MOBILE PHONE PROTOTYPE FOR RESEARCH KNOWLEDGE MANAGEMENT AT THE NATIONAL MUSEUM OF KENYA

BY

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DECLARATION

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This thesis is my original work and has not been submitted for examination in any other University.

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DEDICATION

This thesis is dedicated to my family members for their support and perseverance during my research. To my late father Jeremiah Rotich and my mum Hellen Rotich for struggling so hard to bring me up during those very difficult years of childhood and with inadequate resources, taking me to school.

Dad may your soul Rest in Peace, Mum may God bless you and grant you joyful life.

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ABSTRACT

Knowledge is recognized as a key resource and a variety of perspectives suggest that the ability to marshal, deploy and share knowledge within an organization is important for organizational success. The National Museum of Kenya (NMK) was established with the purpose of enhancing knowledge and to provide a sustainable utilization of research information resources by stakeholders. However, as a result of diversification of knowledge sources; the process of creating, organizing, storing and dissemination of knowledge has become tedious. It has led to inefficiencies in the entire knowledge management process, leading to inadequate, disorganized knowledge for utilization and sharing. Despite the adoption of knowledge management systems, mobile phone technology has not been utilized in research activities. The aim of this study was to develop a mobile phone based prototype to enhance knowledge management and sharing at the NMK. The objectives of the study were to: examine the existing knowledge management systems at the museum; investigate challenges facing researchers while generating knowledge; suggest solutions to the challenges; and finally develop a mobile phone based prototype to enhance knowledge management processes at the NMK. This study was guided by the Knowledge management process theory. The research design adopted was qualitative case study with experimentation. The target population was 1180 staff at the NMK. Purposive sampling method was used to select a sample of 35 respondents who are the key informants. Data was collected using interviews as research instruments and analyzed qualitatively through narrative analysis. Three-tier architecture was adopted in the design of the prototype. Rapid Application Development methodology was used in the development stage, while Unified Modeling Language (UML) was used as a standard way to visualize the design of the application. Interfaces were created by using PHP for both mobile tools and web platforms. On the other hand, Java and C# programming languages were used to develop the core business logic while MySQL was used to develop the database. The findings showed that NMK had implemented web based systems that support knowledge management activities. However, mobile phone technology had not been adopted in any part of the museum as knowledge management support tool. It was also found out that researchers and staff still experienced challenges during specimen collection and general compilation of research knowledge. Consequently, a mobile phone application was designed and developed to bring solutions to the challenges relating to research knowledge management at NMK. This study concluded that though NMK is yet to embrace the use of mobile technology in their research activities, the technology has the potential to improve efficiency in its role of research knowledge management. The study recommended that NMK should consider adopting the developed mobile phone prototype for knowledge generation, sharing and management.

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ABBREVIATIONS

API – Application Programming Interface

DIM – Documentation and Information Management

DSS – Decision Support System

EIS – Expert Information Systems

FTEA - Flora of Tropical East Africa GPS – Global Positioning System

ICT - Information Communication Technology

IT – Information Technology

KDD – Knowledge Discovery Database

KENET – Kenya Educational Network

KM – Knowledge Management

KMS – Knowledge Management Systems

KWDM – Knowledge Worker Desktop Model

NMK – National Museum of Kenya

PDAs – Personal Digital Assistants

RAD – Rapid Application Development

RDL – Rapid Development Language

SECI – Socialization, Externalization, Combination and Internalization

UML – Unified Modeling Language

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Information Communication Technology (ICT) is today considered the driving force behind the unprecedented economic growth period in the last few decades (Ulka & Milind, 2012). It has provided the infrastructure for economic development, helped create the knowledge based society, contributed to innovation and created value for the economy. More importantly, ICT has brought the world closer together by improving on dissemination of information, sharing of knowledge, accelerating research, stimulating innovation and facilitating collaboration (Petrides & Nodine 2003).

Knowledge management is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organization's objectives (Rowley 2014). Elias & Awad (2016) defines knowledge management as a systematic, organized, explicit and deliberate ongoing process of creating, disseminating, applying, renewing and updating the knowledge for achieving organizational objectives. It is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organization's objectives (Ahuja and Shankar, 2009).

Knowledge management entails all of the processes associated with the identification, creation, organizing, storing and sharing of same knowledge. This requires systems for the creating, storing and maintaining knowledge repositories, and to cultivate and facilitate the sharing of knowledge and organizational learning (Davenport & Prusak 2002). The development of ICTs has changed knowledge management activities significantly in recent decades. Technology allows many operations to be automated (Norton, 2013; Flanagan and Marsh, 2014).

At best, automation takes care of many routine tasks, thus, people have additional time for more demanding tasks. Technology has also improved access to information (Shin, 2010; Flanagan and Marsh, 2014; Ahuja and Shankar, 2009) and communication has become easier due to such provision as; Internet, online chats, mobile phone calls and video conference calls. Furthermore, the increased use of ICT has improved the quality of information shared among users (Suwardy *et al*., 2017).

However, the development of technology has not had only positive consequences. ICT is associated with a lot of dissatisfaction (Karr-Wisniewski and Lu, 2010). A poorly functioning or difficult to use systems cause frustration and inefficiency for many people (Kaplan and Arnoff, 2016). For this reason, more and more attention is used to improve the usability of the systems. Having information is important but too much information leads to inefficiency in searching for the right information and may create stress for knowledge workers. ICT is a key source of information flooding (in the form of emails, social media messages, news items, spammings among others) encountered by knowledge workers daily (Lee, 2010).

Technologies such as mobile computing have become ubiquitous; they are in the form of notebooks and converged devices such as smart-phones. Mobile computing presents many opportunities for collaboration, for example mobile devices are always with the user (Watson-Manheim and Belanger, 2007). With the enormous progress of mobile computing and wireless communication capabilities of small devices such as smart phones, PDAs, and wireless enabled laptops, we have seen an emergence of various applications supporting mobile collaboration. These hand-held devices are becoming much more powerful than before, thereby attracting people to use them in their work and social lives (Litiu & Zeitoum, 2014).

With the flexibility offered by smart devices, people can frequently work while on the move (Dustdar & Gall, 2013). For example, it has become very common to see people using their laptops or PDAs on the street or at meetings to take notes, reply to e-mails, and stay up-to-date. This study therefore, focuses on mobile technology and its significance in enhancing knowledge management in research at the National Museum of Kenya.

1.1.1 The National Museum of Kenya

The National Museum of Kenya (NMK) is a state corporation established by an Act of Parliament, the National Museums and Heritage Act, 2006 No. 6 of 2006. NMK is a multi-disciplinary institution whose role is to collect, preserve, study, document and present Kenya's past and present cultural and natural heritage. This is for the purposes of enhancing knowledge, appreciation, respect and sustainable utilization of these resources for the benefit of Kenya and the world, for now and posterity (Kibet, 2011).

The NMK underwent structural evolution in 2005 meant to improve governance, accountability and performance which led to adjustments of the administrative units even at the departmental level. The historical East African Herbarium established in 1902 was no exception having been retained as a sub-department, and together with Nairobi Botanic Gardens, now form the Botany Department (Kibet, 2011).

Despite the changes, the primary role of the East African herbarium as a reference for collections of plants and fungi, tool for species identification and arbitration of authentic names, and as a comprehensive data bank of the regional flora has been upheld. These functions are addressed through seven sections key among them being the Taxonomy and Curation, which includes Bryophytes, Non Seed Vascular species, Rosids, Asterids and Monocots sub-units (Kibet, 2011).

This section, complimented by mycology, is responsible for basic taxonomic and evolutionary research using various taxonomic evidences such as morphology, anatomy, molecular and herbarium collections data to revise specific plant groups in contribution to monographs and floras in the region such as Flora of Tropical East Africa (FTEA) (Kibet & Nyamweru, 2008). They also provide advice in related fields including species conservation, ecology, phytochemistry and pharmacology. Above all, the section oversees the routine curation duties such as incorporation of incoming collections, update of species names according to taxonomic changes and general management of close to one million voucher collections.

The rich botanical collection attracts many researchers around the world who visit to study the specimens in a serene and user-friendly setting. Local botanists in collaboration with visiting scientists have intensified national plant explorations in various ecosystems since 1970s. Most of the recent collections have been obtained from the coastal forests and eastern arc mountains, montane and afro alpine (including Mounts Kenya, Elgon and Aberdares) and lowland rainforest (Kakamega Forest) ecosystems. The collection numbers are expected to increase tremendously following focused studies on cryptogamic plants and fungi in the last 10 years (Kibet & Nyamweru, 2008).

The sections on economic Botany and Information and documentation are central in gathering and dissemination of data on plants. Field label database of close to 80,000 plant specimens indicating species localities and uses has been captured in user-friendly software (Botanical Research and Herbarium Management System).

Together with the enormous literature held in the Museum and herbarium libraries, the database is increasingly instrumental in planning future botanical explorations and plant biodiversity conservation studies, as well as predicting changing climatic patterns following historical shift of plant phenology. The education and training section coordinates specialized courses in herbarium techniques and supervises students on attachment (Wabuyele *et al*. 2012).

1.1.2 Documentation and Information Management Section

Documentation and Information Management section provides leadership in the application and dissemination of ICTs to enhance the department's capacity in research information management. In line with the strategic direction of research at the NMK, the section has a mission to develop and provide a world class platform for all stakeholders interested in botanical and other forms of research with state of the art reference materials and well-curated knowledge bases for national and regional posterity.

The main function of NMK in general, is to serve as a center of excellence in the dissemination of research knowledge, information and services that ultimately enhance decision-making in biodiversity conservation, ecosystem management, and preservation of cultural and natural heritage. Ultimately, this study dwelled on the application of ICTs in information and knowledge management activities in the NMK.

1.1.3 Knowledge Management Systems and their importance

Knowledge is the capacity of people and communities to continuously generate and renew themselves to meet new challenges and opportunities (Awad and Ghaziri 2008). The ability to manage knowledge is crucial in today's knowledge economy. The creation and diffusion of knowledge have become increasingly important factors in competitiveness. More and more, knowledge is being thought of as a valuable commodity that is embedded in products and services (especially high-technology products) and in the tacit knowledge of highly mobile users (Ulka and Joshim 2012). Technological advancements have contributed dramatically in changing the way knowledge is produced, disseminated and consumed. Knowledge is a dynamic and smooth flow of specialized experiences, values and insights (Ulka and Joshim 2012).

According to Awad *et al.*, (2008), knowledge management is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organization's objectives. The knowledge to be managed includes explicit, documented, tacit, and subjective knowledge. Management entails all those processes associated with the identification, creation, distribution and sharing of knowledge. This requires systems for the creation and maintenance of knowledge repositories, and to cultivate and facilitate the sharing of knowledge and organizational learning. The development of IT systems has changed knowledge management activities significantly in recent past (Bettiol 2012).

Earlier information technologies were designed to assist managerial and professional workers by processing and disseminating vast amounts of information to manager's organization-wide information system. Several decades later, systems evolved to focus on providing tools for ad-hoc decision analysis to specific decision makers (DSS), and to systems that provide updated, often real-time, relevant information to senior and middle managers (EIS) (Hahn & Subramani, 2015). These systems each contributed to individual and organizational improvements in varying degrees and continue to be important components of an organization's information technology investment.

An emerging line of systems targets professional and managerial activities by focusing on gathering, creating, organizing, and disseminating an organization's 'knowledge' as opposed to 'information' or 'data'. These systems are referred to as knowledge management systems (KMS). KMS are tools to effect the management of knowledge and are manifested in a variety of implementations including document repositories, expertise databases, discussion lists and context-specific retrieval systems incorporating collaborative filtering technologies (Davenport & Prusak 2002).

Beyond the technical infrastructures that are implemented, the information system has to bring, to each individual, useful information. Moreover the digital information system has to supply means to share the knowledge with distant colleagues, and to enable access to essential knowledge for resolving problems and decision making (Rosenthal and Grundstein, 2011).

According to Bhatt, Pankaj & Rodger (2014) KMS provide ability to the organizations to be; flexible and respond more quickly to changing market conditions, more innovative as well as improving decision making and productivity. KMS can be used for a wide range of cooperative, collaborative, adhocracy and hierarchy communities, virtual organizations, societies and other virtual networks, to manage knowledge; interactions and work-flows and to enhance, leverage and transfer new outcomes of knowledge by providing services using new formats or interfaces and different communication channels.

1.2 Problem Statement

In the NMK, specimen collection is carried out manually posing a lot of challenges to the researchers. Researchers spend a lot of their time in the field; collect specimens that are brought physically to the research center for digitization and storage to a knowledge database. Consequently, the process of capturing, organizing, storing and disseminating the research knowledge is tedious and complicated. It has led to inefficiencies in the entire knowledge management process, leading to out-dated and inadequate knowledge sharing and distribution.

It is a fact that mobile applications are increasingly becoming a very attractive application platform: mobile phones have improved from a simple device used for phone calls and messaging into a multitasking device. However, despite today's abundance of feature-rich mobile phone hardware and powerful software platforms, research institutions have not fully utilized this technology.

It is evident that NMK has no single knowledge based system that is running on mobile phone technology. It is as a result of this fact that this study was carried out to explore viability of mobile phone technology in capturing, sharing, distributing and utilizing knowledge at the museum. This is due to the fact that mobile technology has become pervasive and more convenient for users who are geographically dispersed.

1.3 Aim of the Study

The aim of this study was to design and develop a Mobile Phone based prototype to enhance knowledge management and sharing at the National Museum of Kenya.

1.4 Objectives of the Study

The research was guided by the following objectives:

1. To examine the currently available knowledge management systems at National Museum of Kenya;
2. To establish challenges faced by researchers while collecting data/specimens and compiling knowledge at National Museum of Kenya;
3. To suggest solutions to the challenges faced by researchers while collecting and compiling research knowledge at the National Museum of Kenya;
4. To design and develop a mobile phone based prototype for knowledge management at the National Museum of Kenya.

1.5 Research Questions

1. What are the current knowledge management systems available at the National Museum of Kenya?
2. What are the challenges facing researchers while collecting data/specimens and compiling knowledge at National Museum of Kenya?
3. What are the best solutions to the challenges faced by researchers while collecting and compiling research knowledge at the National Museum of Kenya?

4. How can a mobile phone based prototype be developed for knowledge management at the National Museum of Kenya?

1.6 Significance of the Study

The findings of this study provide understanding on the level of ICT adoption in research institutions and especially in the National Museum of Kenya. It shows how mobile phone technology is used to support knowledge management and to automate research information management procedures such as; creation, storing, sharing, application and distribution of research knowledge. Consequently, other information centers in Kenya will find the study valuable to their operations and more so, use it as a benchmark to improve on knowledge management processes.

Furthermore, this study contributes to the body of knowledge in the field of knowledge management. It illustrates the design and implementation processes of how mobile phone technology can aid in research and knowledge management. Strategically, the study provides insights on how research institutions can adopt mobile phone applications to aid research knowledge generation, compilation, sharing and storage for future use.

The National Museum of Kenya will use the findings emanating from this study to formulate policies that are geared towards knowledge management and use of ICTs. The results will also be useful to other research institutions, as a basis of formulating knowledge management policies, which can be effectively adapted to aid in problem solving and decision making.

Kenya Education Network (KENET), a National Research and Education Network will benefit from the findings of this study, specifically on innovative insights such as the application of mobile technology in research knowledge management. The mobile application that was developed in this study can be adopted by other institutions that carry out similar research activities. In addition, other researchers and the academic community will use this study as a basis for further studies on the areas of mobile computing technology and knowledge management.

1.7 Scope of the Study

The study was carried out at the National Museum of Kenya with a focus on those departments that deal with knowledge management. The study focused on the development of a mobile-based system for knowledge management. It entailed obtaining relevant information from employees who are involved in the knowledge management process. The end product of this study was a mobile phone prototype that can be utilized for research knowledge management at the museum.

1.8 Limitation of the Study

From the technical level view, there are still several unresolved issues concerning the design and implementation of mobile computing architectures to enable dynamic configuration of mobility services at a large scale. As a result, this research was not concerned about how to solve all issues related to mobile computing. For example, it did not consider how to enlarge the battery power capability or to develop new mobile architecture; instead it focused on the development of a prototype application that utilizes the available architectures.

1.9 Assumptions of the study

This study had an assumption that the sample population engaged in this study was representative of the population (knowledge workers and researchers at the museum) and that they were well informed of the subject being investigated. It was also assumed that respondents were going to cooperate and truly give all the necessary information as stated in the interview schedule. Finally, there was an assumption that the mobile phone prototype obtained through this study will resolve challenges faced by researcher while compiling research knowledge at the museum.

1.10 Definition of Terms

Metadata – These are data or information about articles, records or documents captured or created and stored digitally for future use, for instance, it is all about the context of the record's creation, the system and processes that generate and mange them, and about the activities that the record support.

Mobile computing technology – Technology used for cellular communication, which has enabled portable telephone that can make and receive calls over radio frequency carrier while the user is moving within a telephone services area or a cell.

Mobile phone application -A mobile application (or 'app') is software that has been created for a mobile device like a smart-phone and is running on it. Applications for mobile platforms are either pre-installed, integrated into the operating system or can be downloaded from a marketplace on the Internet.

Smartphone - is a mobile or cellular phone with more advanced features than a common mobile phone. Other than telephoning and exchanging text messages, smart-phones offer the capability to access the Internet and browse the World Wide Web, send and receive e-Mails and to deal with multimedia content like audio, images and videos.

Prototype– An early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from. It is an original model on which something is patent.

CHAPTER TWO

LITERATURE REVIEW

This chapter provides literature review on utilization of ICT tools in knowledge management. It gives an overview of concepts, discussions and findings of other existing studies, as postulated by scholars and other relevant authorities on the application of ICTs in knowledge management in research institutions. Different sources of information such as books, policy reports, previous research materials, topical journals, online publications and other materials dealing with pertinent issues were consulted.

2.1 Information Communication Technology concepts

ICT can be defined as the set of activities that facilitate the capturing, storage, processing, transmission and display of information by electronic means or it can be defined as, any device, tool, or application that permits the collection or exchange of data through interaction or transmission (Simone & Christopher, 2015).

ICT is an umbrella term that includes anything ranging from radio to satellite imagery to mobile phones or electronic money transfers. Second, these ICTs depend very much on development of other infrastructure like power and connectivity for data transfer (Monyatsiwa, Ferguson & Phumaphi, 2013).

One of the most remarkable aspects of ICTs is their crosscutting nature and speed in terms of progress and easy adoption. For example, nearly three decades ago postal deliveries, landline and television broadcasting were major mediators of information flows in one direction only whereas today the world is globally interconnected through various ICT facilities (Williams 2011).

ICT is not only an industry on its own but pervades all areas of human life. A study by Dzidonu, (2010) demonstrated that ICTs have a significant impact on the society and their appropriate utilization has proved to have important results for socioeconomic development at large and knowledge management in particular. While this is true, in many developing countries like Kenya, little has been done to pinpoint ways through which ICTs can contribute towards knowledge management in research institutions.

As a foundation, information systems have been seen as key tools in the facilitation of knowledge creation, storage, transfer and use, and there is no shortage of literature and case studies detailing use of information systems for these purposes in large organizations (Anderson and Mohan, 2011; Baloh *et al*., 2012; Su, 2011). A number of other scholars, such as Corso *et al.* (2007) and Lai (2006), cite ICT benefits as: quick and easy access to external sources of knowledge and new and more intense communication channels; aiding knowledge capture processes, such as online debriefings, audio diaries and post-project reviews; and avoiding loss of organizational memory.

According to Evangelista *et al.*, (2010), information systems 'may have a positive impact not only on innovation and operational management, but also on the identification of market opportunities'. Information systems play a very important role in improving an organization's performance and its increased competitive capacity. Therefore, it is essential for organizations to decide what the most important business processes are and core competencies that have to be supported by an information system and what kind of information system has to be implemented that conforms to the organization's requirements (Su, 2011).

Knowledge management systems are mostly built over existing information systems, thus it is difficult to determine when an information system becomes a knowledge management system or what kind of features are encompassed in the former and not in the latter (Awad and Ghaziri 2008). Based on these facts, this study explores the role of ICTs and related information system in enhancing knowledge management in research institutions.

2.2 The Concept of Knowledge Management

The term 'Knowledge Management' describes approaches connected with the creation, processing and dissemination of knowledge and the technological know-how of it (Laudon and Laudon, 2010). A knowledge management system thus creates an enabling environment to foster better knowledge and experience sharing, so that organizations can leverage their collective knowledge. This involves making a direct connection between the organization's intellectual assets; both explicit (recorded) and tacit (personal know-how).

In that way, employees are able to collectively use knowledge as they do their jobs in order to achieve efficiency. According to Darroch (2015), the basic objective of knowledge management is to increase, capture, refine, share and apply knowledge as an enterprise's information asset. These information assets may include databases, documents, policies, procedures, as well as the un-captured tacit expertise and experience stored in individual minds. To increase knowledge includes discovering, research, perusing and studying knowledge. Therefore, the key objective of knowledge management is to improve the processes of acquisition, integration and usage of knowledge (Jelena, Vesna & Mojca, 2012).

According to Abdul and Muhammad (2015) capturing of knowledge includes writing and recording both sound and image knowledge. To refine knowledge includes verifying, correcting, updating, augmenting, clarifying and generalizing knowledge. To share knowledge includes presenting, publishing, distributing and discussing knowledge. To apply knowledge includes planning, deciding, designing, building and solving problems (Abdul and Muhammad 2015).

