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Guidelines for the Library to effectively support eResearch Activities at the Obafemi Awolowo University, Nigeria

Mini-dissertation by

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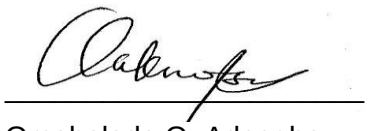
October 2015

DECLARATION

I, Omobolade Opeyemi Adeagbo declared that this mini-dissertation is my original work and that I have duly referenced all sources used. It is submitted in partial fulfilment of the requirements of Masters of Information Technology Degree at the Department of Information Science, University of Pretoria. I am certain that this research work has not been submitted in any form to another university.

Signed



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Date

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ABSTRACT

eResearch, a term used in the international academic community since the early 2000s facilitates scholarly collaborative and interactive research by providing access to shared data, institutional repositories, research tools and services through the internet. eResearch initiatives are globally allowing researchers to collaborate using ICT.

This paper will report on a study which sought to establish eResearch activities in Obafemi Awolowo University, Nigeria, identify the challenges faced by researchers in carrying out eResearch in their various work environments and propose a guideline for effective library support of such projects.16 participants were interviewed for this empirical study. These participants were drawn from 6 Departments cutting across four of the 13 University Faculties. The researcher used purposive and snowballing sample techniques. Interviews were transcribed and responses of all the respondents analysed based on the research questions. Eight collaborative eResearch projects were identified during the course of this study. The participants indicated that these projects took place within the University Community but across country boundaries. It is worth noting that the researchers that participated in this study engage in quality collaborations both within Africa and also beyond. Most of the researchers gained their skills and practices through personal development while on the job, therefore, there is a need to advocate the inclusion of eResearch methodology in postgraduate programmes.

It is of concern that the researchers have not been able to appreciate the roles that the library can play in supporting their online research activities. To change this view, the library must proactively survey the various online research projects going on in the University and provide the necessary support. Thus, this paper will share some of the insights gained and recommend a number of initiatives a library could put in place to embed within eResearch projects – all in the interest of more effective research.

DISSERTATION SUMMARY

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LIST OF ABBREVIATIONS

OAU	Obafemi Awolowo University
HOL	Hezekiah Oluwasanmi Library
ICT	Information and Communication Technology
VRE	Virtual Research Environments
URC	University Research Committee
INTECU	Information Technology and Communication Unit
REN	Research and Educational Networks
NgREN	Nigerian Research and Educational Networks
IfeREN	Ife Research and Educational Networks

CHAPTER 1: BACKGROUND TO THE STUDY

1.1 Introduction

eResearch, a term which has been used in the international academic community since the early 2000s, facilitates scholarly collaborative and interactive research by providing access to shared data, institutional repositories, research tools and services through the internet. It is a term that connotes the use of information technology to support new and old research. eResearch depicts the new methods of conducting research and describes the digital environment in which research takes place. It has extended e-Science and cyber infrastructure to the humanities and social science disciplines and according to Australian eResearch Infrastructure Council, eResearch *"encapsulates research activities that use a spectrum of advanced ICT capabilities and embraces new research methodologies"* (Australian eResearch Infrastructure Council 2010, p. 1).

Rapid changes in the field of Information and Communication Technology (ICT), data generation and infrastructure supporting data over the past decade have greatly impacted the various aspects of research life-cycle and the activities engaged in by researchers in all disciplines while carrying out research. There are indications that most researchers are enthusiastic in using these new technologies and given the opportunity, they are willing to take advantage of eResearch infrastructure, tools and services to improve the outcome of their researches (Bradbury & Borchert 2010, p. 3).

The challenge is also there for libraries to widen their support for these research activities. They must ensure that information literacy programmes encompass skills needed for data and information retrieval, presentation, storage, use and re-use. Various researches (Hellmers 2009; Bradbury & Borchert 2010; Carusi & Reimer 2010) have revealed that libraries, especially academic libraries have a major role to play in the support of eResearch.

Obafemi Awolowo University, a dynamic institution, ranked first in Nigeria (Web Ranking 2015) is the leading University in ICT in Nigeria. The University strives daily to incorporate these new technologies in an effort to maintain the institution's standard. This necessitates that the researchers at the Obafemi Awolowo University be proactive in order to measure up to the University standard - especially in the use of the new technologies. It also points to the acquisition of required skills and technology. It is therefore necessary for the library to

establish the existing level of eResearch activities, skills and practices of researchers at Obafemi Awolowo University so that the library could effectively support eResearch and proactively make necessary adaptations in providing training materials as well as any needed services in order to support effectively the new breed of researchers.

1.2 Research Objectives

The objectives of this study are:

1. To gain a clear understanding (from literature) what eResearch involves and how library services could support and enable eResearch activities.
2. To establish the existing level of eResearch activities, skills and practices of researchers in Obafemi Awolowo University.
3. To identify the challenges faced by researchers in carrying out eResearch in their various work environments at the Obafemi Awolowo University.
4. To identify those activities that the library could implement to support eResearch activities in Obafemi Awolowo University.
5. To propose guidelines to the library for effective support of eResearch in Obafemi Awolowo University.

1.3 Research questions and sub questions

The study will be guided by these two research questions:

1. What could be regarded as eResearch activities?
2. How can the library effectively support and enable these activities at Obafemi Awolowo University?

The following are the research sub questions:

1. Are researchers in Obafemi Awolowo University practising these eResearch activities?
2. What are the eResearch skills possessed by researchers in Obafemi Awolowo University and where are they having difficulties?
3. To what extent are the researchers collaborating with researchers outside Nigeria and how do these collaborations deal with the sharing of resources (e.g. their data and access to literature and equipment)?
4. What is the level of knowledge, regarding eResearch, in the library?
5. What guidelines could the library put in place to develop a plan that will ensure effective support of eResearch in the future?

1.4 Demarcation of the field of study/ Scope and limitations

The study will focus on researchers in Obafemi Awolowo University which include the lecturers and postgraduate students. There are thirteen faculties in the University; four of these faculties will be selected using purposive sampling. The result of the survey will provide an overview of the eResearch activities of these researchers only. There are 147 universities in Nigeria, 46 Federal Universities, 40 State Universities and 61 Private Universities (National Universities Commission (NUC) 2015). Due to time limitations and funding, this research will be restricted to Obafemi Awolowo University, a Federal University in Nigeria.

1.5 Justification for the research /Rationale for the study

The purpose of the research is to establish the presence of eResearch activities in Obafemi Awolowo University, provide an overview of the various eResearch skills and practices of researchers, identify the challenges faced by researchers in carrying out eResearch in their various work environments and finally, to justify the need for the library to provide effective support for eResearch in the university. This survey will provide a database for eResearch activities in Obafemi Awolowo University and propose guidelines that will be useful for the University library to effectively support eResearch activities in the University. These guidelines will assist the library to form polices that will promote eResearch in the University and ensure that the various needs of researchers are adequately provided for. The study will also serve as a knowledge base for researchers and other libraries in Nigeria and Africa who will like to engage in eResearch.

1.6 Overview of the literature

eResearch simply defined, is using ICT as tools to enhance research (McAlpine & McIntosh 2014). eResearch is a new way of doing research, collaborating globally and nationally while making use of ICT infrastructure to do research (Fernihough 2011, p. 2). According to Appelbe and Bannon (2007, p. 83), “eResearch is a paradigm shift that is changing the way that research is conducted and organized in many academic disciplines and research institutions”. eResearch is performed by researchers that are geographically separated using Information and Communication Technology. These research activities are realised through Virtual Research Environment (VRE) systems which can be built on eLearning framework like Sakai (van Deventer 2015). eResearch initiatives are globally allowing researchers to collaborate and to make use of ICT in carrying out research. Clearly put by Perrot and Harmer (2008), “the eResearch initiative aims to revolutionize research and allow researchers to share and coordinate technical resources”. The importance of eResearch to any community can be surmised in the declaration made by the Australian e-Research

Coordinating Committee in 2006, “e-Research has the potential to increase the efficiency and effectiveness of research endeavours across all disciplines. Greater interactivity between researchers and an increased ability to access research outputs will benefit industry, governments and the Australian community as a whole” (Australian Government 2006).

