in terms *Anyhow Access* and *Personalized Access*. Second, OMAL approach can allow flexible availability of research project supervision that is significantly higher than existing learning approaches that do not support anyhow access. However, the flexible availability level afforded by OMAL is not significantly different from M-Learning approaches that have been developed using similar combinations of concepts. Examples, OMMR, OSMR and OCSMR that have been developed by combining cloud computing services, OERs and mobile technologies.

5.3 Contributions.

This study has made several contributions in the field of technology supported learning. These can be categorised into two main categories. That is, pedagogical contributions that extend existing pedagogical M-Learning frameworks and technological contributions that expand existing technology models for learning support.

5.3.1 Pedagogical Contributions

The proposed classification framework for ambient learning is viewed as a pedagogical contribution to the field of technology enhanced learning. The framework describes three types of ambient learning that aims at allowing flexible learning support (high quality and personalized content delivery at anytime, anywhere and anyhow). The three types are distinguished by the mobility of the enabling technology. They are:

(i) Mobile interface ambient learning (MIAL) that is enabled by use of mobile devices only

(ii) Fixed interface ambient learning (FIAL), which uses location dependent devices only for learning support

(iii) Hybrid interface ambient learning (HIAL) that utilizes both mobile and location dependent devices to achieve the objective of ambient learning (Mwendia et al., 2013).

5.3.2. Computer Science Contributions

The proposed communication oriented design science research methodology (CODSRM) extended design science research methodology proposed by Peffers et al.(2008) by integrating communication activity in every stage of the methodology. The aim of integration was to allow immediate delivery of results to relevant audiences so that they can use the knowledge when it is still new and relevant. As a result, five publications were published. They include two book chapters and three conference papers. Both book chapters are published by IG Global publishers (Mwendia et al.,2014; Mwendia et al., 2015) whilst the three conference papers are published in three different internationally recognized publishers. These are Institute of Electrical and Electronics Engineers (IEEE), Japan Institute of Advanced Technology (JIAT) and UNESCO (Mwendia et al., 2013;Mwendia and Buchem 2014; Mwendia et al.,2014).

The study also proposed a novel approach known as *Inverted-T* adoption approach that is suitable for guiding the adoption of design science methodologies. The approach extends the phased approach described by Craig et al. (2008) to address the problem of generalization that is associated with design science methodologies (Saltuk and Kosan 2014). In this study, the *Inverted-T* adoption helped was successfully used to guide the adoption of CODSRM.

Through this study, new system architecture was proposed to support instantiation of OMAL applications. During the proceedings ICCE2014 conference in Nara, Japan, the authors of the paper describing the architecture were awarded a certificate of recognition. That is, certificate for proposing best technical design in the field of Class, Ubiquitous computing and mobile technologies (CUMTEL). The architecture can help to provide a theoretical foundation for instantiating OMAL applications in 'mobile rich' but 'computer-poor' M-Learning contexts similar to African countries (Mwendia et al., 2014).

In the field of artificial intelligence, a new searching technique known as Dynamic Heuristics - Greedy Search (DGS) was proposed. The technique enhances Greedy Best -first search method (Rich, Knight, and Nair, 2009) by using dynamic heuristics rather than static heuristics to find a solution. DGS helps to automatically generate a search query when using mobile devices with small screens for retrieving relevant information like OERs. It is recommended for situations where users do not know the titles of materials with information that is relevant to the current research goal. A paper that describes DGS technique was submitted to Africhi06 conference call for proposals. The paper was accepted after undergoing two rounds of rigorous peer review process. During the first round, the paper was accepted with major changes but after undergoing the second round review, it was accepted with minor changes (Mwendia et al. 2016).

Finally, an ambient learning application was developed to implement and demonstrate the application of OMAL model (Mwendia et al.,2014). The application allows users to access relevant OERs from cloud-based repositories like Drop box and Google drive. It was evaluated by comparing its effectiveness with three other developed mobile applications. These are Open single mode representation (OSMR), Open mixed modes representation

(OMMR), and Open context aware single mode (OCSMR). Although not significantly, the overall results showed that OMAL application performed better than the other three mobile applications in terms of enhancing flexible availability.

5.4 Limitations

There are few limitations that are associated with this study. They include the following:

(i) The study focused on investigating the development of an ambient learning model based on the learner perspective. The model was therefore learner-centric since it aimed at addressing challenges encountered by research students such as non-availability supervisors and limitations of mobile phones.

(ii) Out of the three proposed categories of ambient learning (FIAL, MIAL and MIAL), only mobile interface ambient learning (MIAL) that was evaluated through OMAL application (Mwendia et al., 2013; Mwendia et al., 2014; Mwendia and Buchem, 2014). However, the effectiveness of similar remaining categories (FIAL and HIAL) was not established.

(iii) The study focused on using smartphones to implement the OMAL model that could not allow authoring of assignments (Mwendia et al. 2016). Therefore, there is need for evaluating the application of other mobile devices like Personal digital assistants (PDAs) to implement OMAL.

5.5 Recommendations

Based on what was achieved in each specific objective, we recommend the following research tasks to be carried out in future:

(i) **From objective one results** we recommend regular research surveys for providing up to date information on M-Learning context in East African universities. This is particularly important due to the dynamic nature of mobile penetration among African countries that is exhibited by high mobile growth rate (ITU 2014).

(ii) **From objective two results** there is need to investigate the existence and associated features of ambient learning cases in other M-Learning contexts. Examples are primary and secondary schools in African countries. The results of such an investigation can help to understand the adoption level of ambient learning in lower level education as well as its potential benefits.