Wellman (2017) affirms that when an effective knowledge management system is implemented in an organization, it greatly facilitates the collection and sharing of meaningful knowledge. Thus employee knowledge can be converted to corporate knowledge via organizational learning. Learning by individuals within an organization happens through activities such as training and formal education. But organizational learning is through the interaction that takes place among individuals. A learning organization actively creates, captures, transfers and mobilizes knowledge to enable it adapt to a changing environment (Mills & Smith 2011).

2.3 Importance of Knowledge Management

Knowledge is perceived as an important success factor for achieving and sustaining competitive advantage of organization (Lee & Lan 2011); knowledge has significant importance in human life (Liu & Deng 2015). Notwithstanding, knowledge can easily be obsolete and useless if left without proper management within the organizations (Karimi & Javanmard, 2014). Therefore, it is very crucial for an organization to develop series of processes or procedures in order to manage their knowledge assets.

According to Mutt (2010), knowledge management is important in facilitating innovative thoughts, sharing of beneficial work points and knowledge that would otherwise stay explicit. In the view of Singer and Hurley (2014), knowledge management helps to make the best use of available knowledge, while creating new knowledge in the process.

Knowledge Management helps in exploiting and realizing knowledge of the user and building a culture where knowledge sharing can thrive (Zolfaghari, 2017).

Knowledge management is often facilitated by information technology (Jashapara, 2009).Knowledge management represents a deliberate and systematic approach to ensure the full utilization of the organization's knowledge base, coupled with the potential of individual skills, competencies, thoughts, innovations, and ideas to create a more efficient and effective organization(Walter, 2017). Without any doubt, knowledge has become an integral asset of production, next to labor, land and capital. Even though some forms of intellectual capital are transferable, internal or personal knowledge is required to be organized to a form that is easily articulated, captured, retained, disseminated and reused (Fatemeh & Jamal 2017).

2.4 Empirical review on Knowledge Management using ICTs

Knowledge management is the systematic and explicit management of knowledge-related activities, practices, programs and policies within the enterprise or the art of creating organizational value by leveraging intangible assets (Sveiby, 2007). Accordingly, knowledge is defined as a justified belief that increases an entity's capacity for effective action (Huber, 2017). Knowledge can be further viewed as a state of mind, object, process, condition of having access to information, or a capability (Alavi & Leidner, 2010).

The development of ICT has changed knowledge work significantly in recent decades. Technology allows many operations to be automated (Norton, 1995; Flanagan and Marsh, 2014). At best, automation takes care of many routine tasks and thus people have additional time for the more demanding tasks. Technology has also improved access to information (Flanagan and Marsh, 2014; Ahuja and Shankar, 2009) and communication has become easier due to, e.g. mobile phones and video conference calls. Furthermore, the increased use of ICT has improved the quality of information (Suwardy *et al*., 2003).

Other knowledge management studies have also shown that appropriate ICTs can aid in the creation, sharing and transfer of knowledge (Alavi and Leidner, 2010; Goh *et al*., 2008; Chudoba *et al*., 2011). The goal of many organizations is thus to use appropriate ICTs so that knowledge management initiatives can be conducted effectively (Broos and Cronje, 2009). Unsurprisingly, the knowledge management literature is replete with work relating to knowledge management and ICTs. For example, Zack (2009) contended that ICT plays the important roles of obtaining, defining, storing, identifying, and expressing the content from various knowledge management projects.

Davenport and Prusak (2008) believed that weaving ICT into knowledge management initiatives in the organization would create a common controllable environment such that knowledge can be shared within the organization, thus helping to ensure the success of such initiatives. Further, Hendriks and Vriens (2009) found that ICTs have both a direct and indirect influence on the motivation for sharing knowledge because they can eliminate hindrances, provide channels to obtain information, correct flow processes, and identify the location of the knowledge carrier and knowledge seeker. In general, these studies have highlighted that ICT can play important roles in facilitating knowledge management in organizations, and as such the perceived usefulness of ICT in facilitating knowledge management initiatives is likely to be rather positive (Hendriks 2011).

However, ICT alone cannot ensure the success of knowledge management initiatives, as its use could hinder how an organization functions in specific circumstances. For example, the various types of ICTs in use could cause problems in how teams or group of people work together. This problem is further exacerbated by a variety of factors (Vakola and Wilson, 2014), such as personality, trust and age, which could lead to different attitudes in technology use and hence cause tension among team members (Robert *et al.*, 2009). In particular, implementing knowledge management initiatives and managing knowledge management projects in a distributed workplace are likely to be challenging because of different time zones, local cultures and perspectives (Cramton, 2011; Kraut *et al*., 2002), indicating that organization members may develop different perceptions regarding the use of ICTs to facilitate knowledge management initiatives.

Moreover, even with modern tools, the process of knowledge creation and sharing is inherently difficult, since those who have knowledge may not be conscious of what they know or how significant it is, or be able or willing to share it with others. Further, even when individuals are willing, the readiness to accept the wisdom of others is often not obvious (Robert *et al.*, 2009). Previous research findings have also shown that negative perceptions of ICT may develop due to past failures, and that such perceptions may create resistance in the use of technology (Senior, 2017). Taken together, the research indicates that perceived usefulness of ICT may be negatively affected by past experiences or the complexity involved in the use of ICT to support certain organizational activities, and this in turn will affect the use of ICT to support future organizational activities.

According to Ajiferuke (2003), ICT is often used in knowledge management programmes to inform clients of latest innovations and developments in the business sector as well as to share knowledge among employees. Also, ICT facilitates accumulating organizational knowledge, providing access to retrievable knowledge and enhancing collaboration for knowledge sharing and creation (Ryan and Prybutok, 2012). The main role of ICT use in knowledge management is to step up the speed of knowledge transfer to workers and general users (Bhatt 2011). ICT facilities, infrastructure and applications (such as World Wide Web, Facebook, Twitter, YouTube, portals, blogging sites, video and teleconferencing) are catalysts in the knowledge management process.

In the view of Robbins and Coulter (2009), ICT has rapidly changed the way organization members communicate and share information resources. It has significantly improved a manager's ability to monitor individual's performance, allowed employees to have more complete information to make faster decisions and provided employees more opportunities to collaborate and share information. Besides, ICT has made it possible for people in organizations to be fully accessible anytime regardless of where they are. Ho (2017) notes that ICT has provided the infrastructure for economic development, helped create the knowledge society, contributed to innovation and created value for the economy.

2.5 Empirical review on Use of Mobile Technology in research

The use of mobile technology for health-related research is overwhelming because of its functional and structural properties, which are attractive to low-income countries (Mechael, 2019). Studies within this domain deal with solving immediate health problems or improving the delivery of health services. However, the majority of these studies were 'action research', with no clear theoretical underpinnings. The studies explored the capability of mobile technologies such as support in monitoring, case detection and health interventions (Callaway *et al*., 2012; Deribe and Roda, 2012; Haq, 2013; Shao *et al*., 2015), medical supplies inventory (Asiimwe *et al*., 2011; Barrington *et al*., 2010), community-based health training (Chang *et al*., 2012) and health science research (Glickman *et al*., *2012*).

Researchers are in consensus that mobile technology is an efficient and effective tool to speed up diagnosis and treatment of patients in a remote area specially when combined with local knowledge and support (Deribe and Roda, 2012; Haq, 2013; Shao *et al*., 2015; Teng *et al*., 2014). It also helps improve health workers performance and efficiency which eventually leads to improving the health of patients (Chang *et al*., 2012). Similarly, in a study in Tanzania, Lund *et al*. (2012) observed this improved performance evidenced by a significant increase in skilled delivery attendance in women living in urban areas. This contributed to saving the lives of women and their newborns and thus achieving MDG4 and MDG51 goals.

In business field, Furuholt and Matotay (2011) and Mtega and Msungu (2013) showed how farmers in Tanzania use their mobile phones throughout the entire farming cycle and value chain which allows them to control their situation. This not only helped them in accessing markets but also empowered farmers to increase their bargaining power, control over external events and increased market opportunities. However, studies show that factors affecting the adoption and implementation of m-commerce are unique from country to country. Another study in Malawi by Saidi (2010), found that m-commerce implementation is constrained by infrastructure, authentication problems and mobile handset limitations. He noted in his succeeding study that m-commerce is also hindered by the high cost of investment, low user acceptance, low levels of literacy of users, over-reliance on cash transactions and the lack of government policies .

In the learning domain, the use of mobile technologies for the improvement of educational outcomes has been lauded (Aker *et al*., 2012; Bello-Bravo and Baoua, 2012), and in conducting research (Dillon, 2012). In a study at Niger, Aker *et al.* (2012) found that the use of mobile phones harnessed by better-educated teachers to improve students' educational experiences resulted in increased student effort and motivation within the classroom and enabled students to practice these skills outside the classroom. The changes brought about by teachers in their classrooms was influenced by the continued training and professional development they received, which may also be implemented through such mobile technologies as open or distance learning.

In a study about SMS-based quiz in Tanzania, Mtebe *et al*. (2015) found significant improvement for those who participated in the project. They argued that mobile phones can be used as tools to enhance teaching and learning in rural secondary schools. Shahnaz *et al*. (2014) evaluated the effectiveness of m-learning, Learning through Interactive Voice Educational System, (LIVES) on Afghan parents for their child development. They concluded that mobile technology is highly effective and less costly platform for mass education particularly those who are challenged by illiteracy and geographical isolation.

A study by Bello-Bravo and Baoua (2012) in Niger also highlighted the effectiveness of using video animations through mobile technologies for broader audience with low literary rate and multiple local languages. In conducting research, Dillon (2012) and Muyinda *et al*., (2009) used mobile technologies and found strong potential in supporting research activities, such as collecting high-frequency panel data at a reasonable cost. However, Muyinda *et al*., (2019) concluded that more investment is required to use mobile technologies in research supervision in low resourced countries.

In banking industry, mobile technology has transformed financial transactions between customer and banking institutions. The study of Abiud *et al*., (2013) employed Technology adoption Model (TAM) and found out that perceived ease of access/use, perceived usefulness, perceived cost and perceived risk all influence the commitment of customers on mobile banking services in Rwanda. However, Parvin (2013) contends that mobile banking in Bangladesh is quite new, where the banks still have not got the true shape and understanding while their customers' demand for additional mobile banking services is on the rise.

According to Duncombe (2012), simple market modeling that depicts 'informal and formal' social networks or 'banked or unbanked' population is inadequate to assess m-finance potential. He also argues that the perception, behaviour and capability of users and forms of user appropriation, should be a paramount concern. Vong *et al*., (2012) illustrated that mobile money services are gaining traction and acceptance when used for daily business life in rural Cambodia. Mobile money services complemented or enhanced access to financial services that helped improve rural Cambodian livelihoods as well as micro or small businesses in terms of reduced operational costs, higher profit margin and higher market access opportunities.

2.6 Theoretical Review

This study was guided by three theories; the Knowledge worker Desktop Model (KWDM), Socialization, Externalization, Combination and Internalization (SECI) model and the knowledge management processes.

2.6.1 The Knowledge Worker Desktop Model (KWDM)

According to Grundstein (2007), knowledge workers utilize available information or data, this coupled with their own intentions, restrictions which influence their decisions and their knowledge and know-how; they must analyze and process information in order to make decisions. This vision has been materialized under an empirical model form called KWDM, described below in figure 2.1:

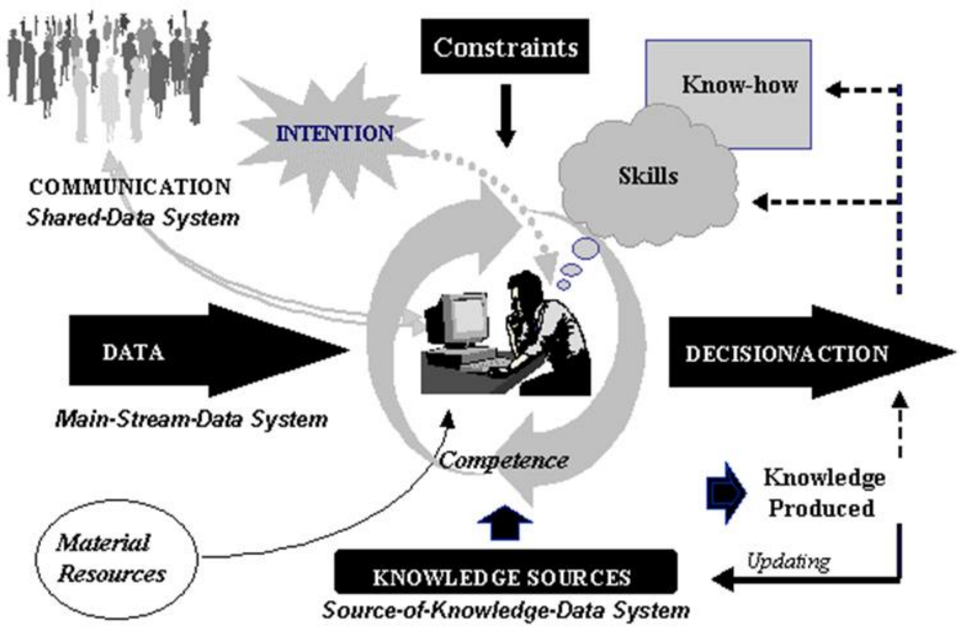

Figure 2.1- Knowledge Worker Desktop's Model (Grundstein, 2007)

The knowledge worker engaged in business line processes is subjected to constraints inherent to the processes (available financial and human resources, costs, delays, quality, security and specific objectives to achieve). The knowledge worker uses physical resources (working environment and tools) and also available knowledge and skills. To make a decision and act, he activates a cognitive process that shows his capability to put together his knowledge, his skills and his ethical attitude, under constraining conditions of his task situation. Knowledge and skills can prove to be insufficient to solve the out-of-routine problem.

In that case, data that interacts with knowledge worker's cognitive system become new knowledge enabling him to solve the problem, make decision and act. During this process, there is production of new knowledge. One important point in this vision is the creative relations, between the knowledge worker and his activity, taking into account his 'intention', the end purpose of his action, and the orientation of knowledge towards an operational objective (Morrey *et al.*, 2000).

In this regard, KWDM can be used as a pattern of reference to conceive digital information system architecture using multifunctional software applications characterized by the type of data they are processing. This model therefore expresses viable knowledge management architecture with its relevant components and procedures. This model gives a knowledge worker a practical approach to knowledge creation, processing, representation and dissemination.

2.6.2 The SECI Model

Nonaka and Takeuchi (1995) proposed the Socialization, Externalization, Combination and Internalization (SECI) model to understand the dynamics of knowledge creation, organization and utilization. According to this model, there are two different types of human knowledge: *tacit knowledge*; and *explicit knowledge*. Tacit knowledge is hard to formalize, codify or communicate, whereas explicit knowledge is codified, systematic knowledge that can be transmitted in formal language. This model posited that four phases i.e. Socialization, Externalization, Combination, and Internalization occur when tacit and explicit knowledge interact with each other, and that these phases are fundamental in any knowledge creation and management. The four modes of knowledge conversion (Socialization, Externalization, Combination and Internalization) interact in the spiral of knowledge creation. The spiral becomes larger in scale as it moves up through organizational levels; it triggers new spirals of knowledge creation, and processing and applications (see Fig. 2.2).

Socialization: This is the process of transferring tacit knowledge between individuals through observations and working with more skilled people (tacit to tacit). Examples here are face to face meetings, video and tele-conferences (Daneshgar and Parirokh, 2007).

Externalization: Externalization is the process in which an individual turns his tacit knowledge into explicit knowledge through documentation, verbalization, etc., (tacit to explicit), through documents, manuals, e-mails, web pages and portals etc.

Combination: This is knowledge conversion involving the combination of different types of explicit knowledge (explicit to explicit). It happens when people exchange knowledge via documents, telephones and meetings. Creative use of a database to get business report, sorting, adding, categorizing is an example of this combination process.

Internalization: This is the process where an individual internalizes explicit knowledge to create tacit knowledge (explicit to tacit). As explicit sources are used and learned, the knowledge is used to modify the user's existing tacit knowledge. By reading training manuals and documents, the staff internalizes the tacit knowledge and tries to create new knowledge.

The repeated succession of these four modes creates an upward spiral of organizational knowledge and this would accelerate further knowledge creation, sharing and distribution required in knowledge management (see fig. 2.2 below).

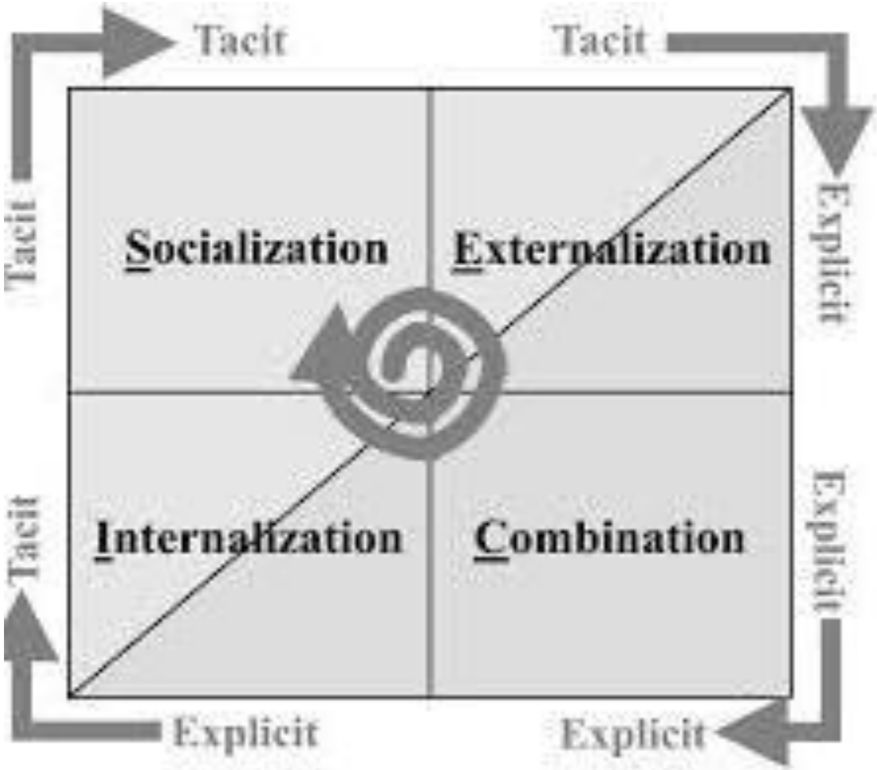

Figure 2.2 – SECI model

Source: Nonaka and Takeuchi (1995)

The creation of knowledge is a continuous process of dynamic interactions between tacit and explicit knowledge. The four modes of knowledge conversion interact in the spiral of knowledge creation. The spiral becomes larger in scale as it moves up through organizational levels, and can trigger new spirals of knowledge creation (Nissen, 2002).

2.6.3 The Knowledge Management Process Model

This model attempts to offer a more realistic overview of the knowledge management processes. This model does include the creation of new knowledge as a specific knowledge management initiative. According to Botha *et al* (2008) this model focuses on three approaches; human/people oriented, organizational and technology focused. This model asserts that knowledge management processes focuses all the three dimensions: Human focus, organizational focus and technological focus. The three approaches are integrated to yield rich knowledge management solution. The entire knowledge management process involves knowledge creation, capture, organization, sharing and dissemination which touch all the three aspects as illustrated in Fig. 2.3 below.

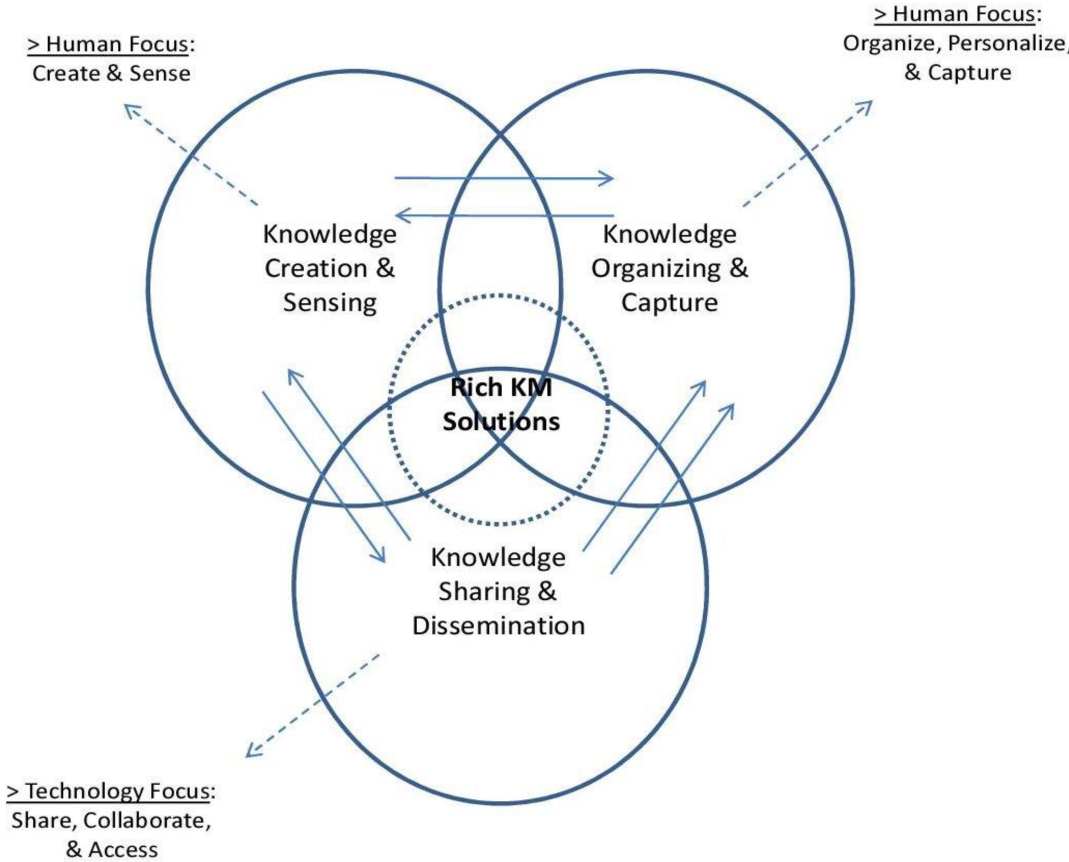

Figure 2.3 – Knowledge Management Process Model
Source: Botha *et al.*, (2008)

2.6.4 Analysis of the Models

All the three models described above (fig. 2.1, fig. 2.2 and fig. 2.3), demonstrate knowledge management processes. KWMD model shows how knowledge management supports decision making process in organizations. The source of knowledge – data coupled with the laid procedures assist knowledge workers and the general user, knowledge to make decisions based on the given problem.