Although, not all researchers require the same level of expertise and skills to be involved in eResearch activities as stated by Henty (2008), “a minimum level of awareness is required”. Moreover, the nature of most research all over the world is becoming very complex and the methods keep changing with advances in ICT. Researchers are required to update their skills and become literate in the use of the data, tools and services continually made available by new technologies to remain relevant to this generation. The need for researchers to improve on their skills and practices in conducting research activities in the various digital environments then becomes inevitable.

A model constructed by Page-Shipp, Hammes, Pienaar, Reagon, Thomas, van Deventer and Veldman (2005, p. 3) listed the key components of eResearch as computation and data transmission infrastructure, research tools and applications, willingness and ability to share primary e-Science data, scholarly discourse: commercial and open access to eContent, digital curation and preservation, innovation projects. This model was faulted by Fernihough (2011, p. 19) in three ways. Firstly, the model does not include e-learning, a crucial component in developing skills. Secondly, the model did not address collaboration and collaborative knowledge development on which eResearch is based. Thirdly, the model was unable to fully grasp the importance of computing resources, which is a major requirement for eResearch.

Fernihough (2011) opines that “e-Research components would need to reflect processes or infrastructure to incorporate at least these aspects of information management which are gathering, analysing, communicating and storing of information. In view of this, Hellmers (2009) surmised that the underlying idea behind eResearch are “information management, retention and sharing; research methods, tools and services; research collaboration and dissemination”. The value of adopting eResearch framework in African institutions cannot be overemphasised. Some of these values include sustenance of the African institutions’ research in the global arena, provision of ongoing access to information for all researchers in African institutions, generation of improved knowledge for the institutions and reduced time spent on searching for reliable information on the internet by researchers. Also, risk of loss of content will be reduced since the system will be jointly owned by African institutions, creation of new challenges for library and information professionals, and finally opportunities

for collaboration in research activities among researchers in African institutions that are geographically separated (Fernihough 2011, p. 52).

1.7 Locating theoretical framework

This study will be based on Fernihough eResearch Implementation Framework and the collaboration theory. Fernihough (2011) designed an eResearch framework for South African organisations in which the large variety of components could be placed within a layered framework. Although it is necessary to understand the possibilities of such a framework as background, it definitely is not necessary for any individual to understand the detail behind each and every component. What is more important is to know that eResearch requires a layered infrastructure where the components are all interconnected and that VREs make it easy for the researcher to drill down through the various layers of infrastructure without realising that this is what is happening. Libraries are able to embed in the products and services layer. That will therefore be the focus of this research.

The collaboration theory was reviewed by Harley and Blismas (2010) as it applies to the online environment and gave an understanding of the constituents of collaborative online research activities. The emerging online toolsets to facilitate and manage collaborative research environments further add to the opportunities resulting from the social aspects of collaboration which is evident in the geographical spread of the research team and the need for them to access distributed information and data. This theory proved that collaboration within eResearch environment involves activities that cut across cooperation, coordination and collaboration.

1.8 Research Methodology

This study will be carried out in Obafemi Awolowo University. The first approach to the study will be the review of previous works on eResearch that are reported in literature. The research paradigm and the research design that will be employed for this study is the qualitative approach and case study design respectively. This approach will be used to capture the eResearch activities of researchers in Obafemi Awolowo University and how the library can effectively support and enable the activities.

The target population will be researchers involved in performing research in an online digital environment in Obafemi Awolowo University (OAU), Ile-Ife, Nigeria. Four Faculties out of the 13 Faculties in the University will be selected using purposive sampling while snowballing technique will be used in selecting the departments and the researchers. The sampled population for the study will be based on the number of researchers selected using the two

sampling techniques.

The data collection instrument that will be used for this study is interviewing. Data gathered through the interview schedules in respect of the research questions and sub questions for this study will be analyzed using descriptive statistical procedures like tables, percentages, charts, transcribing software and Microsoft Excel for tabulations.

1.9 Value of the study

The study will provide a database for the various eResearch activities obtainable in Obafemi Awolowo University, Nigeria. It will provide guidelines that can be use to support the effective practice of eResearch in the University. It will also help the University library to effectively support and promote eResearch activities especially at the university and most especially among researchers already engaged in eResearch. The result of this research will also serve as a knowledge base for researchers in Nigeria and Africa who will like to engage in eResearch.

1.10 Clarification of key terms

Working definition of key terms is as follows;

Table 1.1 Definitions of key terms

eResearch	**"encapsulates research activities that use a spectrum of advanced ICT capabilities and embraces new research methodologies" (Australian eResearch Infrastructure Council 2010, p. 1).**
eResearch skills	skills that enable better and quality research through the use of advanced information and communication technologies (University of Melbourne 2012).
eResearch practices	various research practices that are enhanced by technology
eResearch tools	are data-handling tools used in eResearch activities.
Cyber infrastructure	an infrastructure of distributed computer, information, and communication technologies (Jankowski 2009).
Virtual Research Environment	an environment that helps researchers from all disciplines to work collaboratively by managing the increasingly complex range of tasks involved in carrying out research (JISC 2013).
Researchers	those that investigate and devote themselves to research. For this study, researchers include lecturers and postgraduates students.

1.11 Division of chapters

Chapter 1 will provide the introduction and background to the study, the statement of problem, the objectives of the study, the research questions, the scope of the study, the significance of the study and working definition of terms.

Chapter 2 will review the literature on eResearch skills and practices to give a better understanding of the research. It will also explore the theories, underlying principles, paradigm, the components of eResearch and the theoretical framework on which the study will be structured.

Chapter 3 will describe the research methodology and the procedures that will be employed for the study under the following sub-headings; research design, population of the study, sample procedure and sample size, data collection instruments, validity and reliability of the instruments, data collection procedure and method of data analysis.

Chapter 4 will report the research findings, interpretation and discussion of the results from the analysis. The result from the questionnaire will be discussed in this chapter.

Chapter 5 will present the conclusions reached after the study, elaborate on the implications of the study, propose guidelines for the effective support of eResearch and make recommendations that will guide future activities of the library. Suggestions for further studies will also be proposed.

1.12 Conclusion

eResearch is a dynamic tool in conducting research. Many researchers are striving to incorporate these new technologies to learning and researches. In this study, interview will be used to gather information about the various eResearch activities of researchers in the selected faculties of Obafemi Awolowo University. This is with a view of establishing the eResearch activities of researchers at the Obafemi Awolowo University. The research will also reveal the challenges faced by the researchers in conducting eResearch activities in their various work environments and finally, propose guidelines for the University Library to support eResearch.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents a general overview of the concept of eResearch. It also attempts to delve into understanding of eResearch and its components, including virtual research environments (VREs) and the strategy for their implementation. It also reviews studies on eResearch and highlights a theoretical framework on which eResearch could be based.