(iii) **From objective three results,** we suggest three future research activities**.** First, there is need for extending OMAL model so that it can integrate perspectives of research project supervisors. This is likely to enhance further flexible availability of the research supervisors in university level learning. Secondly, additional investigation is required to establish potential benefits of combining FIAL and HIAL categories with other concepts. For example, combining with Cloud Computing Services, open education resources and mobile phone-centric ambient technologies (Mwendia et al., 2014). Results of such a study can be used to widen the adoption of ambient learning globally since it is still limited (Winkler et al., 2011). Thirdly, there is need for incorporating data mining module in OMAL architecture in order to automate knowledge extraction process. The module may be connected to the context database that contains huge amount of context data that accumulates over time. The extracted knowledge may be used for improving ambient learning systems to achieve their goals.

(iv) **From Objective four results** we suggest further demonstration of how OMAL can be applied using other mobile devices rather than using smartphones only. For example, Personal digital assistants (PDAs), windows phones and dumb phones. This is likely to increase the degree of freedom to choose mobile devices for accessing *personalized* research project supervision services at *anytime, anywhere* and anyhow*.* Such a study can focus on the most prevalent mobile devices among the target group to promote education inclusion.

(v) **From objective five results** we recommend further evaluation of OMAL to establish its effectiveness in other information rich domains. These include tourism and hospitality industries, where a lot of information services are delivered to target potential customers.

Thesis statement

"The strength of a shepherd is a rod but the strength of a scholar is knowledge"

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APPENDICES

Appendix 1: Publications

This appendix contains a list of publications that have been published from this study.

1. Mwendia, S., Wagacha, P.W., Oboko, R., 2015. Ambient Learning Conceptual Framework for Bridging Digital Divide in Higher Education, in J. Keengwe(Ed.), *Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies(243-273),* Hershey, PA: IGI Global. doi:10.4018/978-1-4666-6343-5. Can be retrieved from: http://www.igi-global.com/chapter/ambient-learning-conceptual-framework-for-bridging-digital-divide-in-higher-education/115479

2. Mwendia, S.N., Manske,S.& Hoppe,U.(2014),*Supporting E-Learning in Computer-poor Environments by Combining OER, Cloud Services and Mobile Learning*. Paper presented at the 22nd ICCE2014 Conference, Nara,Japan. (545-550), ICCE 2014 Organizing Committee, Japan ISBN 978-4-9908014-1-0.Can be retrieved from: http://icce2014.jaist.ac.jp/icce2014/wp-content/uploads/2014/12/ICCE2014-Main-Proceedings-lite-1.pdf.

3. Mwendia.S.N, Buchem I.,2014,*'Open mobile ambient learning: The next generation of mobile learning for mobile-rich but computer-poor contexts*, Paper presented at UNESCO Mobile Learning Week 2014,Paris-France. can be retrieved from: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ED/pdf/R9WAMB2-SimonNyaga-KCAUniversity.pdf.

4. Mwendia, S., Waiganjo, P., Oboko, R., 2013. *3-Category Pedagogical Framework for Context Based Ambient Learning*. Paper presented in: IST-Africa 2013 Conference Proceedings. Nairobi, Kenya. IEEE, ISBN:978-1-905824-38-0. Can be retrieved from: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6701749&url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D6701749.

5. Mwendia, S., Wagacha, P.W., Oboko, R., 2014. Culture Aware M-Learning Classification Framework for African Countries.In S..J. Keengwe, G Schnellert & K Kungu (eds): *Cross-Cultural Online Learning in Higher Education and Corporate Training (98-111)*. IGI Global. Pennsylvania,USA. . DOI: 10.4018/978-1-4666-5023-7.ch005 . Can be retrieved from:http://www.igi-global.com/chapter/culture-aware-m-learning-classification-framework-for-african-countries/92440

Appendix 2: Permission to Conduct Research

This appendix contains appended copies of permission to conduct research letters from various institutions. They include one letter from National Commission of Science and technology (NACOSTI) and several letters from some of the sampled universities

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/13/013/79**

Date: **2nd July 2013**

Simon Nyaga Mwendia
University of Nairobi
P.O Box 30197-00100
Nairobi.

RE: RESEARCH AUTHORIZATION

Following your application dated **26th June, 2013** for authority to carry out research on "***Context aware Model for ambient intelligent Mobile learning in Higher learning institutions.***" I am pleased to inform you that you have been authorized to undertake research in **Selected Counties** for a period ending **31st December, 2014.**

You are advised to report to **the Vice Chancellors of Selected Universities** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The Vice Chancellor
Selected University.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Simon Nyaga Mwendia
of (Address) University of Nairobi
P.O Box 30197-00100, Nairobi.
has been permitted to conduct research in

Location
District
Selected Counties

on the topic: Context aware Model for ambient intelligent Mobile learning in Higher learning institutions.

for a period ending: 31st December, 2014.

PAGE 3

Research Permit No. *NCST/RCD/13/013/79*
Date of issue *2nd July, 2013*
Fee received *KSH. 2000*

Applicant's Signature

For Secretary
National Council for
Science &Technology

UNIVERSITY OF NAIROBI

OFFICE OF THE DEPUTY VICE - CHANCELLOR

(Research, Production & Extension)
Prof. Lucy W. Irungu B.Sc., M.Sc., Ph.D.

P.O. Box 30197-GPO.
00100,Nairobi-Kenya
Telephone: +254-20-2315416 (DI), 318262

Fax:0202317251
Email:dvcrpe@uonbi.ac.ke

August 15, 2013 UON/RPE/3/5

Mr. Simon Nyaga Mwendia
C/o School of Computing and Informatics

Mr. Mwendia

PERMISSION TO CARRY OUT RESEARCH

I write to inform you that your request to conduct your Ph.D. research study in the University of Nairobi, Kenya entitled: ***"Context aware Model for ambient intelligent Mobile Learning in higher learning institutions"*** for the award of degree from the University of Nairobi, Kenya is hereby approved.

On completion of your research study, you are required to share the findings of your study by depositing a copy of your research findings/thesis with the University Librarian.