Looking at SECI model, it demonstrates the stages in knowledge creation, organization, access and process of dissemination considering the two dimensions of knowledge i.e. *tacit knowledge*; and *explicit knowledge*. The phases in SECI model are fundamental in any knowledge creation process, access and utilization of generated knowledge. The transfer of tacit and explicit knowledge, codification, sharing and utilization of both forms of knowledge is explained.

The KM process model illustrates knowledge management process in three main perspectives; human, organizational and technology. It implies that effective knowledge management process involves human intellectual activities, organizational processes and technological aspects. This model asserts that technology serves as the necessary platform for knowledge creation storage and distribution while human generate, utilize and share same knowledge within and across organization setups.

As a result, KM process model is found to be appropriate for this study, because it emphasizes on the adoption of technology in knowledge management process, i.e. knowledge creation, capture, organization, sharing and dissemination for use and to support decision making and problem solving.

2.7 Research Gap

From the literature review, many scholars (Bender & Fish 2000; Mack *et al*., 2001; Zack 2009; Goh *et al*. 2008; Alavi & Leidner 2010; Ahuja & Shanker 2009) assert that ICT tools have provided the necessary platform for knowledge creation, organization and sharing. Davenport and Prusak (2008) believed that weaving ICT into knowledge management initiatives in the organization would create a common controllable environment such that knowledge can be shared within the organization, thus helping to ensure organizational success. By efficiently selecting and organizing useful information, ICT plays a vital role in information retrieval, because it allows simple access to large amounts of independent information sources. It also supports internal knowledge retrieval, synthesis and exchange of tasks by knowledge workers.

The rapid innovations and advances in ICT specifically increase in processing power, memory, and connectivity for mobile, handheld devices, have made mobile devices more interactive and media-rich than ever before. Moreover, mobile devices require substantially less infrastructure and electricity, which gives them many advantages over computers. These features have made mobile phones more permeable and accepted in most communities and societies.

From the empirical review of literature, mobile phone technologies have been adopted in various fields like, medical diagnosis (Callaway *et al*., 2012; Deribe and Roda, 2012; Haq, 2013; Shao *et al*., 2015) and medical supplies inventory (Asiimwe *et al*., 2011; Barrington *et al*., 2010). It has also been adopted in business field, (Furuholt and Matotay , 2011; Mtega and Msungu 2013). In the learning domain, the use of mobile technologies for the improvement of educational outcomes has been lauded (Aker *et al*., 2012; Bello-Bravo and Baoua, 2012), and in conducting research (Dillon, 2012). In banking industry, mobile technology has transformed financial transactions between customer and banking institutions (Abiud *et al*. 2013; Parvin 2013; Duncombe 2012).

It is noted that mobile devices also have an advantage over computers with respect to content generation and sharing. A key limitation of computer-centric initiatives is the lack of varied and robust applications for sharing knowledge. The rapid growth of mobile applications (i.e. apps) on mobile phones has greatly expanded opportunities for sharing and distributing information/knowledge with mobile devices. Nevertheless, no research work has been done explicitly on mobile phone applications in relation to knowledge management at NMK, and in particular knowledge generation, distribution and management.

This study reviewed three models that take different approaches to knowledge management processes (see pg. 24-30, theoretical review section). Although KM process model emphasized on adoption and use of technology in knowledge management process in general, there is one other important aspect relating to this study that has not been directly dealt with by these models. This is the use and adoption of mobile phone technology to capture, process, organize, store and disseminate knowledge. The conceptual framework below is formulated to address this deficiency and to illustrate a more effective approach for this study.

2.8 Conceptual Framework

Like any other organization, the primary purpose of building the knowledge management system is to leverage the collective wisdom and knowledge at group as well as organization level and make faster and effective decisions, solve problems, seek opinions exchange ideas, acquire skills via training/learning etc. KM process model demonstrates how knowledge management process is supported by technology, human and organization components. The conceptual framework formulated in Fig. 2.4 has been informed by KM process model, which brings the concept of technology use, users (knowledge workers &

researchers) and organizational perspectives in knowledge generation and management at the National Museum of Kenya.

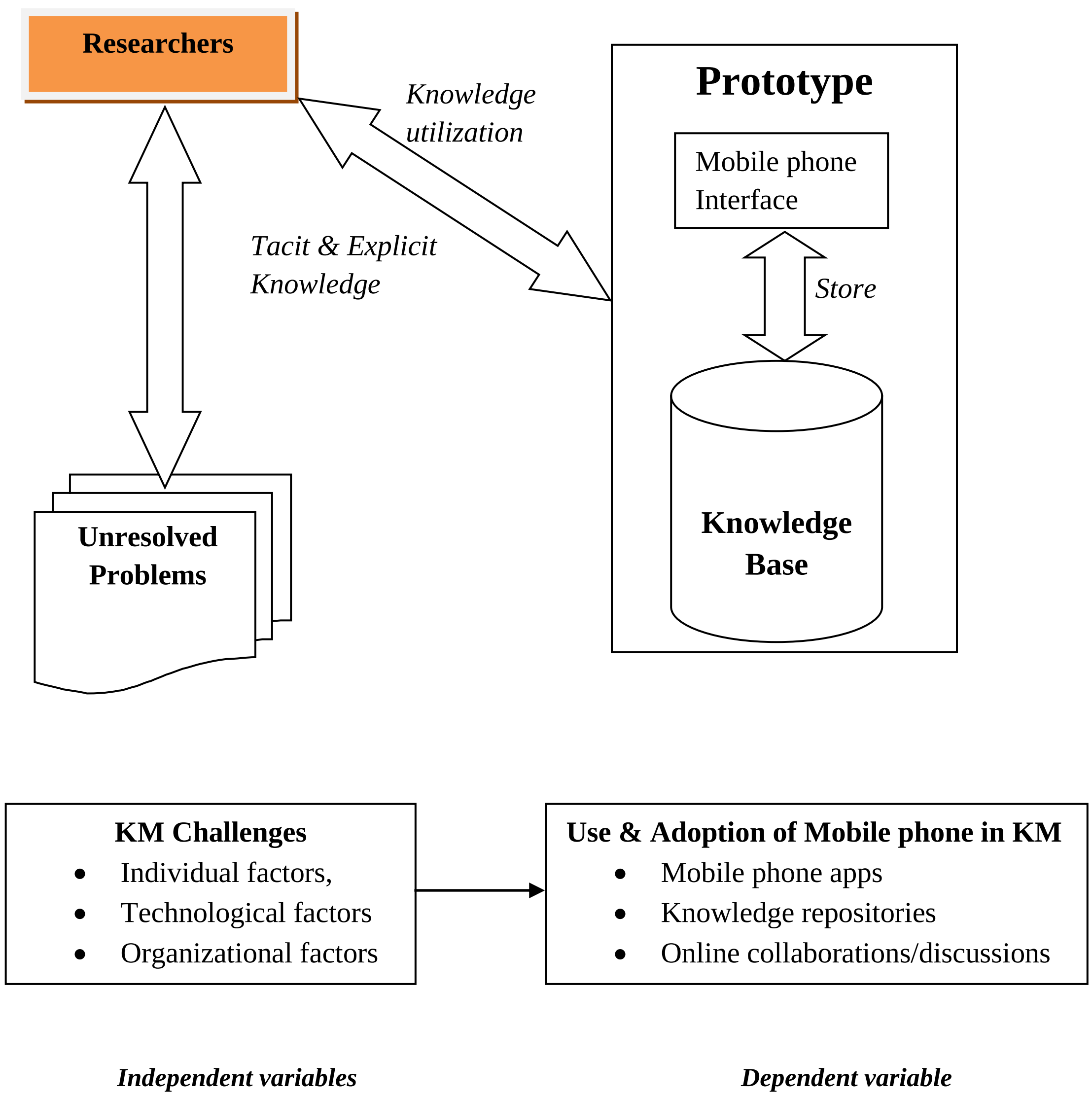

Figure 2.4 – Conceptual framework for mobile phone prototype in Knowledge management

2.8.1 Explanation of Conceptual Framework

The conceptual framework in Fig. 2.4 showed how unresolved problems yield research ideas or problems. Researchers engage in researching to resolve problems; this process may be inhibited by individual, technological and organizational challenges or factors. By utilizing both explicit and tacit knowledge, researchers undertake studies which eventually generate new knowledge.

This framework shows that ICTs simplifies research process for researchers at the museum by providing a more convenient and agile approach in knowledge generation, sharing and management. In this case, the mobile phone platform would resolve research challenges by providing a solution that resolves KM challenges and provide an efficient and effective platform for research knowledge management at the museum.

Using technology, (e.g. mobile phone prototype) researchers conveniently work to generate knowledge that could be shared or stored in the knowledge base for all other users to access. Similarly, other researchers can easily access the available knowledge in the repository to further generate more knowledge. Consequently, technology becomes a solution to KM challenges through use and adoption of mobile phone prototype in knowledge management process. Thus, the independent variables are KM challenges (individual, technological and organizational) while dependent variable is the adoption or use of mobile phone prototype in knowledge management at the museum.

2.9 Chapter Summary

From the literature review, it is well informing that knowledge management helps in exploiting and realizing knowledge for users and building a culture where knowledge sharing can thrive. It is also clear that knowledge management is often facilitated by information and communication technology tools. However, the uniqueness of the knowledge management context may make it difficult for traditional systems development methodologies to be directly applicable.

The nature of adaptations required to the traditional systems development and deployment methods in the context of knowledge management systems is therefore an important issue. The three theories that were reviewed in this study were; the Knowledge worker Desktop Model (KWDM), Socialization, Externalization, Combination and Internalization (SECI) model and the Knowledge management processes theory. KM process theory was finally adopted for this study; this is because it emphasizes on use of technology in knowledge management process.

From the literature reviewed, it was clear that a number of mainstream knowledge management systems have been developed. However, there are limited studies on the application of mobile phone technology in knowledge management. This study therefore formed the base by which more advanced studies can be explored on the same subject.

CHAPTER THREE

RESEARCH AND SYSTEM DEVELOPMENT METHODOLOGY

This chapter provides the outline of the procedure the researcher will use to conduct the study. It covers research design, sample size, sampling techniques, data collection procedures, data analysis techniques and ethical issues that are pertinent to this study.

3.1 Research Design

This research was a qualitative case study with experimentation. Data and requirements were qualitatively gathered and analysed qualitatively to generate system requirements that were used for the design and development of a mobile phone based prototype for knowledge management. The system development methodology is described below.

3.2 System Development Methodology

Evolutionary prototyping methodology was adopted in the development of the mobile application based prototype. According to McConnell (2006), prototyping concentrates on the delivery of the product and involves the user from the start and focuses on the user's needs and uses an incremental approach, keeps the project plan updated, applies development fundamentals, and manages risks to avoid catastrophic setbacks. This study adopted five prototyping steps below:

1. Interviewing of stakeholders to gather requirements: this involved interviewing IT personnel, researchers and section heads at the NMK.
2. Modeling of a quick design; this involved use of UML- use cases, activity, sequence, class and ER diagrams to come up with quick design (as illustrated in figure 5.1, figure 5.2, figure 5.3, figure 5.4, figure 5.5, figure 5.6, figure 5.7, figure 5.8, figure 5.8 and figure 5.10).

3. Prototype implementation and user testing: involved coding (creation of interfaces using PHP, developing the core using Java/C# and database using MySQL (*as explained in* pg. 66-68)
4. Iterative deployment delivery and feedback: this involved presenting the prototype to users for testing, scrutiny and identifying improvements.
5. Keeping review and meeting users informally.

The first component (step 1.) of prototyping was achieved through requirements gathering and analysis which is discussed in this chapter 3 and chapter 4. Requirements were gathered from a sample of staff from a population derived from the National Museum of Kenya. Step 2-5 were achieved in chapter 4 on system design, development and implementation (UML design, UML implementation, ER model and system implementation).Ideally, the prototype serves as a mechanism for identifying software requirements. If a working prototype is built, the developer attempts to use existing program fragments or applies tools that enable working programs to be generated quickly.

3.3 Requirements Gathering

The main goal in requirement gathering is to truly understand the requirements of the anticipated system. In this case, it involves getting the right people to participate in providing necessary information to aid design and development of the application.

3.3.1 Study Population

The study population comprised of staff at the head quarters of the National Museum of Kenya, specifically from those departments dealing with research activities and information management. Specifically, this study focused on a population of one thousand one hundred and eighty (1180), (NMK HR, 2017), however, given the nature of this study, only staff who participate in knowledge creation and management were targeted, totalling to three hundred and twenty seven (327). They comprised of management representatives, representative of research departments, ICT staff, library staff and researchers working at the institution.

3.3.2 Sampling design

A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher would adopt in selecting items for the sample (Kothari 2004). Sample design may as well lay down the number of items to be included in the sample i.e., the size of the sample.

In this case, stratified purposive sampling procedures were used to determine samples in the groups, who in this case are believed to be the key informants, they included; management representatives, representatives of research sections, library staff, researchers and ICT staff.

Stratified sampling was used to separate the population based on their roles and units that they represent; additionally, purposive sampling technique was also co-opted to sample the specific respondents that hold key information in different departments at NMK. According to Mugenda and Mugenda (2003), a sample size of 10-50% is acceptable, therefore, a sample ratio of 0.1 (10%), was used to calculate a sample size of thirty three (33) respondents as shown in table 3.1.

Table 3.1 – Sample size

Strata	**Target population**	**Sample ratio (10%)**	**Sample Size**
Management representatives	22	0.1	3
Heads of research Units	69	0.1	7
ICT staff	48	0.1	5
Library staff	76	0.1	8
Researchers	132	0.1	14
Total	**327**		**33**

3.3.3 Requirement Gathering

Requirements were gathered using Interviews. The interviews sought to describe the meanings of central themes as stated in the objectives in chapter one. The main task in interviewing is to understand the meaning of what the interviewees say (Kvale, 1996). In this case, interviews were conducted to obtain information from all the respondents that are involved in this study thus, collecting requirements for system development.

Interviews provide the researcher with an insight into the knowledge managers' thoughts, ideas and memories in their own words rather than those of the researcher. Furthermore the face to face interactions help the researcher to delve deeper into the issues and to clarify any doubts that arise. The interview guide (used for all respondents) was semi-structured, comprising pre-determined questions with specific topic areas. Structured open response interviews were used to acquire requirements for system development. These involved both functional and non functional requirements that were needed to derive specification and functionalities of the system.

3.4 Reliability and Validity of the Instruments

3.4.1 Reliability

Prior to visiting the institution for requirement gathering, the researcher pre-tested the instruments. According to Kasomo (2006), pre-testing provides a check on the feasibility of the proposed procedure for data collection and shows up flaws and ambiguities in the instruments of data collection. It also yields suggestions for improvement of data gathering tools. The test-retest technique of measuring reliability was used in this case. This involved conducting interviews with two pilot knowledge managers who eventually were not part of the sample; this was done twice with a time lapse of one week. The reliability was the degree of getting consistent results from the instruments.

3.4.2 Validity

On the other hand, the validity of the instruments was assured by ensuring that each of the items in the interview schedule addresses specific objective in the study. Moreover, the instruments were given to two experts, who were not included in the sample and who assessed the concepts which the instruments try to measure. The end result was that the instrument was appropriate in terms of content validity. Eventually, validity and reliability of the tools for data collection was ascertained, hence used to collect data from the sampled respondents in the institution under study.

3.5 Data Analysis Procedure

Qualitative analysis approach was used for data analysis. The qualitative data collected from interviews were categorized in themes in accordance with research objectives and reported in narrative form to give system requirements.

3.6 Modeling and Software tools

During design stage, UML diagrams e.g. use case, activity diagram, class diagram, sequence, package and deployment diagrams were used to model the system. ER diagram was used to model the database. On the other hand, various software tools were used to develop the application: PHP framework was used to develop interfaces (for both mobile and web). Java and C# was used to develop the core - business logic (Java for Android and C# for windows platforms), while MySQL was used to create the database.

3.7 Ethical Issues

The major ethical issues that were adhered to in this study bordered on the reliability and integrity (authenticity) of data collected. First, the researcher sought research authorization from the National Commission for Science, Technology and Innovation. Secondly, the researcher sought informed consent of the respondents and also informed them in advance, about the actual purpose of the research for which their opinions and views were sought.

Thirdly, the respondent’s right to confidentiality was ensured and observed throughout the study period; any data collected was purely for academic purposes and not any other intentions. Finally, all other legal requirements, including; data protection, informed consent, respect to privacy and other permissions were all adhered to as a requirement for ethics in any research work.

3.8 Chapter Summary

This study illustrated the research methodology approach that was used in the study. It explained the research design, system development methodology, study population and sampling methodology. It also expound on data gathering processes, which involve use of interviews. The chapter also gave explanation on major ethical issues that were adhered in the study.

CHAPTER FOUR

FINDINGS AND REQUIREMENT ANALYSIS

This chapter provides how system requirements were analyzed and derived. The information obtained through interviews provided the basis for requirement analysis.

4.1 Requirement Analysis and Presentation of Findings

Data was gathered by use of interviews and analyzed qualitatively. The process involved conduction of interviews from the sample (see Table 3.1); the raw data was captured by recording the responses during interview sessions. Thereafter, data reduction exercise was carried out to develop sense of usable data, hence general categories were created. More so, short narratives based on actual responses were formulated; this was guided by the objectives of the study. Therefore, analysis of data was carried out by categorizing and coding data and inductively developing themes that gave yield to stories or narratives as discussed and interpreted below.

4.2.1 Availability of Knowledge Management Systems

Objective one of this study sought to examine the currently available knowledge management systems at National Museum of Kenya. The findings showed that National Museum of Kenya has automated most of its functions and operations; there is availability of knowledge management systems that have been adopted to support research activities within the institution. There is network infrastructure that supports the functioning of various information systems in place. However, despite of the availability of KMS at the museum, it was found that they have not embraced new technologies like mobile computing and cloud computing as part of their knowledge management systems. Below are some of the responses from interviewees:

"*…..All the departments are networked and have systems that manage museums' operations, but we have not adopted any mobile phone system…*" Head of Botany department

"*…..Majority of researchers and other users access information through web based knowledge Management Systems e.g. Botanical Research and Herbarium Management System (Brahms) and KE-EMU system, there are no mobile phone enabled systems …*" ICT staff

4.2.2 Technological challenges faced by Researchers

Objective two of the study was to establish challenges faced by researchers while collecting data/specimens and compiling knowledge at National Museum of Kenya. The results showed that researchers and staff have challenges in compiling research data and managing knowledge at the institution. It involves long processes in specimen collection, digitization and organization/storage of knowledge. Most of the research specimens and artifacts are collected and brought to the research unit within the museum for further investigation and processing. This was evident from the following responses from respondents:

"*……Researchers experience a lot of challenges during specimen collections due to distance from their research sites, it takes them a long process to digitize collected data and to put them in a form that can be utilized for research..…..*" Librarian, NMK

"*……The technology adopted to collect and process research data is still wanting; it takes a lot of time to transform specimens into a digital form; specimens are first sorted out, classified, preserved and later digitized through a long process of scanning and storing them in a common database..…*" Researcher1

On whether adoption of modern technologies has any significant impact on knowledge management activities, one of the researchers had to say this:

"…..*Despite the availability of modern technologies, NMK has not taken advantage of such technologies to enhance efficiency and effectiveness of its products and services through adoption of new technologies like mobile computing*….." Researcher2

From the above findings, it was evident that the NMK has systems that facilitate knowledge management activities which involve knowledge creation, codification, storage, utilization and sharing. However, it was established that the National Museum of Kenya has not explored possibility of adopting modern technologies and specifically mobile based applications in research knowledge management. Most of the researchers utilize stored knowledge by use of web-based systems that run in their desktop computers. Therefore, it becomes difficult for researchers who travel to remote areas to carry out research activities.