2.2 Concept of eResearch

The emergence of information communication technology (ICT) has revolutionized the world and has greatly shrunk the world into a global village (Etekwa 2007; Maryann & Udeajah 2014). ICT has greatly improved and will continue to improve efficiency and effectiveness in all spheres of knowledge. It has brought about changes to every discipline and the way things are done. The changes are evident in all spheres of human endeavour, and fields of knowledge (Maryann & Udeajah 2014). One of the biggest changes that ICT has brought is the idea of eResearch. e-Research is simply defined as the use of ICT as a tool to enhance research (McAlpine & McIntosh 2014). CeRDI (2015) opines that *"eResearch describes a set of activities that harness the power of advanced information and communication technologies (ICTs) for research".* eResearch focuses on how ICT assists researchers to collect, manage, share, process, analyse, store, find, and reuse research results. According to Appelbe and Bannon (2007, p. 83), "eResearch is a paradigm shift that is changing the way that research is conducted and organized in many academic disciplines and research institutions".

eResearch initiatives are globally allowing researchers to collaborate and to make use of ICT in doing research. Clearly put by Perrot and Harmer (2008), "the eResearch initiative aims to revolutionise research and allow researchers to share and coordinate technical resources". The importance of eResearch to any community can be summarized in the declaration made by the Australian e-Research Coordinating Committee in 2006,

> *"e-Research has the potential to increase the efficiency and effectiveness of research endeavours across all disciplines. Greater interactivity between researchers and an increased ability to access research outputs will benefit industry, governments and the Australian community as a whole"* (Australian Government 2006).

eResearch, as a concept, originated in the 2000s with the expectation of providing a unified framework to evaluate the breadth and depth of the digital divide between more and less developed or developing countries in terms of learning and research (Hanafizadeh, Hanafizadeh & Khodabakhshi 2009, p. 7). The concept has been given impetus by the rapid rate of internet penetration throughout the world, and the dramatic advancement in the use of Information Technology (IT) in academic circles, business and industry (Ongori 2009). eResearch is a new way of doing research, collaborating globally and nationally while making use of ICT infrastructure to do research (Fernihough 2011, p. 2). eResearch is performed by researchers that are geographically separated using ICT. These research activities are often realized and coordinated through a Virtual Research Environment (VRE) interface which can be built on top of an eLearning framework like Sakai (Yang & Allan 2006, p. 5; van Deventer 2015).

According to Berman and Henry (2005, p. 2), “convergence of exponential increase in bandwidth, collaboration, computing, online sensors and storage has led to the rise of eResearch”. Characterized by large-scale global collaboration, eResearch is supported by the next generation of cyber infrastructure. eResearch is typically conducted by a multidisciplinary team working on problems that have only become solvable in recent years with improved data collection and data analysis capabilities. These characteristics fundamentally alter the ways in which scientists carry out their work, the tools and workflows they use, the types of problems they address, and the communications resulting from their research. The revolutionary potential of eResearch is the ability to work at a much greater scale and intensity using distributed networks and powerful tools. Luce (2008) stated the examples of eResearch projects to “range from distributed computational astronomy to complex systems such as social networks, climate changes, multifactorial diseases, and pollution remediation”. According to Berman and Henry (2005, p. 2) virtually every field in science and engineering has been changed by the convergence of these technologies, yielding entirely new ways of thinking about and understanding of physical, biological, and social phenomena. These revolutionary developments will require a corresponding disruptive change in the ways in which libraries serve scientists' needs.

Although, not all researchers require the same level of expertise and skills to be involved in eResearch activities as stated by Henty (2008), “a minimum level of awareness is required”. Moreover, the nature of most research all over the world are becoming very complex and the methods keep changing with advances in ICT, researchers are required to update their skills and become literate in the use of the data, tools and services continually made available by new technologies to remain relevant to this generation. The need for researchers to improve

their skills and practices in conducting research activities in the various digital environments then becomes inevitable (Susan & Baby 2012).

Sargent (2006) strongly believes that eResearch encapsulates research that use a spectrum of advanced ICT capabilities and embraces emerging research methodologies from increased access to:

- Broadband communication networks, research instruments and facilities, sensor network, data repositories with data standards and management tools and high performance computing resources.
- Software and infrastructure services that enables a trust and sharing relationship to be establish between researchers and the wide variety of data repositories, computers, systems and network on which they depend; and
- Application and discipline-specific tools such as graphics, intensive visualization, stimulation software and interactive tools that provide a human interface, allowing researchers to interact with each other and with their instruments, computational facilities and data resources.

Furthermore, eResearch capabilities advance and enhance traditional research methodologies (Khatibi & Montazer 2012, p. 65). Sargent (2006) stated the following growing dependency on eResearch capabilities:

- Discovering knowledge, either digital or physical format;
- Accessing data and software to analyse data;
- Synthesizing, curating and disseminating new knowledge competently;
- Facilitating interaction and collaboration thus allowing researchers to work effortlessly within and between institutions.

Khatibi and Montazer (2012, pp. 64-65) deduce that the main factors that enable researchers to increase the use of ICT for research activities include awareness of the full potential of ICT to enhance their research, seamless connection between the researcher's discipline and the connectivity platform being used, access to expert support, ICT tools, ICT abilities and skills of researchers The ability of eResearch to increase the effectiveness of research by enhancing interactions between researchers and improving access to research output also make it possible to apply eResearch methodologies and capabilities to all disciplines (CeRDI 2015). In addition, the needs, awareness, skills, availability of the necessary resource support and professional expertise determine the range of use of eResearch methodologies by researchers in various disciplines.

2.2.1 Components of eResearch

Page-Shipp, Hammes, Pienaar, Thomas, van Deventer, & Veldsman (2005, p. 3) in their model on eResearch as shown in Figure 2.1 listed the key components of eResearch as (a) e-Science, (b) digital curation and preservation, and (c) access to information.

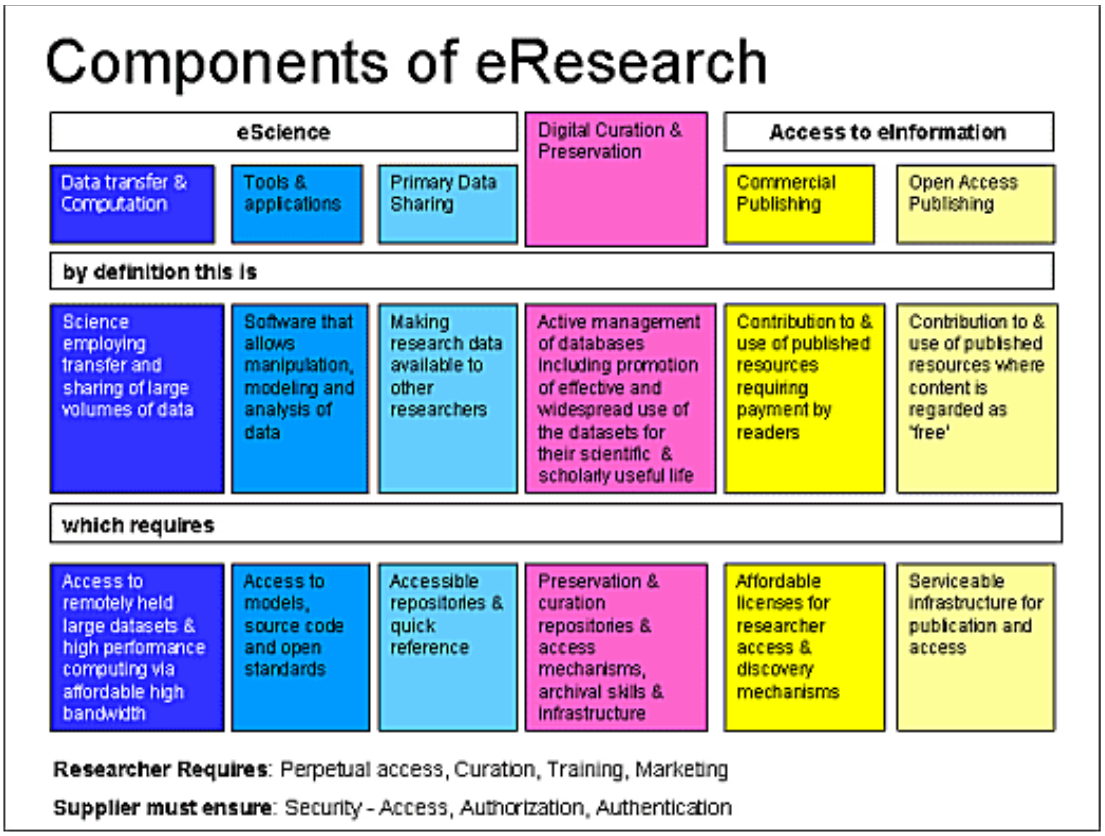

Figure 2.1 Components of eResearch

(Source: Page-Ship et al. 2005, p. 3)