Yours Sincerely

LUCY W. IRUNGU
DEPUTY VICE-CHANCELLOR
(RESEARCH, PRODUCTION AND EXTENSION)
AND
PROFESSOR OF ENTOMOLOGY

cc. Vice-Chancellor
Deputy Vice-Chancellor (AA)
Deputy Vice-Chancellor (A&F)
Deputy Vice-Chancellor (SA)
University Librarian

SWM/

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY

P.O.Box 62000 - 00200, Nairobi. Kenya. Tel: 067 - 52181 - 4, 52711. Fax: 067 - 52017
Email: dvc@aa.jkuat.ac.ke

OFFICE OF THE DEPUTY VICE CHANCELLOR (ACADEMIC)

Ref: JKU/2/003/072

19th July 2013

Simon Nyaga Mwendia
University of Nairobi
P.O. Box 30197 - 00100
NAIROBI

Dear Sir,

RE: REQUEST TO CONDUCT RESEARCH

Your letter on the above subject refers.

On behalf of Jomo Kenyatta University of Agriculture and Technology, I wish to inform you that the request has been granted on condition that the research findings shall be used solely for academic purposes. Kindly note that the title of your research is and should remain **"Context aware Model for ambient intelligent Mobile learning in Higher Learning Institutitons".**

I wish you all the best as you embark on your research.

Yours faithfully

PROF. ROMANUS ODHIAMBO, Ph.D.,
DEPUTY VICE CHANCELLOR ACADEMIC

OFFICE OF THE DEPUTY VICE CHANCELLOR
ACADEMIC AFFAIRS
JKUAT
P. O. Box 62000 - 00200, NAIROBI.

Copy to:

Registrar AA
Dean of Students

RO/es

MULTIMEDIA UNIVERSITY OF KENYA
P .O. BOX 15653 - 00503, NAIROBI, KENYA.
OFFICE OF THE DEPUTY VICE CHANCELLOR (ACADEMIC AFFAIRS/ RESEARCH, PRODUCTION & EXTENSION)

MMU/AC/RESEARCH/30/07/2013 **30th July 2013**

Mr. Simon Nyaga Mwendia
School of Computing and Informatics
University of Nairobi
P O Box 30197 00100
NAIROBI

Tel. 0721 324236

REQUEST FOR AUTHORITY TO CARRY OUT RESEARCH

We are in receipt of your letter dated 24th July 2013 on the above subject.

The University has gone through the contents of your letter and hereby approve that you carry out your data collection exercise at Multimedia University of Kenya.

You are hereby requested to liaise with the Dean Faculty of Computing and Information Technology who will guide and supervise you on the exercise.

Thank you for choosing Multimedia University as your preferred choice and we wish you all the best in your endeavor.

PROF. D. SHITANDA, PhD, REng
AG. DVC - AA/RPE

UNITED STATES INTERNATIONAL UNIVERSITY

2nd August, 2013

Dear Researcher,

Following are requirements for your doing research at USIU.

Any researcher who desires to do research involving USIU faculty, staff, students, property or other related items must first seek permission through the office of Research and Program Development (RAPD) which will provide necessary guidance. However, at the minimum, each research will be required to abide by the Institutional Research Board (IRB) requirements including clearance to do the research. Upon such clearance, the researcher will be responsible for:

1. Abiding by all USIU code of conduct, parking rules and security rules including wearing of the visitors badge at all times while on campus.
2. Payment of costs of doing research including resources used.
3. Hiring priority to USIU students or other personnel where necessary to carry the research.
4. Liable for any damages by researcher or assistants.
5. Signing an agreement letter before commencing the research. The researcher and research assistants will need to carry a copy of the letter with them all the time they are on campus as evidence of authorization should it be required.

USIU has the right to refuse any research activity that would potentially damage its image and reserves the right to review the findings before they are made public.

Thanks.

Prof. Francis W. Wambalaba, Ph.D., AICP
Professor of Economics and
Associate DVC AA Research
United States International University
P.O. Box 14634, Nairobi, Kenya, 00800
fwambalaba@usiu.ac.ke
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Prof. Dr. Ilona Buchem
Tel.: (030) 4504 - 5243
buchem@beuth-hochschule.de

Haus Gauss, Room 230
Luxemburger Str. 10
D-13353 Berlin

19. July 2013

Confirmation letter for a research study in Germany
Simon Mwendia's DAAD application

Dear Sir or Madam,

This is to confirm that I agree to supervise the intercultural research study related to using mobile technologies for learning proposed by Simon Mwendia pursued in form of a DAAD stipend for conducting research at Beuth University of Applied Sciences Berlin, Germany in winter term 2013/2014. I hereby confirm the proposed research plan as submitted on July 5th.

Thank you for your consideration and timely administration so that Simon Mwendia can start his research study with the beginning of the winter term 2013/2014.

Kind regards,

Prof. Dr. Ilona Buchem

Buchem

Professor in Residence for Digital Media & Diversity
Department I Economics and Social Sciences
Gender and Technology Center
Beuth University of Applied Sciences Berlin

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Angewandte Kognitionswissenschaft

Prof. Dr. H. U. Hoppe

Telefon (02 03) 3 79 – 3553

Fax (02 03) 3 79 – 3557

E-Mail hoppe@collide.info

Gebäude Lotharstr, 65, LF Raum 128

Datum 03.09.2013

Simon Nyaga Mwendia
School of Computing and Informatics
University of Nairobi
Kenya

Invitation

Dear Mr. Simon Nyaga Mwendia,

Hereby I want to confirm my willingness and interest to host you in my lab as part of your DAAD-supported PhD studies.

Based on your schedule, I would expect you in Duisburg in March/April next year (2014). The specific activities envisaged for your stay will comprise the testing of your ambient intelligent framework and mobile prototype as well as a presentation and discussion of your pre-final PhD thesis.

Yours sincerely,

Heinz Ulrich Hoppe

Prof. H. Ulrich Hoppe

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47057 Duisburg
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Gebäudeeingang LG

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Stadtsparkasse Bochum
BLZ 430 500 01

Öffentliche Verkehrsmittel
Straßenbahn Linie 901
Bus Linien 923, 924 u. 933

Appendix 3: Sample Results from Instruments Validation

This Appendix presents a sample feedback from experts who validated pre-post experiment questionnaires.