4.2.3 Solutions to the challenges faced by researchers while collecting and compiling research knowledge

Objective three of the study was to suggest solutions to the challenges faced by researchers while collecting and compiling research knowledge at the National Museum of Kenya. It was established that modern and more efficient ICT systems are the best solution to the challenges faced by researchers while compiling research knowledge. Given a well-developed mobile phone application, researchers shall find it easy and more convenient to access and manage existing knowledge. It would also facilitate efficient creation, transmission and compilation of new knowledge. It was out of these idea that functional requirements in section 4.3.1 and 4.3.2 were formulated to serve as a guide in the design and development of mobile phone application prototype for knowledge management.

4.3 Requirements Analysis

Requirements analysis encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product, taking account of the possibly conflicting requirement of the various stakeholders, analyzing, documenting, validating and managing software or system requirements (Laplante 2009). In this case, data gathered through interviews as elaborated above, was used to craft system requirements. The obtained data were checked for errors, validated, coded and finally compiled to form requirement specifications for the anticipated mobile phone based prototype.

Requirements analysis is critical to the success of any systems or software project; it is the process of defining the expectations of the users for an application that is to be built or modified (McConnell 2016). It is a way of documenting, validating, and managing software of system requirements. Consequently, system or software requirements should be documented, actionable, measurable, testable, traceable and related to identified business needs or opportunities, as indicated below for this particular project.

4.3.1 Functional Requirements

The mobile application is a software program that can be installed on both android and windows enabled mobile devices. For this particular research, the functional requirements for the prototype were as follows:

The application shall:-

- Provide interface for new users to register and be able to create, modify or utilize existing knowledge.
- Be able to capture specimens and artifacts instantly from their natural environment.
- Provide an interface for giving details and description of the collected data (specimens and artifacts). This forms metadata of all records or documents created and stored in the repository.
- Allow expertise to collaborate, share knowledge and exchange views on specific research issues.
- Have variety of tools and communication platforms to allow experts create new knowledge and give modification to the existing body of knowledge.
- Provide interface for searching and retrieving stored knowledge.
- Allow general users to access and utilize the existing knowledge in the repository.
- Be able to store complex structured and unstructured information in a centralized repository i.e. knowledge base.
- Provide means and convenient way to distribute and share knowledge.
- Retain logs of all users and their activities; to facilitate easy audit trailing.

4.3.2 Non Functional Requirements

These are aspects of the system or software that are not connected with a defined user action or function. In relation to this study, non-functional requirements for the prototype were as follows:

- *Performance* – The system shall function fast (fast in loading/response time, processing time, query and reporting times).

- *Capacity and Scalability* – The system shall support intended functions and give room for improvements or enhancements in future (relates to throughput, storage capacity and growth requirements).
- *Usability* – the system shall be usable; the application interfaces that are user friendly and understandable to users.
- *Availability* – The application shall be available for use by users at any given time.
- *Security* – The system shall provide security and protection measures against any threat.
- *Recovery* – The system has mechanism of recovery in case of any interruption (restore time, back-up time etc.).

4.4 Chapter Summary

This chapter explained on the requirement analysis and presentation of findings. The findings were presented in narration form based on the objectives of the study. Requirement analysis was carried out and eventually, yielded the functional and non-functional requirements of the system (as stated in sections 4.3.1 and 4.3.2 above).

CHAPTER FIVE

SYSTEM MODELLING AND IMPLEMENTATION

5.1 Development Methodology

The design methodology adopted for this research was prototyping. Prototyping is a System Development Method (SDM) in which a prototype (an early approximation of a final system or a product) is built, tested, and then reworked as necessary until an acceptable prototype is finally achieved for deployment (Laplante 2009). Therefore, in this study, prototyping approach was used so as to realize objective three of the study which is to design and develop a mobile phone based prototype for knowledge management at the National Museum of Kenya. Hence, the steps that were involved during prototyping process are as follows;

- The new system or application requirements were defined; this is after interviewing number of users representing all the functional areas at the NMK to provide necessary information and yielded to system requirements.
- A preliminary design was created for the new prototype; this involved use of Unified Modeling Language (UML), to design and come up with prototype model for the application (see fig. 4.1).
- A first prototype of the new software was constructed from the preliminary design; this was initial product that an approximate characteristics of a final product.
- The users were then allowed to thoroughly evaluate the first prototype, giving its strengths and weaknesses, what needed to be added, and what needed to be

removed. The developer at this point collected and analyzed the remarks from the users, to allow for further improvement of the existing prototype model.

- The first prototype is modified, based on the comments supplied by the users, and a second round prototype was conceived. For the second time, the second prototype is evaluated in the same manner as was first prototype.
- The preceding steps were iterated as many times as necessary, until the users were satisfied that the prototype represented the final product that they desired.
- The final mobile phone application was constructed based on the final prototype. It was then thoroughly evaluated and tested (see pg. 66-72).

5.2 System Design and Modeling

This section explains the process of defining the model, architecture, modules, interfaces, and the data to satisfy specified requirements. As stated above, UML was used as a standard modeling language (see *fig. 5.1*). First, the scope and the requirements for the system developed were defined; this involved system functions and the users. During analysis, developer focused on designing an ideal or logical system that satisfies the laid requirements without being overly concerned about implementation.

On actual design, the work was modified and a concrete physical system or software design was achieved through prototyping technique. Implementation phase involved actual code writing before the initial prototype was tested. After testing, the first iteration ends and the second iteration start with the analysis phase again. The iteration continued until the entire prototype was completed and users were satisfied with the final product (as stated above). The diagram (*fig. 5.1*), illustrated the entire phases involved in the design and development process of the initial prototype.

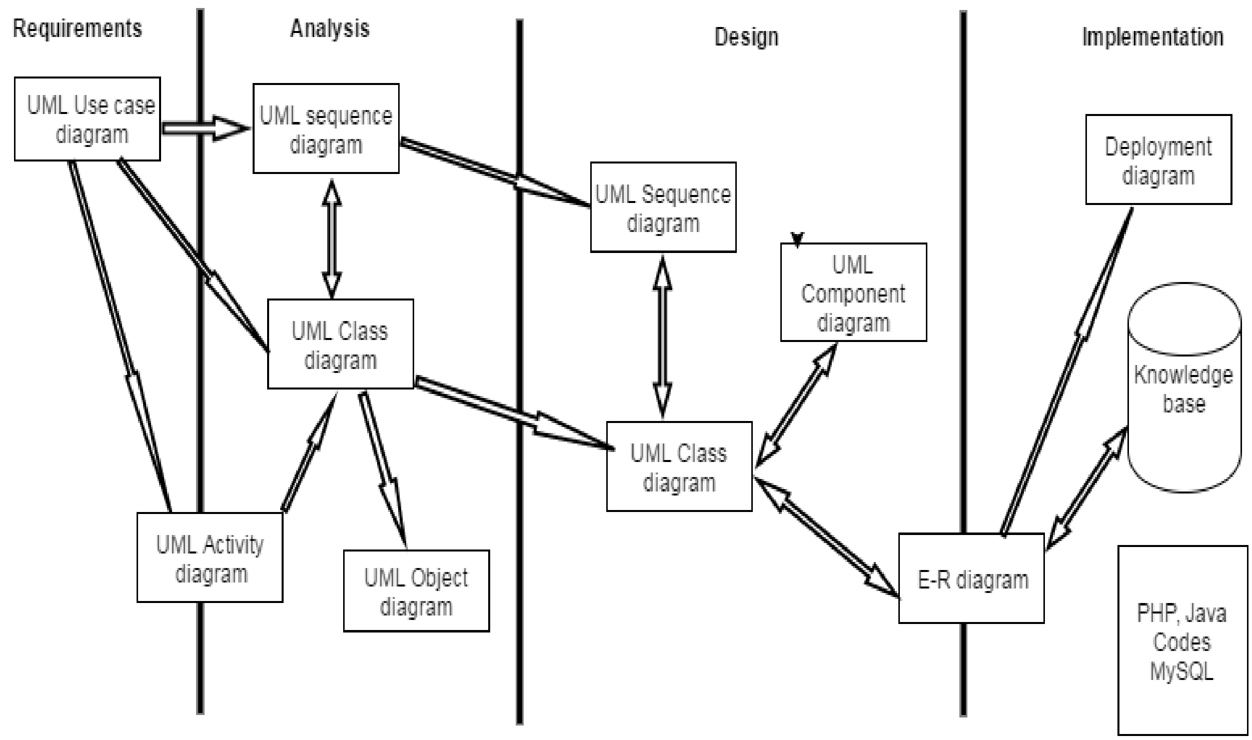

Figure 5.1 – Design Road map

5.3 Application architecture

Architecture determines how application components are identified; the interaction between them and the interface protocols for communication (Roy and Richard 2010). According to Paul, Len and Rick (2008), a 3-tier application is an application program that is organized into three major parts, each of which is distributed to a different place or places in a network. The three parts include; the workstation or presentation interface, the business logic, the database and programming related to managing it. In this case, 3-tier application architecture was adopted as illustrated in Fig. 5.2.

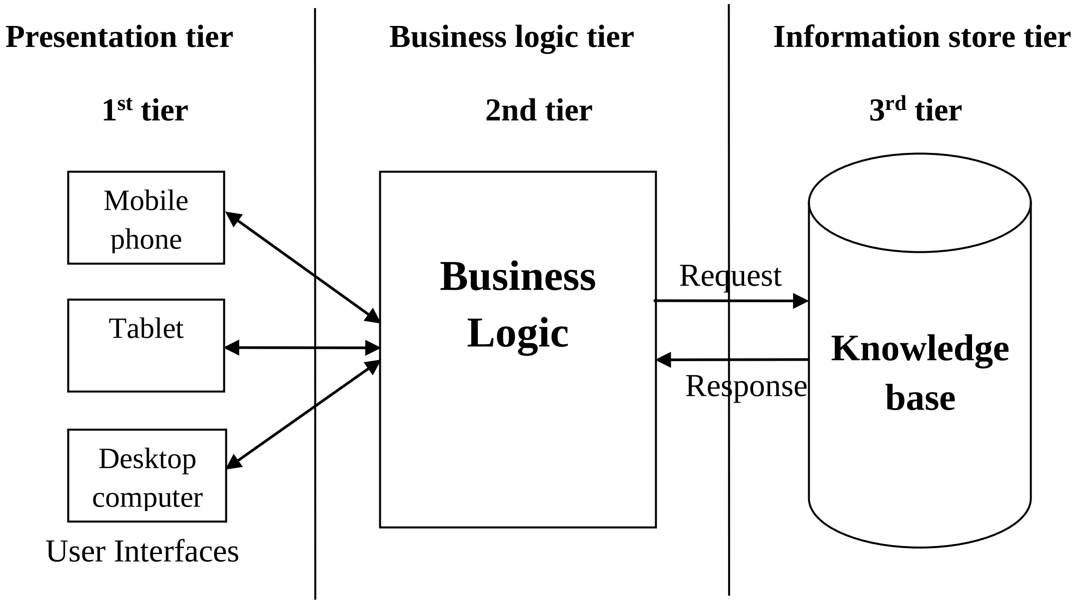

Figure 5.2 – Mobile phone based Prototype architecture (3-tier Architecture)

The first tier (presentation layer) provides the programming, graphical user interface (GUI) and application-specific entry forms or interactive platforms. This was been achieved by coding using PHP. The second tier (the business logic) was achieved by coding using Java and C#; this encodes the real-world business rules that determine how data is created, displayed, stored, and changed. The business logic also acts as the server for client requests from workstations. The third tier (knowledge base) is the database that was constructed using MySQL, for storage of all kinds of data.

5.4 UML Design Diagrams

5.4.1 Use Case Diagram

This type of UML diagram was used to demonstrate the different ways that users interact with the system. Therefore, interactions were modeled according to the authorization of the actors or users in the application. The use cases in this case are such activities as: capturing of research data or specimen collection, knowledge creation or generation, knowledge codification, (conversion from tacit to explicit), knowledge application or utilization and knowledge transfer and sharing. The actors are: researchers and staff at National Museum. The interactions of the actors with the use cases are represented with a line between them as presented in figure 5.3.

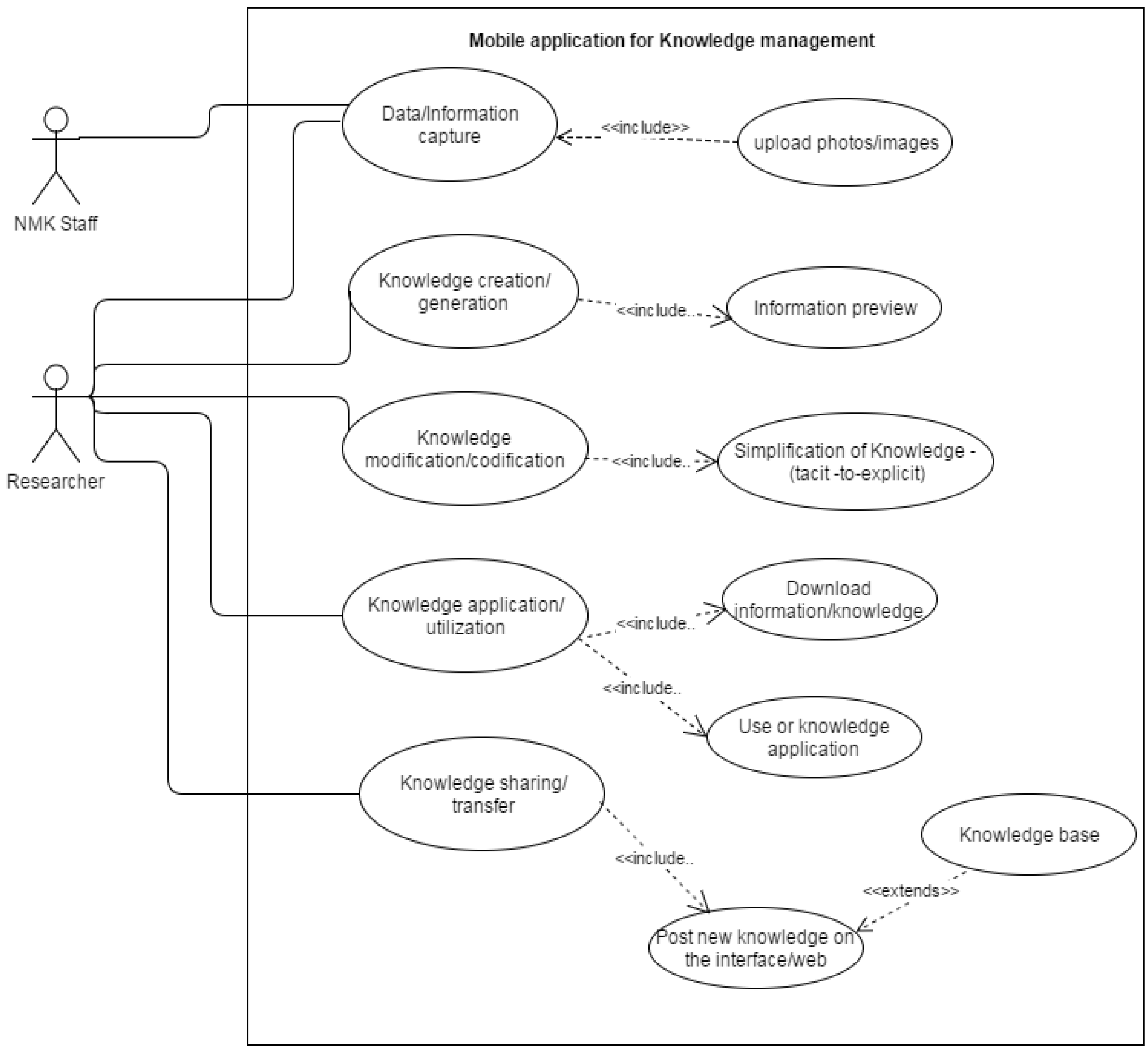

Figure 5.3 – UML Use case diagram

5.4.2 Activity Diagram

The activity diagram was used to visually present series of actions and the flow of control in the new system or application. In this case, it helped to model the work flow of the prototype being designed; consequently important for analyzing use cases by describing the actions that occur in a typical work environment, therefore, the activity diagram is very similar to the workflow diagram in this study. The knowledge management process begins when the researcher start to engage in the research activity.

They first identify knowledge gap or a problem at hand and proceed to carry out a study with aim of resolving a problem or filling the gap. If there is already adequate knowledge in the area of research, the researcher proceeds to utilize or apply. If there is inadequate knowledge, data is captured, metadata is compiled, refined and stored in the knowledge base; consequently, new knowledge is generated and codified for ease of use.

The generated and previously existing knowledge is integrated into the knowledge base ready to share and transfer for utilization by other users as presented in UML activity figure 5.4 below.

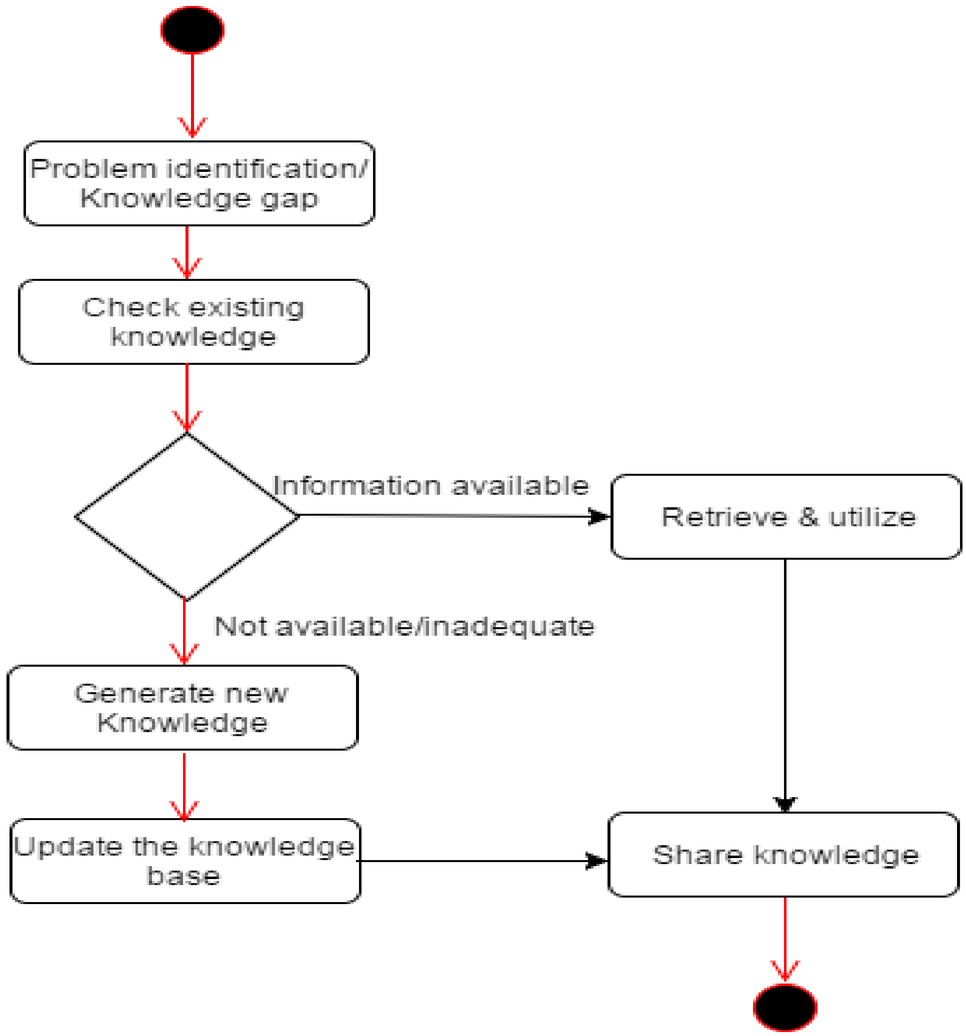

Figure 5.4 – UML Activity Diagram

5.4.3 Class diagrams

In this study, class diagrams were used to give static view of the new application. In this case, class diagrams were drawn to depict the types of objects in the system and the different types of relationships that exist among them. Class diagrams helped in the visualization, description and in documentation of the system as well as aiding the construction of the executable codes for the prototype. The class diagram in fig. 5.5 below, displays classes, attributes and operation in separate designated compartments; this helped in construction of the code that constituted the software application:

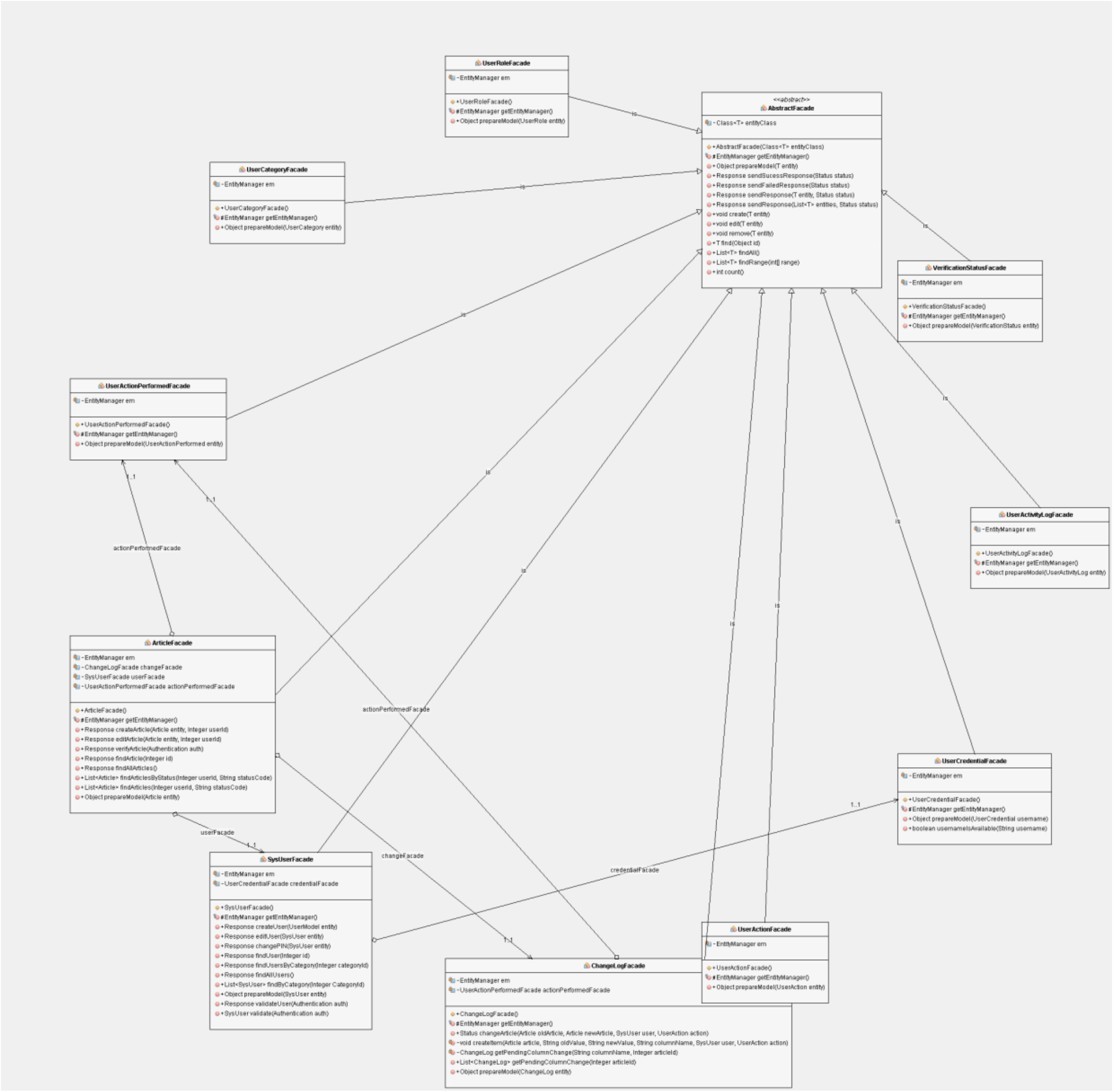

Figure 5.5 - UML class diagram

5.4.4 Sequence Diagram

In this study, sequence diagram was used to depict interaction between objects in a sequential order; the order in which these interactions take place in the system. Sequence diagrams help validate architecture, interfaces, state machine and logic by providing how the system architecture handles different basic scenarios and special cases. Consequently, sequence diagrams used in this study describes how the interfaces are used and what messages or actions are expected at different times, hence giving consistency proper implementation plan. Therefore, fig. 5.6 below shows the interactions between the objects of the classes and the sequence of events for this particular research. The sequence of activities is as follows; researchers collect data (specimen collection) and enter all the descriptions of the specimen including taxonomic and scientific names and other descriptions that relate to the collected specimens.

Using mobile based system (prototype) or a web based system; staff at the National Museum will verify collected data or information. Through the same platform, researchers generate and codify knowledge in order to turn them into useful knowledge. This is the stage where tacit knowledge is converted into explicit knowledge and is very critical to the success of the consequent stages in knowledge management i.e. application and sharing.

In the sequence diagram below, mobile application shall provide ways to check for knowledge duplication, validation and whether the newly generated knowledge exists in the repository. The researcher confirms changes and stores newly created knowledge in the knowledge base for further action and utilization. This knowledge will be available for application and use by other users. The UML sequence diagram is shown in figure 5.6 below.

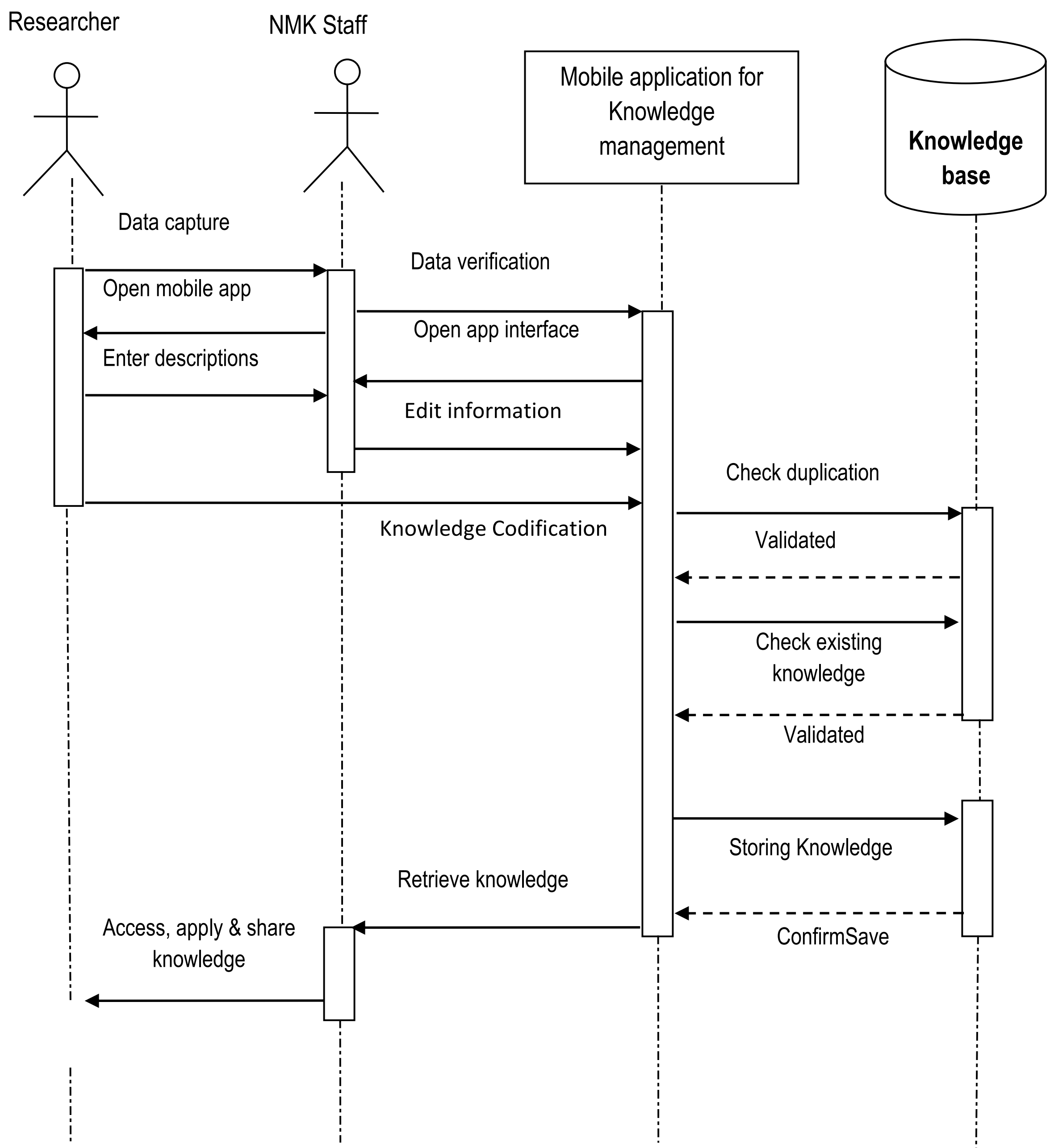

Figure 5.6 - UML sequence diagram

5.4.5 Package Diagram

Package diagrams allow developers to show how classes can be divided into logical software modules, which are called packages in UML. In this research, package diagram was used to describe the arrangement and organization of model elements. It showed the structure and dependencies between the main sub-systems or modules. In this case, presentation layer which contains user interfaces and presentation logic modules is a general classifier. Business logic layer is a specific classifier that inherits features from the presentation layer, while data layer subsequently inherits features from business logic as shown in fig. 5.7 below.

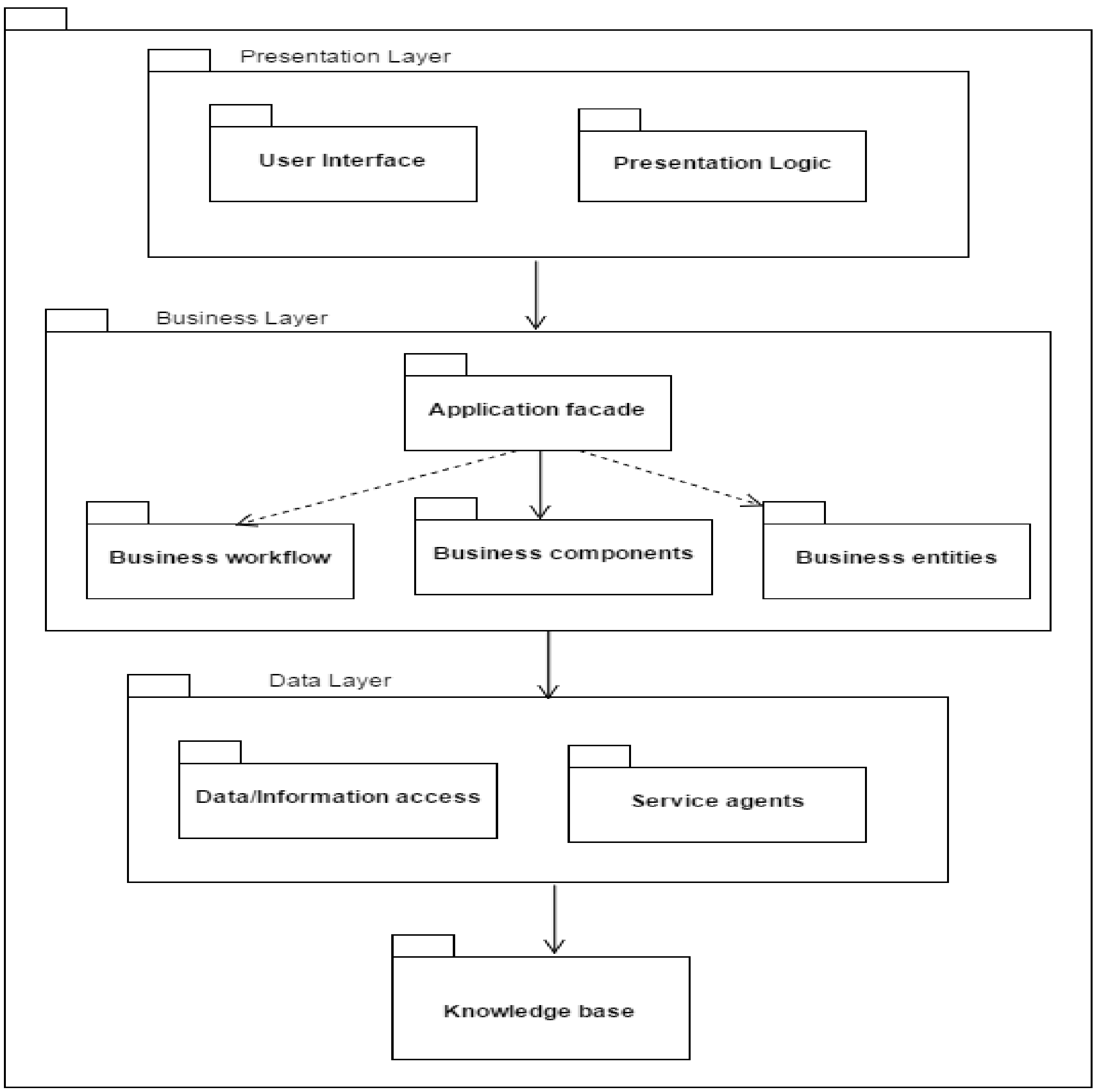

Figure 5.7 - Package diagram

5.4.6 Component and Deployment Diagram

In this case, component diagram identifies the different components of the whole system; it involves all physical components or physical modules that were developed to constitute the newly developed application. The components that are shown in fig. 5.8 below include; web browser and mobile applications running on desktop computers and mobile devices respectively; the log files and database interfaces supported by application server; and Database Management Systems (i.e MySQL) located at the knowledge base.

Additionally, component diagrams in this research were used with deployment diagrams to show how physical modules of code are distributed on various hardware platforms required by the system to execute. Deployment diagrams allowed the developer to model the physical platforms and network connections that were used to support the new application. In this research, deployment diagrams were used to visualize the hardware processors, nodes, or devices of the system, the links of communication between them and the placement of software file on that hardware. This was drawn using the package diagrams to show the execution architecture of the application.

In a nutshell, component diagram shown below, illustrates how users interact with the application in a real execution environment. Particularly, fig. 5.8 below shows how users access knowledge through a desktop client of mobile application, and it has to go through the application server to the knowledge base. It shows the sequence process of knowledge creation, access, utilization and sharing, which are collected as a package. Deployment diagrams helped developer to model the physical platforms and network connections that shall be required to support the application. Components can be placed inside the nodes to show how actual code shall be distributed. A class level or an object level configuration, in which the specific instances of the node, is described. In this case, clients make requests to the application server and it connects to the database server to allow manipulation of the stored data with the help of MySQL program. Therefore, client is dependent on the application server and it dependent on the database server that is part of the knowledge base.

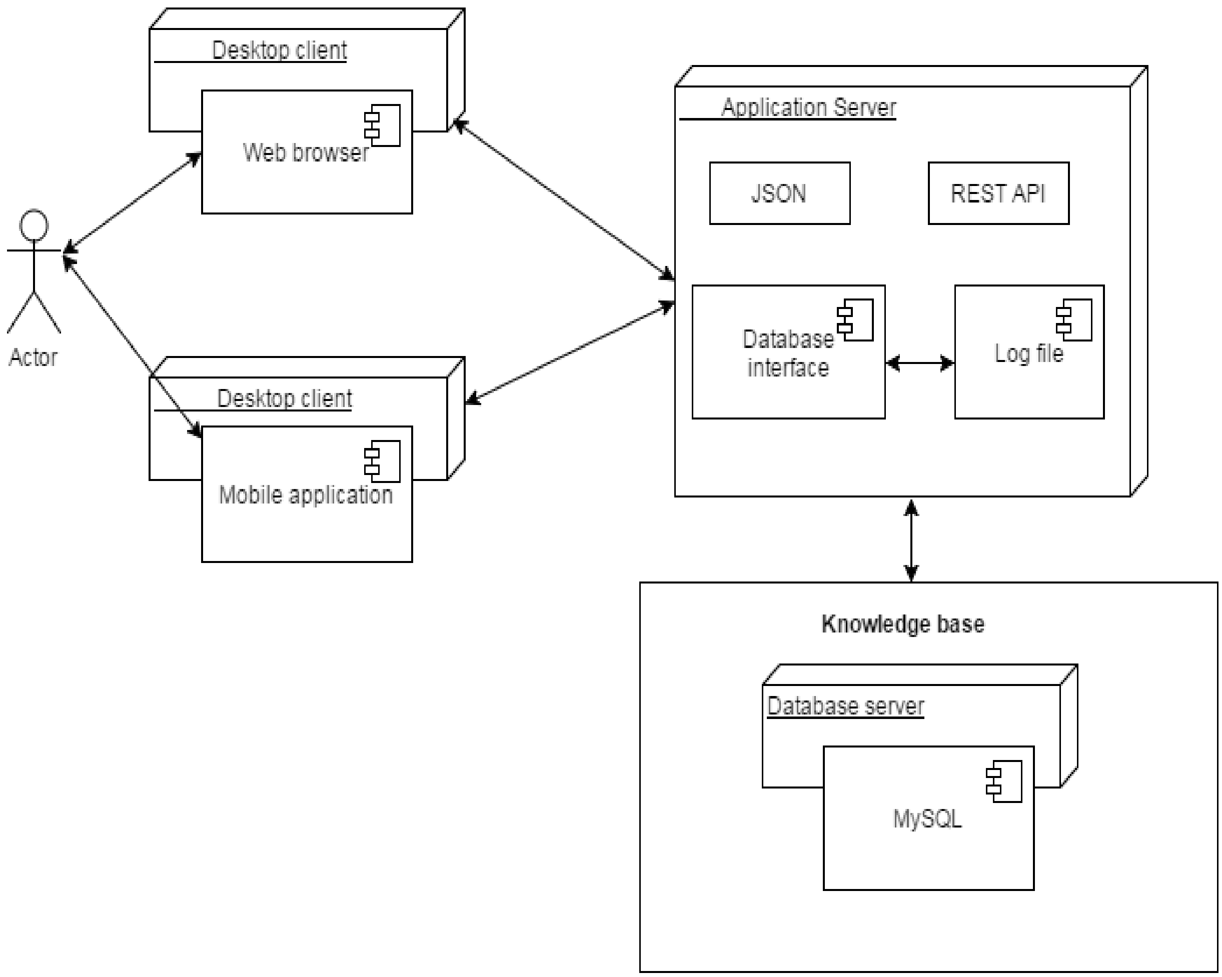

Figure 5.8 - Component and Deployment diagram

5. 5 Design of Data Warehouse

Data warehouse is a central repository, where heterogeneous collections of different data sources are organized under a unified schema (Jashapara, 2011). In this study, top-down approach was used in the construction of data warehouse as shown by fig. 5.9. The external sources are the sources from where data or specimen is collected irrespective of the type and size of the data or specimen; and which can be structured, semi structured and unstructured as well. Since the data or specimens extracted from the external sources do not follow a particular format, they are validated before loading to the repository. In this case, Extracted, Transform, Load (ETL) approach is used; where, extraction occurs when data is extracted from external data sources. Transformation takes place when data is transformed into a standard format, while loading is the process of storing data into the data warehouse. In other words, after the cleaning of data and subjecting them through ETL process, the collected information is data/specimens are stored in the data warehouse as central repository. This involves storing of metadata and the actual data sets (information) in the data marts. Data marts are part of storage component; it stores information of a particular function which is handled by single authority. In this case, data marts are handled by researchers or experts in the various research units of the museum. Data mining forms part of the data warehouse architecture; it is the process of analyzing big data stored in the repository to find the hidden patterns present in the database.

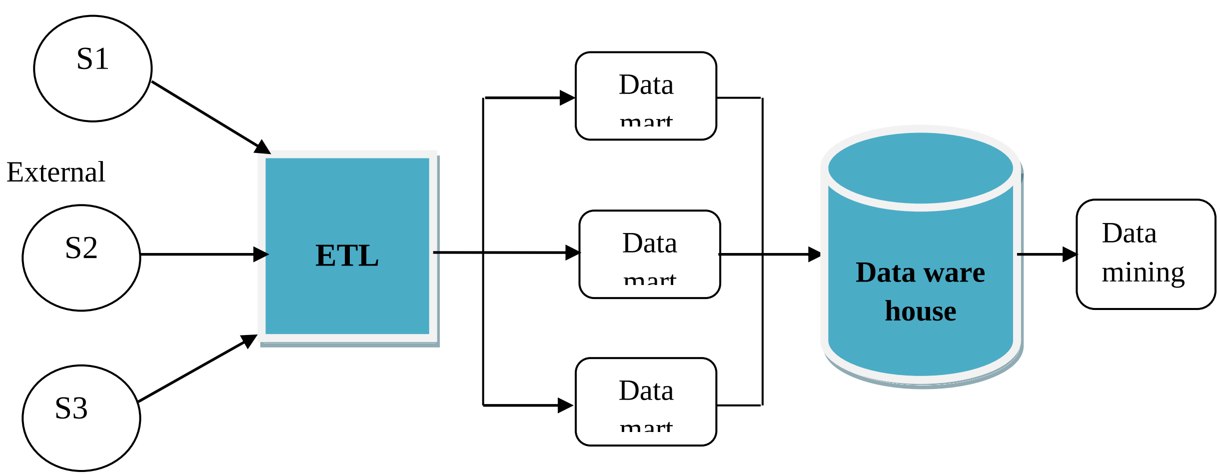

Figure 5.9 – Data warehouse architecture

5.5.1 Data mining and Knowledge Discovery

Knowledge management is a process of data or information utilization; the basis of data mining is a process of using tools to extract useful knowledge from large datasets (Dawei, 2011). Therefore, data mining is part of knowledge management and an essential step in the Knowledge Discovery Databases (KDD) process that produces useful patterns or models from stored data. It is a computational process of discovering new patterns from wealth of data in database by focusing on the algorithms to extract useful knowledge (Lawal, Odeniyi and Kayode, 2015). Basically, information gathered from data mining helps to predict hidden patterns, future trends and behaviors of items studied in research area. In this case, process of data mining was used in retrieval of knowledge and it involves data pre-processing, extraction, evaluation, and knowledge presentation. Knowledge presentation involves visualization and knowledge presentation techniques that are used to present mined knowledge to users.