The authors (Page-Shipp et al. 2005, pp. 3-4) provided the following explanation for their model:

a. **eScience:** In this model eScience encompasses:
   i. **Data transfer and computation:** In this sub- component, the researchers employed ICT to transfer and share large volumes of data. For this to work efficiently the model specified that the researchers require access to large datasets with efficient and effective computing system connected to cost-effective broad bandwidth.
   ii. **Tools and applications:** These are eInfrastructure and research tools that researchers employ in the course of their research. These are majorly software that are used for manipulation, modelling and analysis of data. For

eResearch, the researchers need to unequivocally have access to models, source code and open standards.

iii. **Data sharing:** These are activities that researchers engage in, in making data available to other researchers. These activities are facilitated by repositories and quick reference which are easily accessible.

iv. **Digital curation and preservation:** This component is an aggregate of activities involved in management of database. These involve research activities that aid extensive use of datasets for scientific and scholar usefulness. To successfully implement these activities the researchers need to be well equipped with skills and expertise for archiving of data and its infrastructure. Access mechanism and preservation repositories' are pivotal to success of eResearch.

b. **Access to eInformation:** Researchers can access eInformation through commercial published materials in which they will need to pay for to have unrestricted access. To use these facilities, the eResearchers must be vast in discovery of useful e-materials and must have unhindered access to internet facilities. On the other hand, they could also get information from open source peer reviewed published materials which are usually free.

This model was faulted by Fernihough (2011, p. 19) in three ways. Firstly, the model does not include e-learning, a crucial component in developing skills. Secondly, the model does not address collaboration and collaborative knowledge development on which eResearch is based. Thirdly, the model was unable to fully grasp the importance of computing resources, which is a major requirement for eResearch. Fernihough (2011) opines that "e-Research components would need to reflect processes or infrastructure to incorporate at least these aspects of information management which are gathering, analysing, communicating and storing of information. This confirms what Hellmers (2009) surmised as the underlying idea behind eResearch namely "information management, retention and sharing; research methods, tools and services; research collaboration and dissemination". The Fernihough model is discussed in detail in section 2.3.3 below.

2.2.2 eResearch and its implementation in African institutions

The value of adopting eResearch frameworks in African Institutions cannot be overemphasised. Some of these values include sustenance of the African Institutions' research in the global arena and provision of access to information for all researchers in African

Institutions. It has also been canvassed that eResearch will lead to generation of improved knowledge for the institutions and reduced time spent for searching for reliable information on the internet by researchers. It will also reduce the risk of loss of content since the system will be jointly owned by African institutions. However, it is noted that eResearch will pose new challenges for library and information professionals, but will create opportunities for collaboration in research activities among researchers in African Institutions that are geographically separated and provide strategic directions towards research, teaching, learning, literacy, learning spaces, curation and access to collections as presented in Figure 2.2 (Fernihough 2011, p. 52; Speer, Mathews, & Walters 2013;Byrne, McKenzie & Frances 2012).

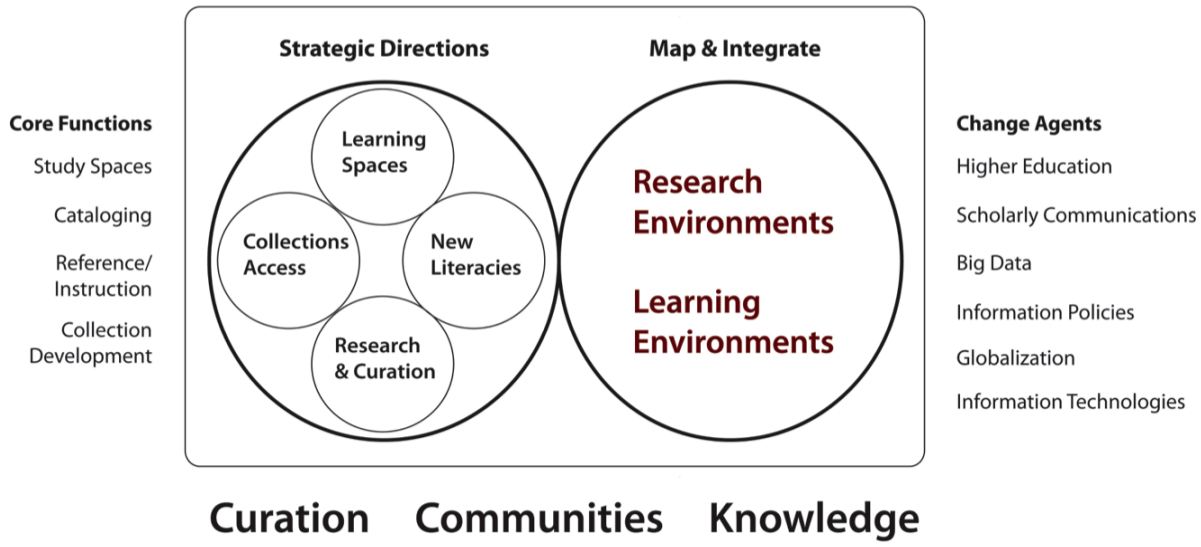

Figure 2.2 eResearch strategic directions
(Source: Speer, Mathews, & Walters 2013)

eResearch initiatives are globally allowing researchers to collaborate and to make use of ICT in doing research. Clearly put by Perrot and Harmer (2008), “the eResearch initiative aims to revolutionise research and allow researchers to share and coordinate technical resources”. The importance of eResearch to any community has been summarized in the declaration made by the Australian e-Research Coordinating Committee in 2006 (Thomas 2011, p. 37; McAlpine & McIntosh 2014).

Activities incorporating eResearch are in various developmental stages of research life growth in most Africa countries. One well-developed team initiative is the Coalition of South African Library Consortia's Site Licensing Initiative project (SASLI) that was created by the tertiary education institutions' library directors and to which the research councils have recently gained access (Page-Ship et al. 2005; Halland 2013). In a few short years, SASLI has made major inroads into reducing the costs of online access for researchers and has

taken on several other relevant initiatives. The challenge relating to national site licensing is that institution's ability to pay determines the sources to which the researcher has access. This policy often boils down to a feast or famine situation where researchers at well-resourced institutions have almost too much information and those in less well-resourced institutions have virtually none. A second challenge relates to sustainability. The SASLI activity, relative to what was later discovered internationally is understaffed and has been dependent on donor funding. Other, sometimes distracting, initiatives have had to be launched to provide reciprocal services for donors or to create alternative funding streams (Halland 2013).

Page-Ship et al. (2005) assert that "because of their novelty, eResearch activities have been characterized by embryonic, relatively small-scale initiatives which have served to build distributed expertise but also contributed to a dispersion of effort". Furthermore, they observed that good use has been made of inputs from other countries but in many cases an initiative was a by-product of the efforts of a research team. Such initiatives make demands on research time and undermine the focus of the team who, unsurprisingly, have little concern for the cost-effective expansion of the services beyond their own needs, especially beyond termination of their research programme. Those groups that lack the expertise to create their own infrastructure are prevented from engaging in e-Research, possibly to the detriment of their visibility in the international research community. There is no coordinating body that is able to identify the entire set of ongoing activities. Asking for a 'coordinating body' should not be seen as a plea for centralization. A coherent, professionally managed, support system would ensure greater efficiency, with more rapid and cost-effective development of hardware and software solutions, while taking advantage of the distributed innovation capacity in the system.