Table 1: Sample results from Experts validating pre and post experiment Questionnaire

Dates	**Feedback through email communication**
02/12/2013	"here is my feedback on the current version: Q8 - what should student who have no profession put there? maybe you can give some alternatives to choose from, also this question should be moved up • Q9 - check the punctuation (comma, spaces) • Q11 - provide choice yes/no • Q15 - cost for you? for your university? per year? per month? Provide categories to choose from like in Q26 • Q17 - give more space to write • Q18 - watch the spelling and starting words at the beginning with capital letters looking forward to the new version,"
11/01/2014	" I have had a look at the questionnaire and here are some minor changes: 1. Remove "for" in Given opportunity to choose, in which format would you prefer for accessing digital study materials 2. Write "not" instead of "Not" in I have access to it but Not on daily basis. 3. Check the entire document for capital and small letters as there are many mistakes like mentioned in point 2 above 4. Please add question 35 related to student wishes on mobile learning, e.g. "Where do you see the largest potential for mobile learning?" and give some choice options, e.g. (a) watching videos like video recordings of lectures, (b) listening to audio recordings like recordings of lectures, (c) collaborative document editing like in Google Docs, (d) collaborative document sharing like in Dropbox, (e) conversations with students and professors like in Whats app, (f) study groups like on Facebook, (g) video/audio web conferences like Skype, (h) accessing course materials like in learning management systems, for example Moodle.
15/01/2014	"yes you can distribute and I will do this for my courses too."

Appendix 4: Instruments Reliability Sample Results:

This appendix contains sample observations obtained from Cronbach's alpha test during evaluating reliability of pre and post experiment questionnaire

Table 2: Sample results from Cronbach's alpha test during Measuring Reliability of pre and post experiment Questionnaire

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I rarely use mobile phone to access content in the E-learning system when at home.	17.81	27.858	.552	.799
I rarely use mobile phone to access content in E-learning system when travelling in a vehicle	19.08	27.014	.426	.833
I rarely use a mobile phone to access E-learning content	18.83	24.695	.696	.767
I rarely use a mobile phone to access E-learning content for more than 15 minutes per session	18.33	26.270	.625	.784
I rarely use mobile phone to access audio content hosted in E-learning system	18.15	26.595	.631	.783
I rarely use mobile phone to access Video content hosted in E-learning system	18.21	26.594	.628	.784
Average	18.40167	26.50433	0.593	0.791667

Appendix 5: Research Instruments

This appendix contains copies of research questionnaires used during research. They include survey questionnaire, pre-experiment questionnaire and post-experiment questionnaire.

PRE-EXPERIMENT RESEARCH QUESTIONNAIRE

Thank you for accepting to participate in this study. Please note that participation is voluntary.

The objective of conducting this survey is to establish appropriate factors for the development of a new approach of Mobile learning for enhancing flexible content access in technology supported learning at universities.

You are hereby requested to take time to think about the answers and answer every question to enable us develop this new approach. If something is unclear, you can ask for clarification from the researcher.

The collected data will only be used for the stated purpose.

Respondents Information

The aim of this section is to obtain some information about study participants. This Information will be treated confidentially, and only group data will be communicated as an outcome of this study.

1. Names:__________________________RegNo______________ Email________________

Phone No___________________

Learning context: learning environment (Q2,)

2 University:_______

User Demographic Information: *Questions for capturing Demographic Information*

3. Degree programme:__________

4. Your academic year: __

5. Current Semester ____

M-Learning Moderators: *Questions for capturing M-L Moderators Information:*

6. Gender: __Female __Male

7. Age Bracket (tick appropriately)

Age Bracket	**Tick**
Below 20 years	
Between 20 and 25 yrs old	
Between 26 and 30 yrs old	
Between 31 and 35 yrs old	
Between 36 and 40 yrs old	
Above 40 yrs old	

8. What level of study currently enrolled in? (Tick one)

□1st year, □2nd year □ 3rd year □ 4th year □other _____

User Demographic: Questions *for capturing user Demographic Information:*

9. Do you receive any study materials for your project or assignments (i.e project/assignment guides) through mobile application (i.e. software) from your supervisor/lecturer?

□Yes □No

IF NO IN QUESTION 9, PLEASE GO TO OTHER APPROACHES SECTION

IF YES IN QUESTION9, PLEASE GO TO MOBILE LEARNING SECTION

A: Other approaches Section

This section applies to those students who do not receive any project study materials or study guides) from lecturer/supervisor through mobile learning application (software).

M-Learning Approaches: *Questions for Establishing the Most Popular ML approach:*

1. Which is the **main (or most common)** method or approach do you use to access study materials for your assignments?

Source	Put a tick where applicable.
Email	
E-learning system	
Internet	
Printed text books	

Moderators*: Questions for Evaluating* Experience*:*

2. How long have you accessed study materials for your assignments through the mentioned approach?

Duration	Put a tick where applicable.
1 Semester	
2 Semester(s)	
More than 2 Semesters	
Other(specify) ________________	

3. How much training did you receive through the mentioned approach to access study materials for your project/assignments?

Duration	Put a tick where applicable.
More than 4 Hours	
1-4 Hours	
1-59 minutes	
Other(specify) _______________	

M-Learning Context: *Questions for Evaluating M-Learning Inhibitors:*

4. Specify limitations or challenges that you face when accessing study materials for your project/assignments through the mentioned approach.
………
…………………………………………………..

5. Approximately how much money do you spend when accessing study materials for your project/assignments through the mentioned approach?

i) …………………..per day ii) ……………per week.

6. To what extent would you agree or disagree with the following statements in relation to barriers of accessing study materials for your project/assignments? (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I consider the cost as a barrier for accessing study materials for your project/assignments through the mentioned approach.				
I consider mobile phone limitations as a barrier for accessing study materials for your project/assignments through the mentioned approach.				