Using Bayesian Machine learning approach, data mining process involved a measure of experts' belief, so that probability is subjective and refers to new knowledge discoveries. The researcher's belief is referred as a prior; data stored in the repository is utilized to update experts' belief and the outcome is a posterior. As more data is obtained and loaded to the repository, the old posterior becomes a new prior and the cycle repeats.

By employing the Bayes rule:

$$P(A | B) = P(B | A) * P(A) / P(B) \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Where, P(A | B), read as ‘probability of A given B’, indicates a conditional probability, how likely is A if B happens.

The Bayes rule above (i) above is used to model parameters (theta) from data (D) in the repository, resulting to equation (ii) below:

P(theta | D)_= P(D | theta) * P(theta) / P(data)……………. (ii)

Where, P(data) is a normalizing constant that cannot be computed, and therefore, when comparing models, only the expression containing theta is important, because P(data) remains the same for each model. P(theta) is a prior, or a belief of what the model parameters might be; in this case researcher’s belief. Inference should therefore converge to probable theta as long as it is not zero in the prior. P(D | theta) is the likelihood of data given model parameters. Finally, P(theta | D), a posterior, and this is the information required by the user. It is a probability distribution over parameters obtained from priors’ beliefs and the existing data in the data warehouse.

5.5.2 Entity Relationship (E-R) Model

Using E-R model, the developer was able to give descriptive and design structure of a database. After the initial class and sequence diagrams were created in the analysis phase, they were enhanced and expanded in the design phase in parallel. From the expanded class diagrams, E-R model of the data structure was drawn, which led to the design of the database. ER diagram was used to describe the logical structure of the database. In this case, all entities, attributes and relationships were illustrated as shown in figure 5.9 below, (see appendix VI, pages 100- 103 for database schemas).

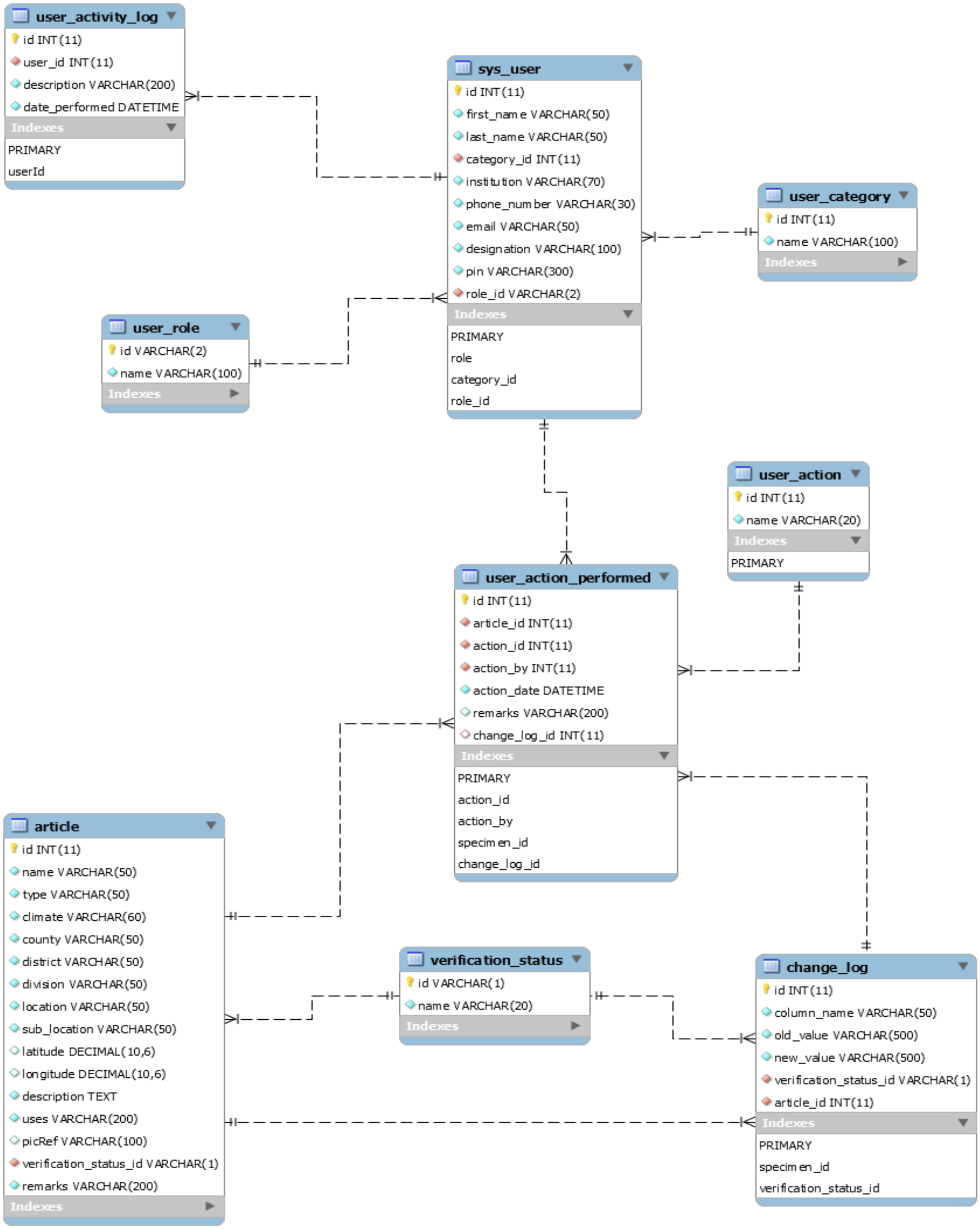

Figure 5.10 - ER diagram

5.6 System Implementation and Testing

5.6.1 Coding

This involved implementation of the logical design specified in the design stages into executable programming language code (see sample codes in appendix IX). The coding was achieved by using PHP to develop user interfaces, (see screenshots in appendix VII, pg.104-105). Java programming and C# was used to develop the core - business logic (Java for Android and C# for windows platforms respectively) and finally MySQL was used to create the database.

5.6.2 Integration and Testing

Testing process was carried out to validate that the code works the way it was intended, and to detect presence of bugs. In this project, three types of testing techniques were adopted; White box testing, Black box testing and User Acceptance Testing (UAT),

5.6.2.1 White Box Testing

This type of test was carried out in order to validate the internal structure and working of the software code; the main focus being to validate the functionality requirements. The testing process in this case involved both code coverage analysis and statement coverage. Specifically this type of testing was carried using an automated tool known as selenium frameworks which is an open source testing tool for testing software applications. With few clicks, selenium framework allowed the setting of a JUnit test run on the local JVM or instrumented test that runs on mobile devices like mobile phone. It involved importing the codes of specific modules of the program and executing them to check for errors. The interface below (fig. 5.11 and fig. 5.12) shows the procedure for exporting the test cases and the outcome of test scenario carried out using selenium framework.

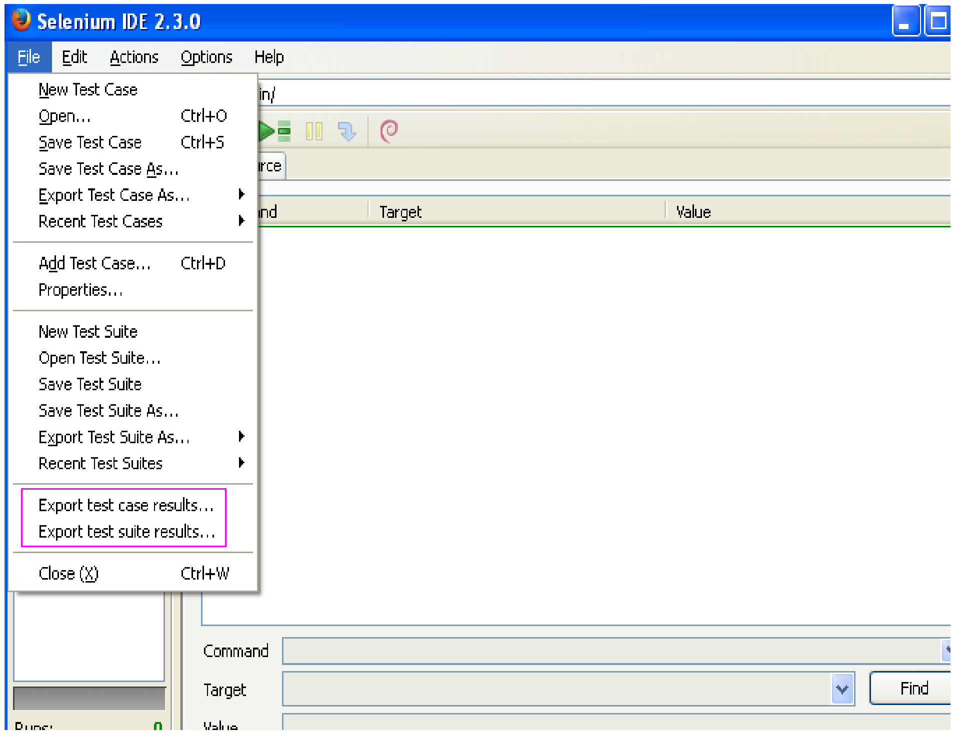

Figure 5.11 - Exporting test cases

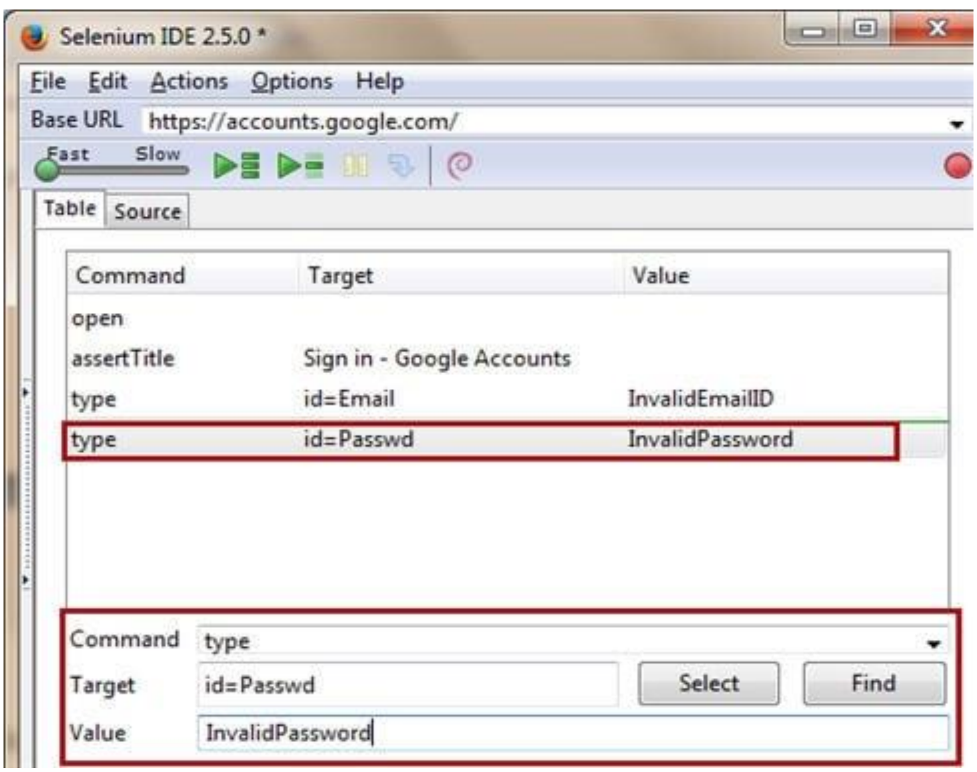

Figure 5.12 – Test case outcome (invalid password)

5.6.2.2 Black Box Testing

This was a type of test to the software application without looking at the internal code structure, implementation details, or knowledge of internal parts of the software. It is also known as behavioral testing; in which the software program in the eyes of the tester is like a ‘black box’; inside which one cannot see. This type of test tries to find errors as incorrect or missing functions, interface errors, errors in data structures or external database access, behavioral or performance errors, initialization and termination errors.

In this study, this type of testing was carried out manually by preparing test scenarios, test cases and test data that eventually executed to show expected results. This type of test was aimed to cover-functional, non-functional and regression tests to ensure that the application functionalities are accurate and perform as expected (see appendix VIII, application UAT checklists, pg. 106-108). It also involved testing carried out by different users, and also testing that was done after code fixes and other system maintenance. The test plan and outcomes are shown in table 5.1 below.

Table 5.1 – Test plan and Results

Tested by:		Samson Too			**Date**	28/05/2019	
Name of the Application		Mobile phone based prototype for Research Knowledge Management					
Test scenario	**Test case**	**Precondition**	**Test data**	**Test steps**	**Expected results**	**Actual results**	**Pass/Fail**
Check login functionality	1. Check response on entering valid username & password. 2. Check response on entering invalid username & password. 3.Check response when username is empty & login button pressed.	The application must be installed and have few users registered	Username: sktoo Password: sam Username: xxxx Password: user Username: none Password: none	1.Launch the application 2.Enter Username 3.Enter password 4.Click OK	Login successful	Login successful	Pass
Check registration of new users to the system	Check response on entering new user details	The application must be installed and provide interface for registering new users	1st name: Sam 2nd name: Too Position: administrator Email:samkiptoo@gmail.com	1.Launch the application 2.access interface for new registration 3.enter 1st name 4.enter 2nd name 5. enter position 6. enter email 4.Click OK	Registration successful	Registration successful	Pass
Check for data capturing and	1.Check responses on	The application must be installed and be	Record identifier: ornament1 Title: Maasai beaded	1.Launch the application	Successful creation of new	Successful creation of new	Pass

metadata creation (for specimen collection)	capturing new specimen 2.Check response in creating metadata; description to newly captured specimen 3.Check response in saving new data	able to provide interface for uploading image or photos, capturing metadata and storing new information on new specimens.	jewelery, Date of creation: 02/02/2018 Indigenous name: xxxxx Purpose: record for storage, posterity File format: .jpeg	2.access interface for entering metadata for the new specimens 3. enter date of creation 4. Take or upload the photo 5.enter enter the record identifier, title or the name of the specimen both exotic and indigenous 6. enter purpose 7.Click SAVE	data	data	
Publish an article for reading	Check whether an article can be published to allow readers access	The application must be running to provide an editor where an article is presented for reading and review	Author's name: Prof. Omar Title of the article: 'Coastal Kenya roots for honey moon showcase' Date of creation: 12/11/2017 Purpose: For reading File format: .pdf	1.Launch the application 2.access interface for publishing articles 3.enter the name of the author, title of the article, date of creation 4.Upload the document in pdf format 5. Click 'eye icon' to feature the article 6. Click finish	You succeeded publishing your article	You succeeded publishing your article	Pass

5.6.2.3 User Acceptance Test

User acceptance testing (UAT) involves actual software users testing the program to make sure it can handle required task in real-world scenarios, and according to the specification. This testing usually happens in the final phase of testing before deployment of the software application to the real work environment. In this study, alpha and beta testing techniques were applied; testing was undertaken during development period by users who were involved during prototyping process.

From the initial prototype development, users were given chance to review its functionalities and the developer then fixed arising issues to improve the usability of the product. Beta testing technique (field testing), was then applied to the final prototype; this took place at the NMK, and involved some extensive testing by a group of users. The beta testers then provided feedback (see appendix VIII application UAT checklists) which was then used to perfect the product.

5.6.3 Validation and Verification

This is the process of evaluating the final prototype to check whether it meets the intended needs and whether it meets the specific requirements. Verification was achieved with use of both informal and formal reviews. There was constant review of every phase and involvement of users during development and testing phases of prototyping. Validation was carried out by consistently testing the codes at any stage. This was achieved by use of test data that are both valid and invalid to check whether the prototype was fit for use and satisfy the expected needs of the users, (See fig.5.13 test login).

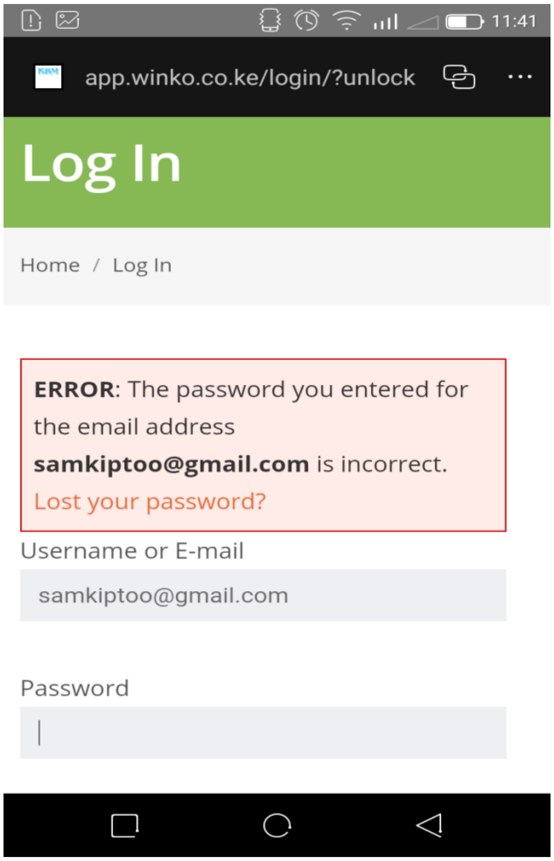

Figure 5.13 – Test login

5.6.4 Deployment

After testing, the prototype was deployed on real mobile phones and tablets running on Android and Windows operating system. Several models of ICT devices were used during testing; Techno POP 2F phone and a tablet both running on Android version 8.1.0 and Infinix mobile phone were provided for this purpose. (You can include a third test using a brand used internationally e.g. Samsung, OPPO, Techno and Infinix are local brands used in Kenya and most African countries.) The application prototype was installed on both phones and found that all the functionalities worked well (see screenshots in appendix VII, pg. 104-105).

Deployment involved setting up the server so that end users can easily install and use the applications. The mobile application was deployed first to the server after which the application was downloaded to the appropriate mobile client. This was necessary to achieve the required level of performance, scalability, security, availability, and connectivity. Security measures such as authentication, authorization, and encryption were supported using the appropriate standards.

The server provided ability to create users, grant privileges to execute applications, and define the data subsets for them, among others. At this level, it was necessary to test for functionality and performance in a real deployment environment. Initial installation involved installing the mobile client and user applications.

In normal circumstances, the volume of data required to install application on a mobile device for the first time could be quite high, necessitating the use of either a high-speed reliable connection between the mobile device and the server, or using a technique known as offline instantiation. In this case, offline instantiation was adopted; everything needed to install an application on a mobile device was put on an external storage device (flash disk) and physically given to the users. Users used this media to install the application on their devices; alternatively, the server could provide a tool for offline instantiation.

After deployment, the application server takes care of managing application updates and data schema evolution. However, the administrator must republish the application and the schema. The application server automatically updates the mobile clients that have an older version of the application or the data. On the other hand, repository (knowledge base) contained all the application data as well as all information needed to run the application server. The repository also contained the knowledge base schema under which all the data mapping and internal tables utilized to maintain data synchronization exist.

This schema also stores the application, application tables and its data published for use with a mobile client. The repository contains some internal tables that the application server uses to perform its functions. Users may query these tables to gain more details about the current state of the environment; however, most of the information needed from tables was already accessible from the mobile phone application. Administration, backup, and recovery of the repository are taken care of and any changes to the repository can only be made using the mobile manager or the resource manager API.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter presents the main findings and conclusions that can be drawn from this research work. In addition, it provides recommendations that can be taken into account for further research.

6.1 Summary of the findings

6.1.1 The Current state of Knowledge Management Systems at the NMK

The National Museum of Kenya (NMK) is a complex organization with a broad mandate and a wide range of activities from the traditional museum activities to the preservation of Kenya's antiques and monuments. Therefore, NMK is responsible for the conservation of Kenya's heritage and collection of cultural, ecological and fossil exhibits, sites and monuments which are unique in Sub-saharan Africa and biomedical and bio-conservation research. Information Communication Technologies (ICTs) are increasingly used to support information services in variety of ways. At NMK, data generation, documentation, dissemination of research information and knowledge management activities relies on the kind of information systems that have been established to support such functions.

Information systems therefore, play a vital role in the management of research knowledge at the museum. The processes of gathering, collecting, processing and storing various data or information is effectively achieved by use of information systems and other information communication technologies. One objective of this study was to examine the currently available knowledge management systems at the NMK. The findings established that NMK has adopted a number of web based systems that support knowledge management activities. Among the Knowledge Management Systems that have been implemented include: Botanical Research and Herbarium Management system (Brahms), Collection Management system (KE Emu), Argus and Gallery systems. These systems are available within the museum and they are used to facilitate research and to support knowledge management activities. The adoption of these systems have created a culture that encourages knowledge sharing among curators, registrars, researchers, librarians and including directors of various sections.

This study established that there is a network infrastructure that provides institutional connectivity and integration of various information systems, and a museum-wide shared resources that are available in one relational database for all users to access, use and contribute to knowledge creation and enhancement. However, new technologies like mobile applications have not been adopted in any part of the museum as knowledge management support tool. This was the central focus of this research work, to explore the beneficial use of mobile applications in supporting research knowledge generation, management and sharing. This would be the best platform for communications and building of relationships among various knowledge management players and creating an efficient and effective way of managing and sharing knowledge for prosperity and development.