2.3 Challenges of eResearch in Nigeria

One of the most important impediments aiding setback in Nigeria educational research is not the issue of incompetent lecturers in the universities but inadequate reading text and nonchalant attitude of the government and university authorities to libraries in Nigeria. Information is a great asset in teaching, researching and learning. Information could be

knowledge acquired through study or experience and the transfer of such knowledge to the people that needed it most. The library is generally believed to be the store-house of information and without it the whole educational system will be paralyzed. Lecturers consult reading texts from the library to teach and also recommend reading texts for students. These bring about the fact that the library is the backbone of the educational system, hence the need for universities to have standard, adequate, well equipped and up- to-date libraries. All walks of life and every discipline are moving towards a globalized world and Nigerian university libraries cannot afford to lag behind as far as globalization is concerned. With the increase in the quest for knowledge, researchers, library clientele, lecturers and other members in the university community are becoming increasingly sophisticated in their search for information due to advancement in technology; they are mobile and seek for information search attitude that is compatible with their emerging life style (Baro & Asaba 2010). The role of academic libraries has been changing and evolving so also are the needs of library users. Library users are becoming ICT frenzy and rely heavily on the innovation brought about by ICT for their information needs to be met effectively the more exposure they get to these ways of searching for information and carrying out their daily endeavour (Maryann & Udeajah 2014).

eResearch is a relatively new concept that has been given impetus by the rapid rate of internet penetration throughout the world, and the dramatic advance in the use of Information Technology (IT) in business and industry (Mutula & Brakel 2006 p. 5). ICTs have brought enormous changes that have reflected in the practice of librarianship. Accessibility and use of ICT have had a huge impact on libraries and the practice of librarianship (Berthon, Leyland, Dianne & Campbell 2008; Ongori 2009). One area where this change has great influence is in the area of acquiring electronic resources into the library for effective information search and research activities in the academic environment. Academic libraries subscribe to these electronic resources through a consortium or by independent subscription. They acquire and disseminate electronic portals and databases. Subscriptions have been made by Nigerian University Libraries (NULIB) consortium to databases like Ebscohost, Access to Global Online Research in Agriculture (AGORA), Health Internetwork Access to Research Initiatives (HINARI), Online Access to Research in the Environment (OARE), Database of African Theses and Dissertation (DATAD), and offline databases like MEDLINE. These global information resources are accessed through the libraries gateways. This is clearly stated in the minimum standards and guidelines for academic libraries in Nigeria (LRCN 2014, p. 18), “the library should strive as much as possible to enhance information access through networking, resource sharing, online information services and use of technological advances”.

The emergence of ICT has repositioned the frontiers of academic library resources, operations, and services as well as expectations of user groups. The practice of walking to the library to consult the card catalogue and browse the shelves is declining in developed countries, and this trend is quickly approaching developing countries as well. Academic libraries must embrace this scenario. The print/e-resources access model can serve as a stepping stone. When such a step is taken, academic libraries must remember expandability, flexibility, and compatibility (Anunobi & Okoye 2008). Electronic information is eroding the monopoly of academic libraries as the sole access point to information, and the print information as not the only means by which user's access materials from the library, now users prefer information in electronic medium more than the print format. Nevertheless, academic libraries can maintain their place by serving as access point to both print and electronic resources (Anunobi & Okoye 2008).

Today, academic libraries are struggling to keep their place as the major source of inquiry in the face of emerging digital technology. Digital technology has emerged not only the way information is packaged, processed, stored, and disseminated, but also how users seek and access information for their diverse needs. Academic libraries no longer restrict themselves to print services such as collection development, cataloguing and classification, circulation and reference services, current awareness, selective dissemination of information and other bibliographic services, but have extended their tentacles to interdisciplinary concepts and computer software and hardware and telecommunication engineering and technology (Anunobi & Okoye 2008). Lombardi (2000) observes that users will prefer more computer content, more and more computer indices, digitized finding aids, digital repositories of articles and online access to newspapers. The convergence of ICT and its implications for library service in academic libraries have received the widest attention among the practitioners of library and information science. No library can be relevant in this modern age (the era of ICT) without access to the Internet (Baro & Asaba 2010).

Before academic libraries can maintain a prominent position in their institutions, they must move from limited or local access to universal access. For academic libraries in developing countries to achieve this, expandability, flexibility and compatibility will be required (Tebbetts 1991). It requires standard hardware, sufficient capacity, networking capabilities, flexible software standard such as MARC for information storage and retrieval, local expertise, and a plan for the next system (Anunobi & Okoye 2008). However, academic libraries are also faced with quite a number of barriers in the adoption of ICT into the library. Abubakar (2011) in a study of academic libraries in Nigeria in the 21st century notes some of the barriers as finance, erratic internet services, lack of hardware and software, non-availability of ICT and

IT illiteracy among academic librarians. Baro and Asaba (2010) identify some barriers to the use of Internet connectivity in Nigerian university libraries as library funding, lack of maintenance culture, lack of technical personnel, power supply and date of establishment of Internet connectivity.

International funding issues have been raised in the past. In particular, British Academy in 2008 observes that:

> *"International collaboration is essential to producing good research in any country; this is particularly true of Nigeria where the level of existing participation in international research is much lower. The role for donors may depend as much on creating and enabling good connections to international research networks, and encouraging the sharing of knowledge and experience, as it does on funding for research projects."* (British Academy 2008)

Odia and Omofonmwan (2013) examine constrains to research and development sector in Nigeria. They note that researchers in Nigeria are looking forward to a better infrastructure and research facilities that can compete with that of their international peers and thus, called on the government and other relevant stakeholders to attend to these aspirations so as to attain the development goals of the nation. The lack of formal training of eResearch has also been raised as an issue in an earlier study (Arcila, Piñuel & Calderín 2013).Also lack of shared initiatives, lack of skilled manpower, lack of financial support and infrastructure, lack of ICT resources, absence of local resources, lack of long-term planning, psychological barriers, lack of ICT training programs, lack of networks and finally lack of e-resources selection policy. Academic libraries must look for ways to totally eliminate the aforementioned barriers (and look for the solution to the barriers for) so as to be effective in their functions and be able to meet the various needs of their clientele. Libraries must employ IT to improve acquisition, capturing, retrieval, sharing, transfer and dissemination of information and also pay attention to the factors influencing ICT adoption for achieving a higher level of e-readiness that will give them an edge among their equals in the developed world (Baro and Asaba 2010).