M-Learning Context: *Questions for Evaluating M-Learning Propellers (Q7, Q8 and Q9):*

7. Which device do you use to access study materials for your project/assignments through the mentioned approach? You can select more than 1 option/row if applicable)

Resources/Devices	**I own the device**	**I have access to it On daily basis**	**I have access to it but Not on daily basis**
Ordinary Phone			
Smart phone			
Desktop			
Laptop			
Tablet			
Iphone			
Other ____			

8. Specify your current mobile network provider (You can tick more than 1 operator if appropriate)

Operator	**Tick where applicable**	**Main reason for subscribing to the operator**
Safaricom		
Airtel		
Yu		
Orange		
Other		

9. To what extent would you agree or disagree with the following statements with regard to accessing study materials for your project/assignments **(**Put a tick (√) where appropriate. Make a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
Mobile telephone connectivity is present in all the place(s) where I access study materials for my project/assignments				
Internet connectivity is present in all the place(s) where I access study materials for my project/assignments				
There is no constant power supply in all the place(s) where I access study materials for my project/assignments				

M-Learning Approaches (MA): *Questions for Evaluating Context Awareness (adaptation):*

10. To what extent would you agree or disagree with the following statements in relation to personalized content access (Put a tick (√) where appropriate. Put a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access study materials for my project/assignments in a sequence through the mentioned approach.(e.g. Task1 materials,Task2 materials..... etc)				
In every study session the mentioned approach provides **study material**s for my current research task/stage only				
In every study session, the mentioned approach provides progress **assessment** for my current research task/stage only.				
In every study session, the mentioned approach provides **name(s) of research group(s)** that I can join or collaborate with.				

Other Approaches (LA): *Questions for Evaluating Mixed Representation of Learning:*

11. To what extent would you agree or disagree with the following statements with regard to interaction modes (i.e. text, video) **(Put a tick (√) where appropriate. Put a single tick per item)**

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access text(pdf /power point/msword) documents for research project through the mentioned approach				
I access video clips (mp4 files) content through the mentioned approach				

Other approaches' Flexibility of access (FA): *Questions for Evaluating Access Place Flexibility:*

12. Usually which location(s) do you mostly access study materials for your project/ assignments through the mentioned approach and why choose that location?

Main Location	**Put a tick (√) where appropriate**	**Reason for choosing that location**
At home		
At my workplace		
At the University where I study		
At an Internet Café		
My friend's office/home		
Other (specify)__________		

13. To what extent would you agree or disagree with the following statements in relation to access places (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I access study materials for your project/assignments **any place** through the mentioned approach.				
I access study materials for your project/assignments through the mentioned approach when at home.				
I access study materials for your project/assignments through the mentioned approach when travelling in a vehicle				

Other approaches' Flexibility of Access (FA): *Questions for Testing Access Time Flexibility:*

14. To what extent would you agree or disagree with the following statements in relation to access time (Put a tick (√) where appropriate)

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I access study materials for my project/ assignments at **anytime through the mentioned approach**				
I access study materials for my project/assignments through **the mentioned approach** 2 or less times a week				
I access study materials for my project/ assignments through **the mentioned approach** 3 to 5 times a week a week				
I access study materials for my project/assignments through **the mentioned approach** more than 5 times a week				

15. Which hours do you find it **difficult or unable** to access study materials for your project/assignments through the mentioned approach (Tick where applicable. You can select more than 1 time slot)

Access time	**Tick**	**Reason for difficulty in accessing study materials for your project for project**
Any time		
Week days 6am-8am		
Week days Between 8am-5pm		
Week days Between 5pm-8pm		
Week days Between 8pm-10pm		
Saturday Between (specify time)		
Sunday Between (specify time)		
Other (specify)		

Other approaches' Flexibility of access (FA): *Questions for Testing Access Cost Flexibility:*

16. During the last one week, which data bundles did you buy and how many of them to in order to access study materials for your project/assignments through the mentioned approach?

Data bundles	Tick where applicable	Number of bundles
5Ksh Bundle		
10Kshs Bundle		
20Kshs Bundle		
50Kshs Bundle		
MORE -100 Bundle		
Other (specify)..........		

(b) Mobile Learning Section

Moderators: *Questions for Testing Experience:*

1. How long have you accessed study materials for your project/assignments through mobile learning application (i.e. software)?

Duration	Put a tick where applicable.
1 Semester	
2 Semester(s)	
More than 2 Semesters	
Other (specify)_________________	

2. How much training did you receive through mobile learning application (software) to access study materials for your project/assignments?

Duration	Put a tick where applicable.
More than 4 Hours	
1-4 Hours	
1-59 minutes	
Other (specify) _____________	

M-Learning Context: *Questions for Testing M-Learning Inhibitors (Q3, Q4 and Q5):*

3. Specify limitations or challenges that you face when accessing study materials for your project/assignments through mobile learning application (software).

………
…………………………………………………………..

4. Approximately how much money do you spend when accessing study materials for your project/assignments through mobile learning application?

i) …………………..per day ii) ……………per week.

5. To what extent would you agree or disagree with the following statements in relation to barriers of accessing study materials for your project/assignments? (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I consider the cost as a barrier for accessing study materials for your project/assignments through mobile learning application (software).				
I consider mobile phone limitations as a barrier for accessing study materials for your project/assignments through mobile learning application (software).				

M-Learning Context: *Questions for Testing M-Learning propellers:*

6. Which device do you use to access study materials for your project/assignments through mobile learning application (software)?