6.1.2 Challenges Faced by Researchers while Collecting and Compiling Research Knowledge at NMK

All over the world, ICTs have gained a lot of recognition in knowledge management and its importance in management of collections in the museums. However, adopting this new paradigm presents a lot of challenges to researchers and information professional fraternity. Objective two of this study was to establish challenges faced by researchers while collecting and compiling research knowledge at the NMK. This study findings revealed that researchers and staff experience challenges while collecting specimens and during compilation of research information. Specimen collection is carried out manually; most of the research specimens and artifacts are collected, brought to the research sections within the museum for further action. They are first sorted out, classified, preserved and later digitized through along process of scanning and storing them in a system. By use of web-based systems, data is transformed into digitized formats and stored in a centralized database that can be accessed by users.

In this regard, it is evident that researchers and knowledge managers, experience a lot of challenges in management of collections and compilation of new knowledge. Museum collections are characterized by heterogeneity and complexity of data; they usually host a plethora of objects of categories that each requires different description policies and metadata standards. In this case, the process of gathering, coding, and compilation of research knowledge becomes a very tedious and difficult and therefore, require better and efficient tools and methodologies to resolve such challenges. This study found out that it is much easier and ideal to allow knowledge users services at their convenience; for instance, with the use of collaborative applications and interactive tours through mobile devices.

6.1.3 Design and development of Mobile application for Knowledge management

The growth of cultural heritage and ICT advancements has led to the evolution of software applications to address the numerous needs that each and every knowledge user requires. Digital museum management systems are growing in number providing a set of options, but also are exhibiting remarkable quality leverage and user satisfaction. Objective three of this study was to design and develop a mobile-based system for knowledge management at NMK. This was to provide solutions to the highlighted challenges that researchers face while compiling knowledge at NMK. The study findings showed that there was no mobile phone applications adopted at NMK to aid research activities. Knowledge inform of digital content was stored and availed on web-based systems. Consequently, in designing the mobile application prototype, there were two guiding principles; *flexibility* and *adaptability* to user needs.

At the NMK, there are varieties of two and three-dimensional data objects that are captured as part of research data; for instance, videos, pictures, clothes, furniture and among other artifacts. Moreover, a diversity of visitors or users may require having access to the digital collection and the compiled knowledge with different goals, e.g. educational, research in various domains and including touristic and entertainment purposes. Therefore, user interfaces and metadata schema design was crucial for this purpose and fulfillment of the mentioned requirements as stated in pg. 45-47. Moreover, the enhancing capabilities of the new prototype provided variety of capabilities which include:

- Allowing users (both researchers and other general users) to install, register and be able to use to access, share and distribute knowledge;
- Collection of various data; in form of images (specimens and artifacts) that are digitally captured, described and retransmitted using the mobile phone based prototype.
- Providing of good user interface that allows users read, reviews and publishing of research information. User interfaces were evaluated using cognitive walkthrough method; it involved choosing of specific task in a particular interface, determine the

correct sequences of actions for that task, then assess whether a hypothetical user would be able to select an appropriate action at each point.

- Provides tags that allow sharing of articles, themes or topical areas by experts in form of collaborations and exchange of knowledge on topical issues.
- Provides range of tools for easy sharing and distribution of knowledge. For instance, the email-to-knowledge-base feature automatically converts an email into a knowledge base article. The user is required to forward the email to the knowledge base and the rest of the users are notified of new article.
- Offers powerful search facility for users to precisely search and retrieve existing knowledge.
- Allow use of GPS function to show the physical location or origin of specific research data e.g. artifacts and specimens that form sources of knowledge.
- Allow submit and comment an article by browsing through the recently submitted articles; users need to install and register before receiving alerts on the existing articles.
- Creates a data warehouse or repository of the acquired knowledge, and allow mining of knowledge stored in the repository;
- Allow users to share links of documents or articles, new articles can also be featured and tagged to experts for interrogation.
- All the logs are retained in the repository, to allow monitoring and tracking of changes done on the documents.

In general, the mobile phone based prototype from this study, is a specialized solution designed to help researchers build and maintain intellectual network for development, sharing and utilization of research knowledge. It was designed with the non-technical business user in mind and making it easy to capture, create, modify, store and share research knowledge at the National Museum of Kenya.

6.2 Conclusion

Museums offer a wealth of information and knowledge to society; hence need to be more and more conscious of their functions and purposes to the public, not only by allowing physical access to their collection, but also leverage on ICTs in providing knowledge or information access to the people. Knowledge management systems and other forms of ICTs, have turn to be a strategic resource in compiling, storing, disseminating, and sharing knowledge within research institutions like museums.

Knowledge is often complex; it is more than simply gathering data and information and transforming that into meaningful contexts. Knowledge is a mixture of various elements; it is fluid mix of individual's experiences, values, contextual information and, expert insights. Knowledge is formally unstructured; it is intuitive and therefore hard to capture in words or understand completely in logical terms. Therefore, it requires a more reliable platform that can allow experts share their intuitive ideas and insights for documentation and for future utilization.

This study found that National Museum of Kenya (NMK), until now, experience challenges in the handling research knowledge management. Knowledge management in this context involves building databases (by capturing data or information), harness intellectual capital, establishing ICT platforms, sharing best practices, leading exchange programs, leading cultural change, fostering collaboration and creating virtual organizations.

The knowledge management systems at NMK support creation, capturing, processing and dissemination of information through a network, and within the museum premises. There is still need for improvement, to leverage new technologies that simplify the entire process f knowledge generation, storing and distribution. This study opined that use of mobile phone technology has recently risen in our society and yet, it has not been co-opted in research endeavor. The driving force behind reliance of mobile technology in Kenya is the tremendous leap in technological adoption, innovative ideas and the increased use of mobile devices in daily life activities.

This research focused on the development of a mobile phone prototype application, as a quest to resolve the existing knowledge management challenges, and as a way to foster collaborative research among various experts at the NMK. The adoption of mobile phone technology in knowledge management is a new paradigm that is intuitive to use and adds an emotional and personal dimension in knowledge generation and sharing. The prototype developed in this research therefore allow expert to share knowledge and organize them for ease of access and utilization.

In addition, this would also make research knowledge sharing easier and more convenient to the museum visitors, online information users and other researchers. As elaborated above, this platform empowers researchers with tools for monitoring changes and improvements made on their articles, share their own ideas. The prototype specializes in knowledge generation, storage, utilization and management. Through this initiative, NMK researchers would easily work together in collaboration to create, review and share research knowledge across disciplines, and provide efficient procedures that would optimize knowledge use.

6.3 Recommendations

6.3.1 Recommendations on Knowledge Management Practices

First, research knowledge is recognized as a key resource. ICT tools can play a variety of roles in support of research knowledge management processes. This study therefore, recommends that NMK should explore new technological innovations like, mobile technology, semantic web, natural language processing, artificial intelligence, cloud technology etc., in the management of knowledge as a way of enhancing access and sharing of knowledge. The NMK management team should play a critical role in establishing the multilevel context for the effective adoption of new ICTs like this new mobile phone application in knowledge creation, storage, retrieval, sharing, and application.

Secondly, this study developed a prototype anticipated to be a future tool for knowledge management processes at NMK and other research institutions. This study recommends that NMK embrace mobile phone technology because of its intuitiveness and to resolve researcher's challenges in knowledge management generation, utilization, and through expertise networks and collaborations. This will enable the creation of communities of experts that encourages exchange of explicit and tacit knowledge, through interactive virtual spaces provided on such platforms.

Thirdly, there is need for NMK and other organizations to envision and emphasize on the design and development of KM technologies locally, to fit the organizational needs and cultural expectations. This can be realized through adoption of friendly, portable and reliable ICTs to allow researchers and other users have the ability to utilize knowledge whenever necessary and wherever it is needed.

6.3.2 Recommendation on the Developed Mobile Phone Prototype

The following are recommendations towards future enhancement of the developed mobile prototype. This is aimed at accommodating different and changing dynamics of knowledge creation, codification, sharing and utilization by researchers. First, the developed prototype is a practical visualization of the idea of the researcher. It has room for further work in design scope and functionality; the prototype can be improved to incorporate for video, animations and cloud storage. Secondly, the current version of the prototype is targeted towards researchers at the NMK. The application can be extended to a larger setting, such as public library users, business organizations, medical institutions or institutions of higher learning.

In order to improve the network reliability and availability, it may require the use of satellite communication link to obtain the desired capacity and coverage within the physical surroundings where the service is required. This will greatly increase the possibilities for conducting research at remote regions. Thirdly, the functionality of the prototype can be further extended to include cloud store, semantic computing and natural language computing to allow more robust knowledge management capabilities. In collaborative research, cloud store can be used to hold variety of knowledge, with varied formats and topical areas originating from experts around the world.

6.4 Suggestions for Further Research

This study recommends for further research in the integration of artificial intelligence and cloud computing. This can potentially make a major contribution to knowledge management within the context of mobile phone technology as a broad socio-technical system. Both mobile technology and artificial intelligence integration will explore capabilities of intelligent agents, natural language understanding and processing, reasoning strategies and knowledge representations through ontologies. It should also be enhanced to support cloud services and IoTs capabilities.

This will transform knowledge management systems and bring considerable change to a number of knowledge management applications, including ‘portable offices’ that roam anywhere with their owners; communication handling systems that organize, abstract, prioritize, make sense of, and in many instances, answer incoming communications; intelligent agents that will not only acquire desired and relevant information or knowledge, but will reason with it relative to the situation at hand.

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APPENDICES

APPENDIX I – RESEARCH AUTHORIZATION PERMIT

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:

20th April, 2015

NACOSTI/P/15/1418/5283

Samson Kipketer Too
Moi University
P.O. Box 3900-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Developing mobile phone based platform for managing Research Knowledge at the National Museum of Kenya''*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for a period ending **1st June, 2015.**

You are advised to report to **the Director General, National Museums of Kenya, the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

On completion of the research, you are required to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR-GENERAL/CEO

Copy to:

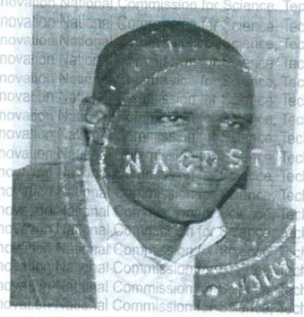
The Director General
National Museums of Kenya.

The County Commissioner
Nairobi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

THIS IS TO CERTIFY THAT:
MR. SAMSON KIPKETER TOO
of MOI UNIVERSITY, 63056-200
Nairobi,has been permitted to conduct
research in *Nairobi County*

Permit No : NACOSTI/P/15/1418/5283
Date Of Issue : 20th April,2015
Fee Recieved :Ksh 1,000



on the topic: *DEVELOPING MOBILE PHONE BASED PLATFORM FOR MANAGING RESEARCH KNOWLEDGE AT THE NATIONAL MUSEUM OF KENYA.*

for the period ending:
1st June,2015

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 4946

CONDITIONS: see back page

APPENDIX II – INTERVIEW SCHEDULE FOR MANAGEMENT AND RESEARCHERS

- Based on your experience, what is the level of ICT adoption at the National Museum of Kenya?
- Has the Museum automated all its operations? Explain
- What Kind of ICT systems are available at the Museum? State them and explain their applications
- When was such systems first introduced in the organization?
- For what purpose are these technologies applied? How do you rate their capabilities?
- What are the current KM systems that are used at the Museum? Elaborate your answer by explaining their functions.
- Has the KMS been developed in-house, outsourced or obtained commercially?
- Do you think the current KM systems are reliable and efficient? Please elaborate
- Do the current KM systems in your institution incorporate mobile technology?
- What are the challenges facing researchers while collecting specimens at the field? What do you suggest as a solution to these challenges?
- What do you suggest as a solution to the challenges facing researchers while compiling research knowledge?
- Do you think a mobile phone application can solve these challenges? Elaborate your answer
- In conclusion, what is your take on the introduction of mobile phone application in management of research knowledge?

APPENDIX III – INTERVIEW SCHEDULE FOR ICT STAFF

1. What Kind of ICT systems are available at the Museum? State them and explain their applications
2. What are the current KM systems that are used at the Museum? Elaborate your answer by explaining their functions.
3. What are the top five problems regarding the knowledge management processes?
4. How do you measure the performance of the knowledge management systems in terms of efficiency and effectiveness?
5. Is there a framework/guideline that is followed in knowledge creation, acquisition, storage, access and dissemination? If yes, is it referred to by knowledge managers or researchers?
6. Is there a process model that is used to control the whole knowledge management cycle?
7. If yes, how formal is it? If not the how is the whole process controlled.
8. Is there any improvement strategy in place to enhance knowledge management processes?
9. What do you suggest as a solution to the challenges facing researchers while compiling research knowledge?
10. Do you think a mobile phone application will resolve knowledge management problems e.g data capture/creation?
11. What else can be done to improve knowledge management processes at National museum of Kenya?

APPENDIX IV – BUDGET

Item Description	**Cost (Kshs.)**
Proposal writing typing and typesetting	7000
Flash disk/CDs and other accessories	5500
Printing 4 draft copies of 50 pages	6000
External hard drive	6500
Photocopy & Binding	1000
Data Collection	8200
2 research assistants	30000
Transport (fuel)	4000
Smartphone(purchase)	27000
Preparation of research findings	
Coding and analysis	3000
Binding & photocopy	4000
Report compilation	3000
Final printing 4 draft copies of 70 pages	6800
Photocopy & Binding hard cover	8100
Miscellaneous	8000
Grand Total (Kshs.)	**130, 100**

APPENDIX V - PROJECT SCHEDULE

	Task	Duration in weeks	Planned Completion	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1.	Topic approval Preliminary Investigation	4	01/10/2013								
2.	Planning the research Gathering literature	1	08/10/2013								
3.	Preparation of Research Proposal	3	28/10/2013								
4.	Feasibility Study Research proposal approval	3	15/11/2013								
5.	Collection of data and analysis	3	18/12/2013								
6.	System analysis & Design	4	28/01/2014								
7.	Coding & implementatio n	6	01/05/2014								
8.	Final defense & Presentation	2	15/06/2014								
9.	Final Report	2	31/06/2014								

APPENDIX VI–DATABASE SCHEMA

System_ users

Server: mysql wampserver » Database: kbm_db » Table: sys_user

Browse | Structure | SQL | Search | Insert | Export | Import

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	id	int(11)			No	None	AUTO_INCREMENT
2	first_name	varchar(50)	latin1_swedish_ci		No	None	
3	last_name	varchar(50)	latin1_swedish_ci		No	None	
4	category_id	int(11)			No	None	
5	institution	varchar(70)	latin1_swedish_ci		Yes	NULL	
6	phone_number	varchar(30)	latin1_swedish_ci		No	None	
7	email	varchar(50)	latin1_swedish_ci		Yes	NULL	
8	designation	varchar(100)	latin1_swedish_ci		Yes	NULL	
9	role_id	varchar(2)	latin1_swedish_ci		No	None	
10	date_created	datetime			No	None	

User_ action_ performed

Server: mysql wampserver » Database: kbm_db » Table: user_action_performed

Browse | Structure | SQL | Search | Insert | Export | Import

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	id	int(11)			No	None	AUTO_INCREMENT
2	article_id	int(11)			No	None	
3	action_id	int(11)			No	None	
4	action_by	int(11)			No	None	
5	action_date	datetime			No	None	
6	remarks	varchar(200)	latin1_swedish_ci		Yes	NULL	
7	change_log_id	int(11)			Yes	NULL	

User_ actions

Server: mysql wampserver » Database: kbm_db » Table: user_action

Browse | Structure | SQL | Search | Insert | Export

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	**id**	int(11)			No	*None*	AUTO_INCREMENT
2	**name**	varchar(20)	latin1_swedish_ci		No	*None*	

Articles_ structure

Server: mysql wampserver » Database: kbm_db » Table: article

Browse | Structure | SQL | Search | Insert | Export | Import | Pr

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	**id**	int(11)			No	*None*	AUTO_INCREMENT
2	**owner_id**	int(11)			No	*None*	
3	**name**	varchar(50)	latin1_swedish_ci		No	*None*	
4	**type**	varchar(50)	latin1_swedish_ci		No	*None*	
5	**climate**	varchar(60)	latin1_swedish_ci		Yes	*NULL*	
6	**county**	varchar(50)	latin1_swedish_ci		No	*None*	
7	**district**	varchar(50)	latin1_swedish_ci		Yes	*NULL*	
8	**division**	varchar(50)	latin1_swedish_ci		Yes	*NULL*	
9	**location**	varchar(50)	latin1_swedish_ci		Yes	*NULL*	
10	**sub_location**	varchar(50)	latin1_swedish_ci		Yes	*NULL*	
11	**latitude**	decimal(10,6)			Yes	*NULL*	
12	**longitude**	decimal(10,6)			Yes	*NULL*	
13	**description**	text	latin1_swedish_ci		Yes	*NULL*	
14	**uses**	varchar(200)	latin1_swedish_ci		Yes	*NULL*	
15	**picRef**	varchar(100)	latin1_swedish_ci		Yes	*NULL*	
16	**verification_status_id**	varchar(1)	latin1_swedish_ci		No	*None*	
17	**remarks**	varchar(200)	latin1_swedish_ci		Yes	*NULL*	
18	**last_modification_date**	datetime			No	*None*	
19	**date_created**	datetime			No	*None*	

Change_ log

Server: mysql wampserver » Database: kbm_db » Table: change_log

Browse | Structure | SQL | Search | Insert | Export | Import

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	id	int(11)			No	None	AUTO_INCREMENT
2	column_name	varchar(50)	latin1_swedish_ci		No	None	
3	old_value	varchar(500)	latin1_swedish_ci		Yes	NULL	
4	new_value	varchar(500)	latin1_swedish_ci		Yes	NULL	
5	verification_status_id	varchar(1)	latin1_swedish_ci		No	None	
6	article_id	int(11)			No	None	

User activity log

Server: mysql wampserver » Database: kbm_db » Table: user_activity_log

Browse | Structure | SQL | Search | Insert | Export | Import

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	id	int(11)			No	None	AUTO_INCREMENT
2	user_id	int(11)			No	None	
3	description	varchar(200)	latin1_swedish_ci		No	None	
4	date_performed	datetime			No	None	

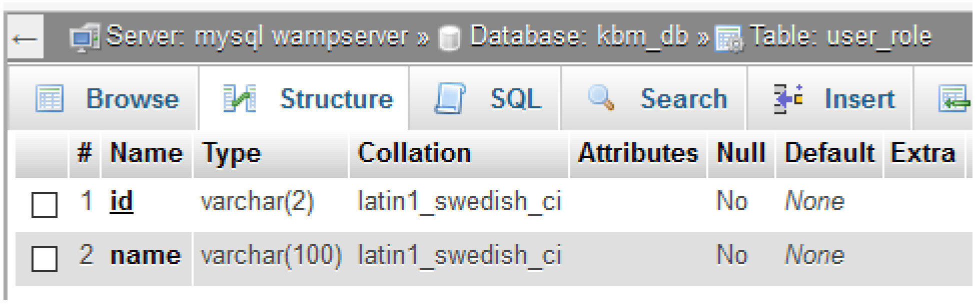
User_credential

Server: mysql wampserver » Database: kbm_db » Table: user_credential

Browse | Structure | SQL | Search | Insert | Expo

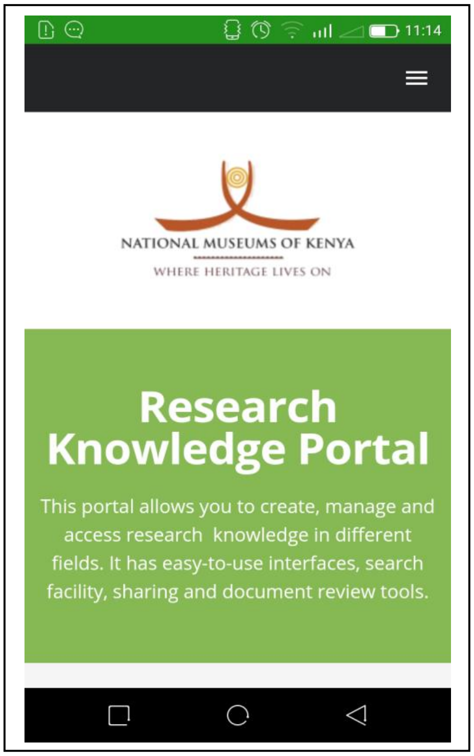
#	Name	Type	Collation	Attributes	Null	Default	Extra
1	id	int(11)			No	None	
2	username	varchar(50)	latin1_swedish_ci		No	None	
3	password	varchar(50)	latin1_swedish_ci		No	None	
4	date_created	datetime			No	None	