2.3.1 Research Life Cycle

For eResearch, each of the phases depicted in the JISC research cycle, needs to happen online or the results of the research process needs to be in a shareable, digital format. This becomes very difficult or close to impossible when systems are not integrated and/or not able to communicate with other systems. The JISC research lifecycle is depicted in the Figure 2.3 below:

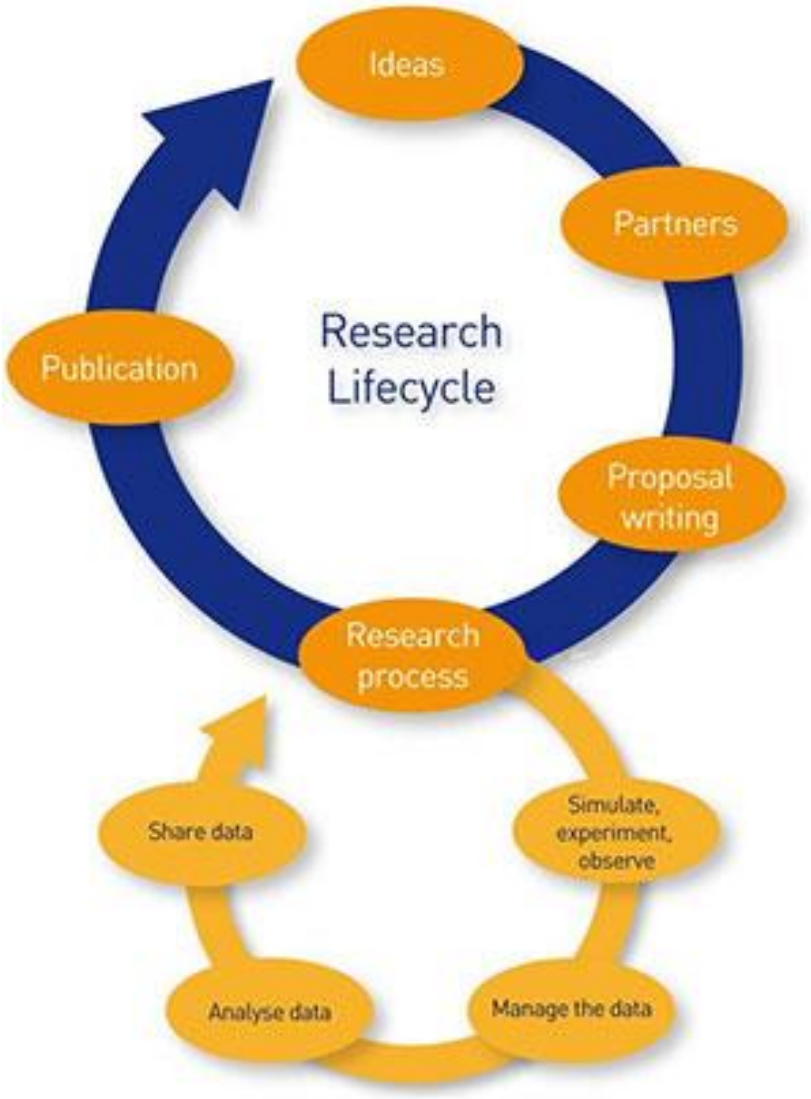

Figure 2.3 JISC research lifecycle

(Source: Brown 2013)

The generic skills needed by the librarians to embed in the research lifecycle according to Leiss and Lockhart (2015) are academic identity management, scientific writing, communication/collaboration, networking and legal issues. Academic identity management improves the visibility of the library and include having knowledge of how to manage research tools like ORCID, Researcher-ID, Google Scholar Account and Scopus Author management; scientific writing will include trainings at institutional, national and international level on issues like guidelines for research integrity and good scientific practices; communication/collaboration would include video/tele/web conferencing technologies like instant messaging, wikis, blogs, online forum and social bookmarking skills; networking would include knowledge and use of collaborative research links like ResearchGate, academia.edu, LinkedIn and so on while legal issues will entail the librarians having an

understating of Author's agreement, citations and plagiarism, data management issues (Leiss and Lockhart 2015).

There has been a natural migration to virtual systems that are easy to link together in an easy to use manner. These systems are commonly known as Virtual Research Environments (VREs). VREs are discussed in more detail in the next section.

2.3.2 Virtual Research Environments

A VRE is an online system that enables researchers to easily collaborate. VRE is the infrastructure that makes it possible to conduct research online (van Deventer 2015). JISC (2011) defines VRE as what “helps researchers from all disciplines to work collaboratively by managing the increasingly complex range of tasks involved in carrying out research”. Characteristics of a VRE include collaboration support like wikis and online forums, hosting of document (dedicated websites), discipline-specific tools like data analysis, data visualisation, computational tools, management of publications, and self-teaching tools such as presentations and slides (Wikipedia 2014). VREs have become the most important fields where research is primarily carried out among team members spanning through institutions and countries providing easy access to information sharing and research outputs (Candela, Castelli, & Pagano 2013). According to Carusi and Reimer (2010, p. 3), the concept of the VRE was studied by UK funding agency JISC in 2010 which highlighted issues such as researcher involvement in VRE design, sustainability, and consideration of the project as primarily one of community building rather than technology. The report also noted synonyms such as "collaborative e-research community", "collaboratory" and "virtual research community" (Carusi, & Reimer 2010, p. 11).

According to Candela (2011), a VRE comprises a set of online tools and other network resources and technologies interoperating with each other to facilitate or enhance the processes of research practitioners within and across institutional boundaries. A key characteristic of a VRE is that it facilitates collaboration amongst researchers and research teams, providing them with more effective means of collaboratively collecting, manipulating and managing data, as well as collaborative knowledge creation.

Common in most institutions nowadays are Virtual Learning Environments (VLEs) that provide students with materials for blended learning, collaboration enabling facilities, feedback and assessment and tools to manage and direct the teaching process (Brown 2013). He stated further that Virtual Research Environments (VREs) are based on a similar principle, providing an integrated analytical research tools as well as access to system

management and administration. As with all new technologies, much of the nature and direction of VREs are continuing to evolve. Whereas early iterations tended to focus on producing unique, bespoke solutions, the focus today tends to be more on developing interoperable frameworks and tools which continue to enable customisation, but in line with agreed sector standards.

A VRE should not be thought of as single ‘a system’. The term VRE is now best thought of as shorthand for the tools and technologies needed by researchers to do their research, interact with other researchers (who may come from different disciplines, institutions or even countries) and to make use of resources and technical infrastructures available both locally and nationally. The term VRE also incorporates the context in which those tools and technologies are used. In short, a VRE has the potential to assist the researcher throughout the entire ‘research lifecycle': from conducting literature reviews as part of initial ideas generation, to preparing grant submissions, reporting results and archiving data.

A paper on VREs was produced in 2011, in the context of the GRDI2020 EU Project (Candela 2011). It surveyed the state of the art, proposed a 10-year vision, discussed current challenges and concluded with recommendations for the evolution of the research field. The authors define VREs as "innovative, web-based, community-oriented, comprehensive, flexible, and secure working environments conceived to serve the needs of modern science" (Candela, Castelli & Pagano 2013). VRE software may be built on a content management system (CMS) platform such as HubZero or Joomla, on a learning management system such as Moodle or Sakai, or through specific VRE frameworks that can be used as enabling technologies to develop and host different VREs such as the gCube System framework (Candela 2011, p. 23).

Interest in VREs is not just constrained to the UK. Further information about how the concept is being taken forward internationally is available from the VRE Collaborative Landscape Study (Carusi & Reimer 2010). A major factor that has been influential in promoting discussions on VRE issues across borders is knowledge exchange through international workshops and publishing of resulting reports (Brown 2013). International organisations, for example, JISC, have created VRE knowledge base with international partners thus providing links to funded VRE projects in the UK and in other countries around the world (JISC 2011).

There is still considerable potential and room for development in the use of VREs. The objective of VREs is to address this challenge by supporting capacity building in interdisciplinary research communities, to empower researchers through development and deployment of service-driven digital research environments and services and tools tailored to

their specific needs (Brown 2013). These VREs should integrate resources across all layers of the e-infrastructure (networking, computing, data, software, user interfaces), should foster cross-disciplinary data interoperability and provide functions allowing data citation and promoting data sharing and trust. Each VRE should abstract from the underlying e-infrastructures using standardised building blocks and workflows, well documented interfaces, in particular regarding application programme interfaces (APIs), and interoperable components. Over time VREs will be composed of generic services delivered by e-infrastructures and domain specific services co-developed and co-operated by researchers, technology and e-infrastructure providers, and possibly commercial vendors.