You can select more than 1 option/row if applicable)

Resources/Devices	I own the device	I have access to it On daily basis	I have access to it but Not on daily basis
Smart phone			
ordinary phone			
Desktop			
Laptop			
Tablet			
I phone			
Other (specify) _________			

7. Specify your current mobile network provider (You can tick more than 1 operator if appropriate)

Operator	Tick where applicable	Main reason for subscribing to the operator
Safaricom		
Airtel		
Yu		
Orange		
Other		

8. To what extent would you agree or disagree with the following statements with regard to accessing study materials for your project/assignments **(**Put a tick (√) where appropriate. Make a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
Mobile telephone connectivity is present in all the place(s) where I access study materials for my project/assignments				
Internet connectivity is present in all the place(s) where I access study materials for my project/assignments.				
There is no constant power supply in all the place(s) where I access study materials for my project or assignments				

M-Learning Approaches (MA): *Questions for Testing* A*daptation:*

9. To what extent would you agree or disagree with the following statements in relation to personalized content access (Put a tick (√) where appropriate. Put a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access study materials for my project or assignments in a sequence through mobile learning application.(e.g. Task1 materials,Task2 materials..... etc)				
In every login session mobile learning application displays study materials for my current **research task only**				
In every login session, mobile learning application displays **progress assessment** for my current research task only.				
In every session, mobile learning application displays **name(s) of research group(s)** that I can join or collaborate with.				

Flexibility of access (FA): *Questions for Testing* A*nyhow Access Flexibility:*

10. To what extent would you agree or disagree with the following statements with regard to interaction modes (i.e. text, video) **(Put a tick (√) where appropriate. Put a single tick per item)**

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access text (pdf /power point/ms-word) documents for project/assignments through mobile learning application				
I access video clips (mp4 files) content through mobile learning application				

Flexibility of Access (FA): *Access Place Flexibility Questions:*

11. Usually which location(s) do you mostly access study materials for your project/assignments through mobile learning application and why choose that location?

Main Location	Put a tick (√) where appropriate	Reason for choosing that location
At home		
At my workplace		
At the University where I study		
At an Internet Café		
My friend's office/home		
Other (specify) ________________________		

12. To what extent would you agree or disagree with the following statements in relation to access places (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I access study materials for your project/assignments **any place** through mobile learning application.				
I access study materials for your project/assignments t through mobile learning application when at home.				
I access study materials for your project/assignments through mobile learning application when travelling in a vehicle				

M-Learning Flexibility (MC): *Questions for Testing Access Time Flexibility:*

13. To what extent would you agree or disagree with the following statements in relation to access time (Put a tick (√) where appropriate)

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I access study materials for my project/assignments at **anytime through mobile learning application**				
I access study materials for my project/assignments through **mobile learning application** 2 or less times a week				
I access study materials for my project/assignments through **mobile learning application** 3 to 5 times a week a week				
I access study materials for my project/assignments through **mobile learning application** more than 5 times a week				

14. Which hours do you find it **difficult or unable** to access study materials for your project or assignments through mobile learning application (Tick where applicable. You can select more than 1 time slot)

Access time	**Tick**	**Reason for difficulty in accessing study materials for your project for project**
Any time		
Week days 6am-8am		
Week days Between 8am-5pm		
Week days Between 5pm-8pm		
Week days Between 8pm-10pm		
Saturday Between (specify time)		
Sunday Between (specify time)		
Other Other (specify)		

Flexibility of Access (FA): *Questions for Testing Access Cost Flexibility:*

15. During the last one week, which data bundles did you buy and how much of them to in order to access study materials for your project or assignments through mobile learning application.

Data bundles	**Tick where applicable**	**Number of bundles**
5Ksh Bundle		
10Kshs Bundle		
20Kshs Bundle		
50Kshs Bundle		
MORE -100 Bundle		
Other (specify).......		

M-Learning Approach (MA): *Questions for Testing Types of M-Learning Approaches:*

16. What is the name of the mobile learning application that you use to access study materials for your project or assignments from your lecturer/supervisor___________________?

M-Learning Context (MC*): Questions for Testing M-Learning Environment:*

17. What is the name (including code) of course unit or project whose study materials are accessed through mobile learning application.________________________________

POST-EXPERIMENT RESEARCH QUESTIONNAIRE

Thank you for accepting to participate in this study. Please note that participation is voluntary.
The objective of conducting this survey is to establish appropriate factors for the **development of a new approach of Mobile learning** for enhancing flexible content access in technology supported learning at universities.
You are hereby requested to take time to think about the answers and answer every question to enable us develop this new approach. If something is unclear, you can ask for clarification from the researcher.
The collected data will only be used for the stated purpose.

Respondents Information

The aim of this section is to obtain some information about study participants. This Information will be treated confidentially, and only group data will be communicated as an outcome of this study.

Participant Identity: *Question(s) for capturing Contact Details:*

1. Names:__________________________RegNo______________ Email________________ Phone No____________________

M-Learning Context: *Question(s) for Evaluating Device ownership:*

2. Describe the type of device you own or have to access to (You can select more than 1 option/row if applicable).

Resources/Devices	**Manufacturer** e.g samsung, nokia, Microsoft	**Operating system** e/g android, windows, symbian, etc
Smart phone		
ordinary phone		
Desktop		
Laptop		
Tablet		
I phone		
Other (specify) ________		

Learning Context: *Question(s) for Evaluating M-Learning environment:*

3. Degree programme:___________

4. Mode of study (e.g. part time, full time) ________________

5. Name of the course unit(s) whose study materials were accessed through experiment : ____________

Moderators: *Question(s) for Evaluating Gender and Age:*

6. Gender: __Female __Male

7. Age Bracket (tick appropriately)

Age Bracket	**Tick**
Below 20 years	
Between 20 and 25 yrs old	
Between 26 and 30 yrs old	
Between 31 and 35 yrs old	
Between 36 and 40 yrs old	
Above 40 yrs old	

M-Learning Environment: *Question(s) for Evaluating Year of Study and Use of Mobile Application:*

8. What level of study currently enrolled in? (tick one)

□1st year,□2nd year □ 3rd year □ 4th year □other _____

9. Do you access study materials for assignments through mobile application?

□Yes □No

<u>IF YES IN QUESTION9, PLEASE GO TO MOBILE LEARNING SECTION</u>

10. IF NO IN QUESTION 9, do you access study materials for assignments **through another approach**? (E.g. Facebook, friends etc)

□Yes □No

<u>IF YES IN QUESTION 10, PLEASE GO TO OTHER APPROACHES SECTION</u>

IF NO IN QUESTION 10, PLEASE GIVE REASON(S):

____

____

____

A: OTHER APPROACHES SECTION

This section applies to those students who access study materials for assignments through other approaches.