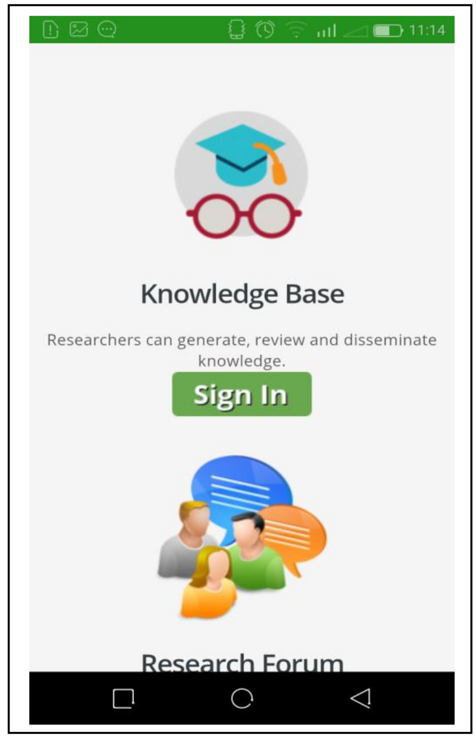
User_role

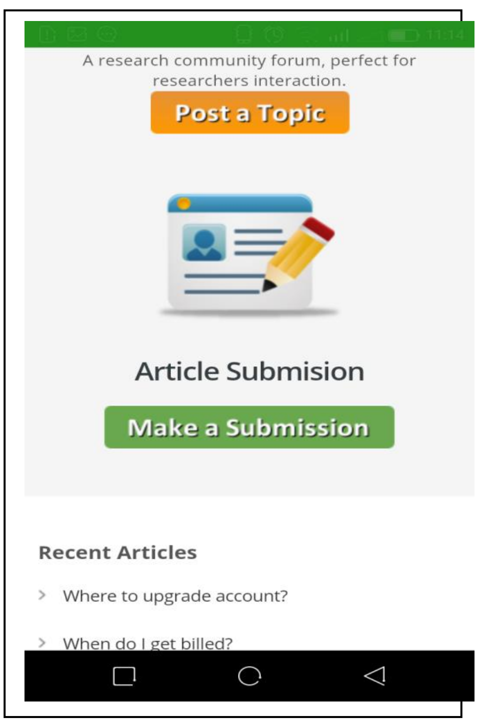


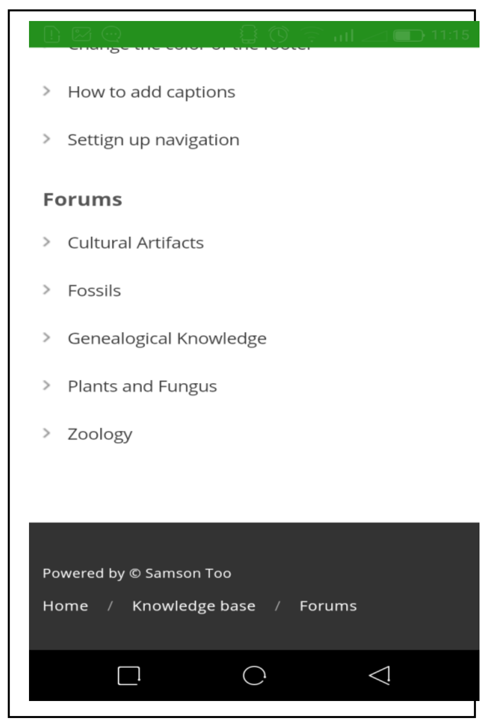
	#	Name	Type	Collation	Attributes	Null	Default	Extra
☐	1	**id**	varchar(2)	latin1_swedish_ci		No	*None*	
☐	2	**name**	varchar(100)	latin1_swedish_ci		No	*None*	

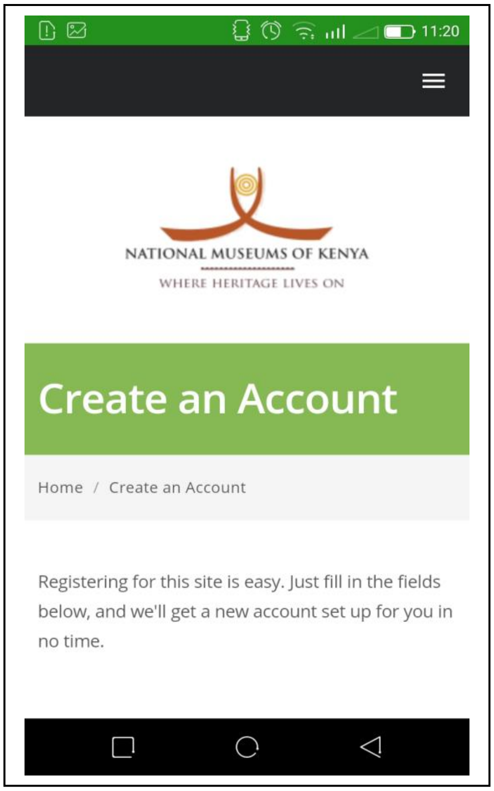
APPENDIX VII – SCREEN SHOTS

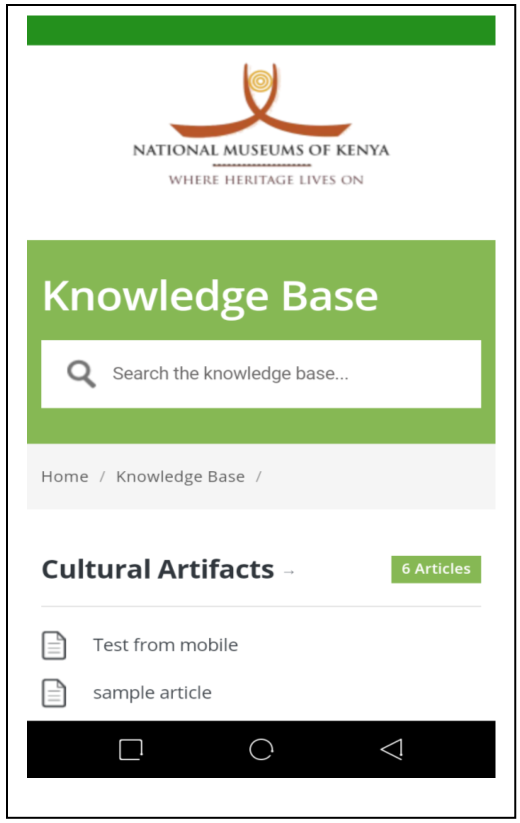


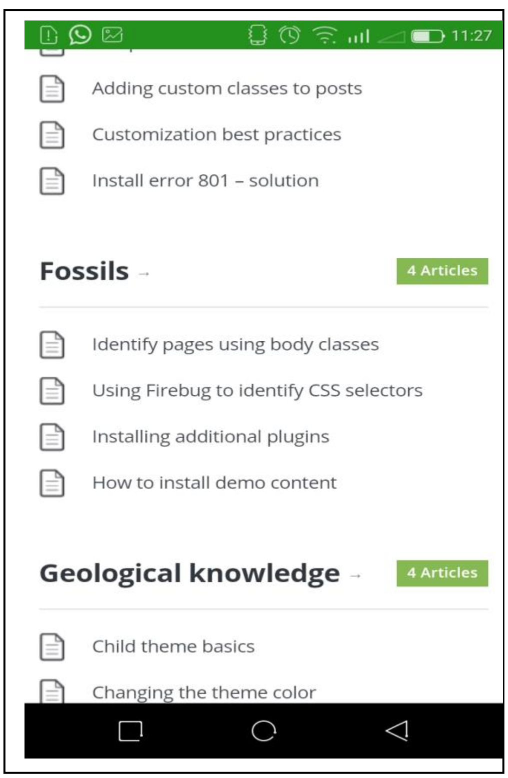


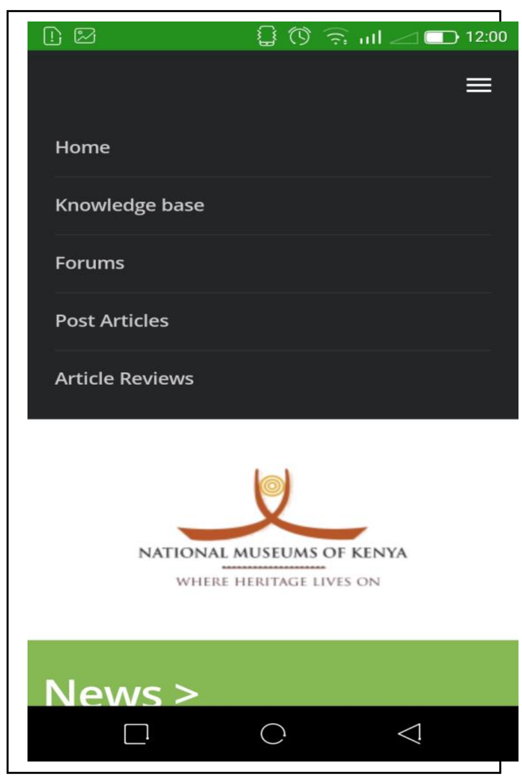





11:20
NATIONAL MUSEUMS OF KENYA
WHERE HERITAGE LIVES ON
Create an Account
Home / Create an Account
Registering for this site is easy. Just fill in the fields below, and we'll get a new account set up for you in no time.


NATIONAL MUSEUMS OF KENYA
WHERE HERITAGE LIVES ON
Knowledge Base
Search the knowledge base...
Home / Knowledge Base /
Cultural Artifacts →
6 Articles
Test from mobile
sample article


11:27
Adding custom classes to posts
Customization best practices
Install error 801 – solution
Fossils →
4 Articles
Identify pages using body classes
Using Firebug to identify CSS selectors
Installing additional plugins
How to install demo content
Geological knowledge →
4 Articles
Child theme basics
Changing the theme color


12:00
Home
Knowledge base
Forums
Post Articles
Article Reviews
NATIONAL MUSEUMS OF KENYA
WHERE HERITAGE LIVES ON
News >

APPENDIX VIII – APPLICATION UAT CHECK LISTS

Application Testing Checklist			
Tested By	Users	Date	28/05/2019
Application Name	Mobile Prototype for Research Knowledge Management		

Procedure	Expected Result	Pass/Fail (P/F)	Actual Results/Comments
Application Functionality			
Performs primary functionality and maintains stability	Yes	P	Opens and allows users to navigate without program errors or hangs.
Installs under a power user account	Yes	P	Installs correctly
Completes a minimal installation	NA	NA	NA
Completes a typical installation	Yes	P	Typical installation completes with no errors
Completes a network installation	NA	NA	NA
The application icon is displayed on the dashboard for all users	Yes	P	Application Icon is listed on the dashboard
Basic Application Testing			
Performs as expected when the applications is open	Yes	P	No errors or hangs when the applications is running
User able to register and login	Yes	P	The application authenticates a user when correctly register
Users logs in and sees the dashboard	Yes	P	Users logs in to the dashboard and functions with no errors
Starts from a document or a file (if the application has associated extensions)	NA	NA	NA
Starts when another instance of the application is already running	No	P	Allows only one instance of the program to run at one time

Application Testing Checklist			
Tested By	Users	Date	28/05/2019
Application Name	Mobile Prototype for Research Knowledge Management		

Procedure	**Expected Result**	**Pass/Fail (P/F)**	**Actual Results/Comments**
Handles copying and pasting functions correctly	Yes	P	Handles copying and pasting functions correctly except for Read-Only articles
Handles editing and review document functions correctly	Yes	P	Handles editing and review document functions correctly
Scrolls up, down, and sideways when you use the wheel on the wheel mouse	Yes	P	Scrolls up, down, and sideways
Opens Help from the Help menu	NA	NA	NA
File System Testing			
Saves a file to, and opens the file from, an NTFS folder that has restricted access permissions	NA	NA	NA
Opens and saves all document types supported by application	NA	NA	NA
Uploads or Imports files of all formats supported by the application (.docx, .txt, .pdf, JPG, GIF, or BMP)	Yes	P	Uploads or Imports files of all formats supported by the application (.docx, .txt, .pdf, JPG, GIF, or BMP)
Opens and display documents that were copied from iOS, Android and Windows devices	Yes	P	Opens and display documents that were copied from iOS, Android and Windows devices

Application Testing Checklist			
Tested By	Users	Date	28/05/2019
Application Name	Mobile Prototype for Research Knowledge Management		

Procedure	**Expected Result**	**Pass/Fail (P/F)**	**Actual Results/Comments**
Un-installation Testing			
Is removed from the dashboard	Yes	P	Removes correctly from the dashboard during un-installation process
Removes all files from the installation directory	Yes	P	Removes all files from installation directory
Removes all application-specific Registry entries	Yes	P	Removes all Registry entries

APPENDIX IX – SAMPLE CODES

```
import androidx.annotation.NonNull;
import androidx.appcompat.app.AlertDialog;
import androidx.appcompat.app.AppCompatActivity;

import android.content.Context;
import android.content.DialogInterface;
import android.content.Intent;
import android.os.Bundle;
import android.text.TextUtils;
import android.view.LayoutInflater;
import android.view.View;
import android.widget.Button;
import android.widget.RelativeLayout;

import com.google.android.gms.tasks.OnFailureListener;
import com.google.android.gms.tasks.OnSuccessListener;
import com.google.android.material.snackbar.Snackbar;
import com.google.firebase.auth.AuthResult;
import com.google.firebase.auth.FirebaseAuth;
import com.google.firebase.database.DatabaseReference;
import com.google.firebase.database.FirebaseDatabase;
import com.gpridesolutions.buberrider.models.Rider;
import com.rengwuxian.materialedittext.MaterialEditText;

import dmax.dialog.SpotsDialog;
import uk.co.chrisjenx.calligraphy.CalligraphyConfig;
import uk.co.chrisjenx.calligraphy.CalligraphyContextWrapper;

public class MainActivity extends AppCompatActivity implements View.OnClickListener {
    FirebaseAuth auth;
    FirebaseDatabase db;
    DatabaseReference users;
    Button login, register;
    RelativeLayout rootLayout;
    private static final int PERMISSION = 1000;

 @Override
    protected void attachBaseContext(Context newBase){
        CalligraphyConfig.initDefault(new CalligraphyConfig.Builder()
                .setDefaultFontPath("fonts/Arkhip_font.ttf")
                .setFontAttrId(R.attr.fontPath)
                .build());
```

```
        super.attachBaseContext(CalligraphyContextWrapper.wrap(newBase));
    }

@Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);

  auth = FirebaseAuth.getInstance();
        db = FirebaseDatabase.getInstance();
        users = db.getReference("riders");

  //init views
        login = findViewById(R.id.sign_in);
        login.setOnClickListener(this);

        register = findViewById(R.id.sign_up);
        register.setOnClickListener(this);
        rootLayout = findViewById(R.id.root_layout);
    }
    @Override
    public void onClick(View v) {
        if(v == login){
            showLoginDialog();
        }else if(v == register){
            showRegisterDialog();
        }
    }

  private void showRegisterDialog(){
        final AlertDialog.Builder reg = new AlertDialog.Builder(this);
        reg.setTitle("Register");
        reg.setMessage("Register with your email address");
        LayoutInflater inflater = LayoutInflater.from(this);
        View register_layout = inflater.inflate(R.layout.layout_register, null);
        final MaterialEditText email = register_layout.findViewById(R.id.reg_email);
        final MaterialEditText password = register_layout.findViewById(R.id.reg_password);
        final MaterialEditText re_pass = register_layout.findViewById(R.id.reg_retype_password);
        final MaterialEditText username = register_layout.findViewById(R.id.reg_username);
        final MaterialEditText phone = register_layout.findViewById(R.id.reg_phone);
        reg.setView(register_layout);
        reg.setPositiveButton("Register", new DialogInterface.OnClickListener() {

   @Override
```

```
            public void onClick(DialogInterface dialog, int which) {
                dialog.dismiss();

             //validation
                if(validate(email, "email") && validate(password, "password") &&
                        validate(re_pass, "password") && validate(username, "username") &&
                        validate(phone, "phone") &&
                        password.getText().toString().trim().equals(re_pass.getText().toString())){
                    auth.createUserWithEmailAndPassword(email.getText().toString().trim(),
                            password.getText().toString().trim()).addOnSuccessListener(new
OnSuccessListener<AuthResult>() {


                   @Override
                        public void onSuccess(AuthResult authResult) {
                            //save user in db
                            Rider user = new Rider(email.getText().toString().trim(),
                                    password.getText().toString().trim(),
                                    username.getText().toString().trim(),
                                    phone.getText().toString().trim());

                      //Use email as key in db
                            users.child(user.getEmail())
                                    .setValue(user)
                                    .addOnSuccessListener(new OnSuccessListener<Void>() {
                                        @Override
                                        public void onSuccess(Void aVoid) {
                                           Snackbar.make(rootLayout, "Registration successful",
Snackbar.LENGTH_LONG)
                                                    .show();
                                        }
                                    })
                                    .addOnFailureListener(new OnFailureListener() {
                                        @Override
                                        public void onFailure(@NonNull Exception e) {
                                            Snackbar.make(rootLayout, "Registration failed "+e.getMessage(),
Snackbar.LENGTH_LONG)
                                                    .show();
                                        }
                                    });

                        }
                    })
                            .addOnFailureListener(new OnFailureListener() {
```

```
                    @Override
                    public void onFailure(@NonNull Exception e) {
                        Snackbar.make(rootLayout, "Registration failed "+e.getMessage(),
Snackbar.LENGTH_LONG)
                                .show();
                    }
                });
            }else{
                Snackbar.make(rootLayout, "Registration failed", Snackbar.LENGTH_LONG)
                        .show();
            }
        }
    });
    reg.setNegativeButton("Cancel", new DialogInterface.OnClickListener() {

   @Override
        public void onClick(DialogInterface dialog, int which) {
            dialog.dismiss();
        }
    });
    reg.show();
}

private void showLoginDialog(){
    final AlertDialog.Builder reg = new AlertDialog.Builder(this);
    reg.setTitle("Register");
    reg.setMessage("Login with your email address");
    LayoutInflater inflater = LayoutInflater.from(this);
    View login_layout = inflater.inflate(R.layout.layout_login, null);

    final MaterialEditText email = login_layout.findViewById(R.id.reg_email);
    final MaterialEditText password = login_layout.findViewById(R.id.reg_password);
    reg.setView(login_layout);
    reg.setPositiveButton("Sign in", new DialogInterface.OnClickListener() {
        @Override
        public void onClick(DialogInterface dialog, int which) {
            dialog.dismiss();
            final SpotsDialog waitingDialog = new SpotsDialog(MainActivity.this);
            waitingDialog.show();
            //validationH
            if(validate(email, "email") && validate(password, "password")){
                auth.signInWithEmailAndPassword(email.getText().toString().trim(),
                        password.getText().toString().trim()).addOnSuccessListener(new
OnSuccessListener<AuthResult>() {
```

```
                @Override
                public void onSuccess(AuthResult authResult) {
                    waitingDialog.dismiss();
                    startActivity(new Intent(MainActivity.this, HomeActivity.class));
                    finish();
                }
            })
                    .addOnFailureListener(new OnFailureListener() {
                        @Override
                        public void onFailure(@NonNull Exception e) {
                            waitingDialog.dismiss();
                            Snackbar.make(rootLayout, "Sign in failed "+e.getMessage(),
Snackbar.LENGTH_LONG)
                                    .show();
                        }
                    });
        }else{
            Snackbar.make(rootLayout, "Sign in failed", Snackbar.LENGTH_LONG)
                    .show();
        }

    }
});

reg.setNegativeButton("Cancel", new DialogInterface.OnClickListener() {
    @Override
    public void onClick(DialogInterface dialog, int which) {
        dialog.dismiss();
    }
});
reg.show();
}

private boolean validate(MaterialEditText editText, String type){
    if(type.equals("password")){
        if(editText.getText().toString().trim().length() < 6){
            Snackbar.make(rootLayout, "Password should be more than 6
characters",Snackbar.LENGTH_SHORT)
                    .show();
            return false;
        }
    }else if(type.equals("phone")){
        if(!TextUtils.isDigitsOnly(editText.getText().toString().trim())){
```

```
                Snackbar.make(rootLayout, "Phone Number contains only
digits",Snackbar.LENGTH_SHORT)
                        .show();
                return false;
            }
        }
        else{
            if(TextUtils.isEmpty(editText.getText().toString().trim())){
                Snackbar.make(rootLayout, "Field "+type+" cannot be
empty",Snackbar.LENGTH_SHORT)
                        .show();
                return false;
            }
        }
        return true;
    }
}
```

```
public class User {
    private String email, password, name, phone;
    public User(String email, String password, String name, String phone){
        this.email = email;
        this.password = password;
        this.name = name;
        this.phone = phone;
    }
    public String getEmail() {
        return email;
    }
    public String getName() {
        return name;
    }
    public String getPassword() {
        return password;
    }
    public String getPhone() {
        return phone;
    }
}
```

```
public boolean onNavigationItemSelected(MenuItem item) {
        // Handle navigation view item clicks here.
        Fragment fragment=null;
        int id = item.getItemId();
        if (id == R.id.nav_login) {
       } else if (id == R.id.nav_register) {
       } else if (id == R.id.nav_reader) {
            Intent intent = new Intent(MainActivity.this, ReaderActivity.class);
            startActivity(intent);
        } else if (id == R.id.nav_generator) {
            Intent intent = new Intent(MainActivity.this,GeneratorActivity.class);
            startActivity(intent);
        } else if (id == R.id.nav_logout) {
            session.logoutUser();
        }else if (id == R.id.nav_profile){
            fragment = new ProfileFragment();
        }else if(id == R.id.nav_report){
            fragment = new ReportFragment();
        }
        if(fragment !=null){
            FragmentTransaction ft = getSupportFragmentManager().beginTransaction();
            ft.replace(R.id.content_main,fragment);
            ft.commit();
        }
        DrawerLayout drawer = (DrawerLayout) findViewById(R.id.drawer_layout);
        drawer.closeDrawer(GravityCompat.START);
        return true;
    }
}
```