VRE proposals should clearly identify and build on requirements from real use cases, e.g. for integration of heterogeneous data from multiple sources and value-added services for computing, modelling, simulation, and data exploration, mining and visualisation, taking due account of privacy aspects. They should re-use tools and services from existing infrastructures and projects at national and/or international levels as appropriate. Projects will define the semantics, ontology, metadata, computing models and levels of abstraction where data are concerned (CORDIS 2015). This is to ensure rich semantics at machine level as well as interoperability. Concept proof, advanced data services and environments prototyping and deployment and connectivity and computing access are supported by VREs.

Furthermore according to CORDIS (2015), VREs may target science and technology areas like ICT, mathematics, web science, social sciences and humanities. The focus must be on ICT infrastructures that can improve the challenges in the society and the number of researchers as potential users indicated. VREs results is seen in more efficient collaborations between researchers having advanced effectiveness and creativity in performing research and also in the improved productivity of researchers due to “reliable and easy access to discovery, access and re-use of data” (CORDIS 2015). They will speed up research innovations by providing uninterrupted access to integrated digital research resources, tools and services across disciplines and user communities and enabling the processing of structured and qualitative data in virtual environments by the researcher. They will contribute to increased take-up of collaborative research and data sharing by new disciplines, research communities and institutions.

Collaborations and creation of VREs is strengthened by collaborative research activities that are geographically distributed in an academic environment (Arcila, Piñuel & Calderín 2013). van Deventer (2015) opines that VREs have become standard infrastructure for what the new/emerging online scientific research is. Furthermore, VRE infrastructure makes collaboration easy and helps in creating structure in specific multi-party projects by making use of the internet. The internet has indeed changed the way research is done and now often drives the work processes required for the research. VREs are the access interface and the infrastructure that allow the researchers to conduct research online (van Deventer 2015).

To better understand the components of the VRE, Fernihough's eResearch framework was also investigated. Section 2.3.3 provides more detail.

2.3.3 An Overview of Fernihough's eResearch Implementation Framework

In a study by Fernihough (2011, p. 113), she designed an eResearch framework for South African organisations (Figure 2.4). The large variety of components that could be placed within a layered framework (a, b, c, d, e, and f below) that was summarized as follows:

a. **Infrastructure or cyber infrastructure layer:** This component depicts the physical infrastructures that are required to build an enabling environment for e-Research, onto which other layers can be built to enhance the use of the infrastructure. These infrastructures include the following:
    i. **National Backbone Network:** This is high speed and large bandwidth network that can be used to connect to all regional or inter - institutional networks together or to connect them to international education and research networks and grids.
    ii. **Regional and/or Inter - Institutional Networks**: This is the network that links all institutions or research centres within a region together and then connecting them to the national backbone network.
    iii. **Data Storage Infrastructure/Repositories**: These are infrastructures for physical storage and retrieval of digital content and assets. These could benational or institutionally based infrastructures. A repository supports mechanisms to import, export, identify, store and retrieve digital assets (JISC 2011).

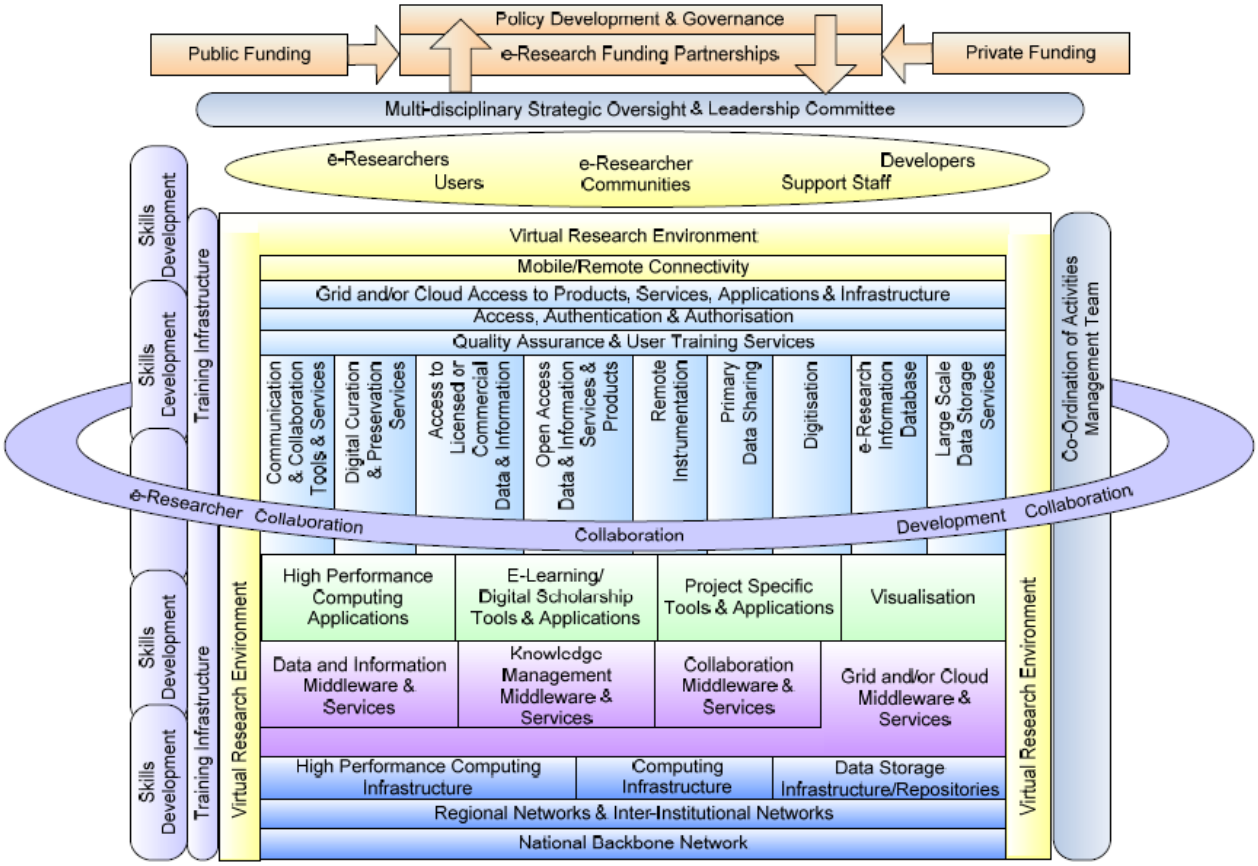

Figure 2.4 Fernihough's eResearch Implementation Framework

(Source: Fernihough 2011, p. 101)

iv. **Computing Infrastructure**: For implementation of eResearch every institution will require high performance computing infrastructure. High Performance Computing Infrastructure is necessary to allow researchers to process large volumes of data at high speed or do complex analysis. A High Performance Computing Infrastructure can "enhance significant research, address grand challenges, and grow computational research" (CHPC 2010). These infrastructures are also required to manage the e-Research applications, products and services. These include desktop machines and mobile devices, such as cell phones and iPads to allow the researchers to successfully do their research.

b. **Middleware & Services layer:** This is the communication layer that allows applications to interact across hardware and network environments. The middleware layer include the following components:

i. **Grid Middleware and Services:** This component provides co-ordination and communication services between the computational and data resources of the grid and the higher - level services that use them (DSTC 2004)

ii. **Data and Information Middleware and Services:** This provides tools and services that enable the indexing, archival, discovery, analysis, integration, management and preservation of large heterogeneous distributed data repositories and digital archives (DSTC 2004).

iii. **Knowledge Management Middleware and Services:** the focus of this middleware is to make use of data and information generated, archived, indexed etc, to mobilize knowledge and aiming towards building a knowledge economy.

iv. **Collaboration Middleware & Services:** These are tools and services that support formal and informal, real time and offline collaborative activities between remotely located researchers, research communities, and resources (DSTC 2004).

c. **Applications:** This layer describes those specific applications that are required for use in the underlying infrastructure and middleware. This layer includes:

i. **High Performance Computing Applications:** These are applications that are used for the high performance computing infrastructure.