M-Learning Environment: *Question(s) for Evaluating Access Methods:*

1. Which is the **main (or most common)** method or approach do you use to access study materials for your assignments?

Source	Put a tick where applicable.
Face book	
Email	
E-learning system	
Internet	
Printed text documents	
Other	

Moderator: *Question(s) for Evaluating Experience:*

2. How long have you accessed study materials for your assignments through the mentioned approach?

Duration	Put a tick where applicable.
1 Semester	
2 Semester(s)	
More than 2 Semesters	
Other(specify) ________________	

3. How much training did you receive through the mentioned approach to access study materials for your assignments?

Duration	Put a tick where applicable.
More than 4 Hours	
1-4 Hours	
1-59 minutes	
Other(specify) _______________	

Learning Context: *Question(s) for Evaluating Inhibitors:*

4. Specify limitations or challenges that you face when accessing study materials for your assignments through the mentioned approach.

……
…………………………………………………..

5. Approximately how much money do you spend when accessing study materials for your assignments through the mentioned approach?

i) …………………..per day ii) ……………per week.

6. To what extent would you agree or disagree with the following statements in relation to barriers of accessing study materials for your assignments? (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I consider the cost as a barrier for accessing study materials for assignments through the mentioned approach.				
I consider mobile phone limitations as a barrier for accessing study materials for assignments through the mentioned approach.				

Learning Context: *Question(s) for Evaluating M-Learning Propellers (device ownership, Mobile connectivity)*

7. Which device do you use to access study materials for assignments through the mentioned approach? You can select more than 1 option/row if applicable)

Resources/Devices	**I own the device**	**I have access to it On daily basis**	**I have access to it but Not on daily basis**
Ordinary Phone			
Smart phone			
Desktop			
Laptop			
Tablet			
Iphone			
Other ____			

8. Specify your current mobile network provider (You can tick more than 1 operator if appropriate)

Operator	**Tick where applicable**	**Main reason for subscribing to the operator**
Safaricom		
Airtel		
Yu		
Orange		
Other		

9. To what extent would you agree or disagree with the following statements with regard to accessing study materials for your assignments **(**Put a tick (√) where appropriate. Make a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
Mobile telephone connectivity is present in all the place(s) where I access study materials for my assignments				
Internet connectivity is present in all the place(s) where I access study materials for my assignments				
There is no constant power supply in all the place(s) where I access study materials for my assignments				

Learning Approaches (MA): *Question(s) for Evaluating Context Awareness.*

10. To what extent would you agree or disagree with the following statements in relation to personalized content access (Put a tick (√) where appropriate. Put a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access study materials for assignments in a sequence through the mentioned approach.(e.g Task1 materials,Task2 materials..... etc)				
In every study session the mentioned approach provides study materials for my current task only				
In every study session, the mentioned approach provides **task assessment** for my current task only.				
In every study session, the mentioned approach provides a link to only one **research group** that I can join or collaborate with.				

Learning Approaches (MA): *Question(s) for Evaluating Modes of Representation:*

11. To what extent would you agree or disagree with the following statements with regard to interaction modes (i.e text, video) **(Put a tick (√) where appropriate. Put a single tick per item)**

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I can access study text documents(pdf /power point/msword) for assignment through the mentioned approach				
I can access study videos (mp4 files) through the mentioned approach				

Flexibility of Access (FA): *Question(s) for Evaluating Access Place Flexibility:*

12. Usually which location(s) do you mostly access study materials for your assignments through the mentioned approach and why choose that location?

Main Location	**Put a tick (√) where appropriate**	**Reason for choosing that location**
At home		
At my workplace		
At the University where I study		
At an Internet Café		
My friend's office/home		
Other (specify) ___________________________		

13. To what extent would you agree or disagree with the following statements in relation to access places (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I can access study materials for assignments at **any place** through the mentioned approach.				
I can access study materials for assignments through the mentioned approach when **at home.**				
I can access study materials for assignments through the mentioned approach when travelling **in a vehicle.**				

Flexibility of Access (FA): *Questions for evaluating Access Time Flexibility:*

14. To what extent would you agree or disagree with the following statements in relation to access time (Put a tick (√) where appropriate)

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I can access study materials for assignments at **anytime** through the mentioned approach				
I access study materials for assignments through the mentioned approach **2 or less times** a week				
I access study materials for assignments through the mentioned approach **3 to 5 times** a week				
I access study materials for my assignments through the mentioned approach **more than 5 times** a week				

15. Which hours do you find it **difficult or unable** to access study materials for your assignments through the mentioned approach (Tick where applicable. You can select more than 1 time slot)

Access time	Tick	Reason for difficulty in accessing study materials for your project for project
Any time		
Week days 6am-8am		
Week days Between 8am-5pm		
Week days Between 5pm-8pm		
Week days Between 8pm-10pm		
Saturday Between (specify time)		
Sunday Between (specify time)		
Other (specify)		

Flexibility of Access (FA): *Questions for evaluating Access Cost Flexibility:*

16. During the last one week, which data bundles did you buy and how many of them to in order to access study materials for your assignments through the mentioned approach?

Data bundles	Tick where applicable	Number of bundles
5Ksh Bundle		
10Kshs Bundle		
20Kshs Bundle		
50Kshs Bundle		
MORE -100 Bundle		
Other (specify)..........		

Propellers: *Questions for evaluating Availability of Wireless Network:*

16. Do you use university wireless network (WIFI) when accessing study materials through the mentioned approach.

□Yes □No

17. If no in question 16, please give reason(s)

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M-Learning Context: *Questions for Evaluating Inhibitors:*

18 Please give reason(s) why you were unable to (or did not) access study materials for assignments through mobile application.

____

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B: Mobile Learning Section

Moderators: *Questions for Evaluating Experience:*

1. How long have you accessed study materials for assignments through mobile learning application?

Duration	Put a tick where applicable.
1 Semester	
2 Semester(s)	
More than 2 Semesters	
Other (specify) ________________	

2. How much training did you receive through mobile learning application to access study materials for assignments?

Duration	Put a tick where applicable.
More than 4 Hours	
1-4 Hours	
1-59 minutes	
Other (specify) ____________	

M-Learning Context: *Questions for Evaluating Inhibitors:*

3. Specify limitations or challenges that you face when accessing study materials for assignments through mobile learning application.

………
…………………………………………………..

4. Approximately how much money do you spend when accessing study materials for assignments through mobile learning application?

i) …………………..per day ii) …………….per week.

5. To what extent would you agree or disagree with the following statements in relation to barriers of accessing study materials for your assignments? (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I consider the cost as a barrier for accessing study materials for your assignments through mobile learning application (software).				
I consider mobile phone limitations as a barrier for accessing study materials for your assignments through mobile learning application (software).				

M-Learning Context: *Questions for Evaluating M-Learning Propellers.*

6. Which device do you use to access study materials for your assignments through mobile learning application? (You can select more than 1 option/row if applicable)

Resources/Devices	**I own the device**	**I have access to it On daily basis**	**I have access to it but Not on daily basis**
Smart phone			
ordinary phone			
Desktop			
Laptop			
Tablet			
I phone			
Other (specify) _________			

7. Specify your current mobile network provider (You can tick more than 1 operator if appropriate)

Operator	**Tick where applicable**	**Main reason for subscribing to the operator**
Safaricom		
Airtel		
Yu		
Orange		
Other		

8. To what extent would you agree or disagree with the following statements with regard to accessing study materials for assignments **(**Put a tick (√) where appropriate. Make a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
Mobile telephone connectivity is present in all the place(s) where I access study materials for my project/assignments				
Internet connectivity is present in all the place(s) where I access study materials for my project/assignments.				
There is no constant power supply in place(s) where I access study materials for assignments				

M-Learning Approaches (MA): *Questions for Evaluating Context Awareness* (*Adaptation):*

9. To what extent would you agree or disagree with the following statements in relation to personalized content access (Put a tick (√) where appropriate. Put a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I access **task materials** for assignments in a sequence through mobile learning application.(e.g. Task1study text ,Task2 study text..... etc)				
In every login session mobile learning application allows access to study materials for **current assignment task** only				
In every login session, mobile learning application allows access to **task assessment** for **current assignment task** only.				
In every study session, mobile learning application provides a link to only one **research group** that I can join or collaborate with.				

M-Learning Approaches (MA): *Questions for Evaluating Mixed Representation of Learning:*

10. To what extent would you agree or disagree with the following statements with regard to interaction modes (i.e. text, video) **(**Put a tick (√) where appropriate. Put a single tick per item)

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I can access **study texts** (pdf /power point/msword documents) for assignments through mobile learning application				
I can access **study videos** (mp4 files) through mobile learning application				

Flexibility of Access (FA): *Questions for Evaluating Access Place Flexibility:*

11. Usually which location(s) do you mostly access study materials for your assignments through mobile learning application and why choose that location?

Main Location	**Put a tick (√) where appropriate**	**Reason for choosing that location**
At home		
At my workplace		
At the University where I study		
At an Internet Café		
My friend's office/home		
Other (specify) ________________________		

12. To what extent would you agree or disagree with the following statements in relation to access places (Put a tick (√) where appropriate. Make a single tick per item).

Criteria	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I can access study materials for assignments **any place** through mobile learning application.				
I can access study materials for assignments through mobile learning application when **at home.**				
I can access study materials for assignments through mobile learning application when travelling **in a vehicle**				

M-Learning Flexibility (MC): *Questions for Evaluating Access Time Flexibility:*

13. To what extent would you agree or disagree with the following statements in relation to access time (Put a tick (√) where appropriate)

Criteria	Strongly Disagree	Disagree	Agree	Strongly Agree
I can access study materials for assignments at **anytime** through mobile learning application				
I access study materials for assignments through mobile learning application **2 or less times a week**				
I access study materials for assignments through mobile learning application **3 to 5 times a week**				
I access study materials for my project/assignments through mobile learning application **more than 5 times a week**				

14. Which hours do you find it **difficult or unable** to access study materials for assignments through mobile learning application (Tick where applicable. You can select more than 1 time slot)

Access time	**Tick**	**Reason for difficulty in accessing study materials for your project for project**
Any time		
Week days 6am-8am		
Week days Between 8am-5pm		
Week days Between 5pm-8pm		
Week days Between 8pm-10pm		
Saturday Between (specify time)		
Sunday Between (specify time)		
Other (specify)		

Flexibility of Access (FA): *Questions for Evaluating* Access *Cost Flexibility:*

15. During the last one week, which data bundles did you buy and how much of them to in order to access study materials for assignments through mobile learning application.

Data bundles	**Tick where applicable**	**Number of bundles**
5Ksh Bundle		
10Kshs Bundle		
20Kshs Bundle		
50Kshs Bundle		
More -100 Bundle		
Other (specify)...........		

M-Learning Context: *Questions for Evaluating Propellers (Availability of Wireless network):*

16. Do you use university wireless network (WIFI) when accessing study materials through the mentioned approach.

□Yes □No

17. If no in question 16, please give reason(s)

____

____

M-Learning Approaches (MA): *Questions for Evaluating Types of M-Learning Approaches:*

18. What is the name of the mobile learning application that you use to access study materials for assignments from your lecturer___________________?