ii. **E-Learning/Digital Scholarship Tools & Applications:** These are tools and applications that enable e- learning environment and are used to provide innovative learning experience for learners (Li et al. 2006).

iii. **Visualisation**: These are tools for converting either numeric data from scientific experiments and simulations or all other forms of data (structured and unstructured text, images and video) to an appropriate graphical representation (Charter 2010).

iv. **Project Specific Tools & Applications:** these are tools required for specific projects.

d. **Products and Services layer:** This layer describes products and services that researchers may require and most of the time not all institutions will require all of the products and services. This is the specific layer in which the library operates and provides both services and products.

i. **Communication & Collaboration:** These are products and services that allow researchers to communicate and collaborate inter-institutionally, nationally and internationally. Collaboration may involve the sharing of data and access to content in repositories and increasing communication and

conferencing (Sargent 2006), including audio conferencing, video conferencing and instant messaging.

ii. **Digital Curation & Preservation:** These are activities for active management of datasets for their scientific and scholarly useful lifetime, including the promotion of effective and widespread use (Page- Shipp et al. 2005).

iii. **Access to Licensed or Commercial Data and Information:** This license provides ready access to published work and data of other researchers, and the facility to publish one's own findings (Page-Shipp et al. 2005). These licenses can be negotiated on a national level and this will allow researchers in any institution to have better access to commercial information.

iv. **Open Access Data and Information Services & Products:** These are products available where a licensing fee is not required. These include access to national and institutional repositories and online journals. Open access digital repositories, operating in parallel with existing commercial publishing mechanisms, can provide a major opportunity to develop a sustainable information infrastructure for both traditional and emerging modes of knowledge production (Houghton et al. 2003).

v. **Remote Instrumentation:** These are services that enable researcher to remotely control instrumentation and equipment.

vi. **Primary Data Sharing:** These are services put in place to make primary research data available to other researchers. It enables storage of the databases and sufficient metadata for a prospective user to find relevant data and be satisfied with its value (Page-Shipp et al. 2005).

vii. **Digitization:** These are products and services that are required to convert data and information into a digital format

viii. **eResearch Information Database:** This is a database that specifically gives specific information on the development of the various components of e-Research. This database highlights specific developments and who is responsible for them and who to contact in order to gain access. This database is aimed at institutions that are looking to gain access to or develop their eResearch components, which can then look at the database to determine if, for example, visualization software has already been developed and where they can acquire the software. In this manner, duplication of development is avoided, costs are saved, and collaborative relationships are built.

ix. **Large Scale Data Storage Services:** These are services for indexing, managing and storing of large scale data.

x. **Quality Assurance and User Training Services:** This describes products and services that ensure quality of data and those that enable researchers to use the underlying infrastructure, products, and services.

xi. **Access, Authentication & Authorization:** These are security technologies that support user and provider requirements such as authentication, authorization, trust, privacy, policy management, and information assurance, all in a user - and provider friendly framework (ISSR 2010).

xii. **Grid and/or Cloud Access:** These are those services that allow underlying infrastructure access to grid and cloud networks.

e. **Users, Access & Mobile/Remote Connectivity:** This layer describes all applications specifically related to the users or being used by researchers.

i. **Mobile/Remote Connectivity:** These are tools, products and services that enable researchers to access the products, infrastructure or services remotely. This include applications, cell phones, iPads and so on that allow access to the infrastructure from remote locations.

ii. **Virtual Research Environment (VRE)** These are the set of online tools, systems, and processes that inter-operate to enable research process across institutional boundaries. VRE provides researchers with the tools and services that are required for efficient and effective research. It also facilitates collaboration between researchers across disciplines and national boundaries.

f. **E-Researchers, e-Researcher communities, Users, Developers, and Support:** These describe all the people who can use, participate in, develop and support the e-Research. It also highlights infrastructures for developing personnel for eResearch

i. **Skills Development & Training Infrastructure:** In each of the layers, specific skills will be needed for different groups of people, thus skills development is in implementing e-Research. Thus, these describe infrastructure that are used for the development of processes, skills and training for researchers, support staff, and IT specialists.

ii. **Multi-Disciplinary Strategic Oversight & Leadership Committee:** These are groups of people from various institutions with diverse background with a strategic vision, direction and co-ordination of effort of research groups involved in eResearch. This committee should further be responsible for establishing working groups. These working groups would, for example, be responsible for the research and development of the components,

iii. **Co-Ordination of Activities Management Team:** This is a team that ensure that the activities across each of layers are well coordinated. This team will

ensure that all eResearch activities like planning, development and implementation are coordinated nationally and they are also responsible for ensuring collaboration on all levels.

iv. **eResearch Funding Partnerships :** This refers to collaboration between government, industry and institutions to fund eResearch activities, including development and implementation of eResearch components nationally and institutionally. These partnerships will require funding from both public and private sector in order to bring about the eResearch framework.

v. **Policy Development and Governance:** This describes decisions that define expectations, grant power or verify performance. It encompasses management and leadership processes that are required for eResearch.

vi. **Collaboration:** This is an important motivation for eResearch. It will be a requirement between all stakeholders inclusive of collaborative funding, collaborative development, and collaboration in conducting research. The advantages of collaboration are enormous and these include cost-sharing across infrastructure investments, potential to develop new research methods, new cross-discipline approaches, new relationships, and enhanced research outputs (AERIC 2006).

Although it is necessary to understand the possibilities of such a framework as background, it definitely is not necessary for any individual to understand the detail behind each and every component. What is more important is to know that eResearch requires a layered infrastructure where the components are all interconnected and that VREs make it easy for the researcher to drill down through the various layers of infrastructure without realizing that this is what is happening. Libraries are able to embed in the products and services layer.

That will therefore be the focus of this research.

2.3.4 Research infrastructure in Nigeria

Without basic research infrastructure, no institution can sustain developments in knowledge economy nor deliver in terms of research. Ebuehi (2012) in his inaugural lecture alludes that the main “challenges facing research in Nigeria is lack of infrastructure and poor funding”. He expatiated that the government needs to invest massively in research. Since higher educational institutions and research agencies are to “drive the process of generating knowledge for national development” (Chafe 2010). The National Universities Commissions (NUC) of Nigeria aligned with this conclusion and the fact that ICT is essential to support online sharing of

information and e-resources and collaborative research among universities in Nigeria. This made establishing a national research and educational network (NREN) a necessity. Thus, the Nigerian Research and Educational Network (NgREN) was established by NUC in 2012 in conjunction with the Committee of Vice Chancellors of Nigerian Universities supported by the World Bank assisted Science and Technology Education Post Basic (Step-B) project (NgREN 2015). NgREN is to provide infrastructure for internet connectivity across national and international borders, facilitate inter-institutional collaboration and knowledge sharing. The Nigerian ICT Forum (FORUM) established in 2005 is charged with the duty of managing the NgREN.

A REN according to Information Technology and Communications Unit (INTECU 2013) is a "Research and Education Network that provides data communications networks and services to the research and education communities". REN provides connectivity at a cheaper rate to member institutions, global sharing of network services like cloud computing, resources sharing across borders, facilitates e-education, offers community services like video conferencing and online collaborations, provides access to high speed network and expensive research instruments and resources, enhances development of content jointly, large database sharing and improves linkages between the academic, research, industrial and governmental environments.

A National REN like NgREN is saddled with the duty of providing data communications networks and services to the research and education community on a national basis. NgREN connects with other networks at regional level, provides support for high speed backbone network and offers dedicated channels. OsunREN is a subset of NgREN while IfeREN is a subset of OsunREN. INTECU, the ICT unit of Obafemi Awolowo University is responsible for implementing ICT strategies and the Wide Area Network (WAN) in the University for the purpose of assisting educational research. INTECU is also in charge of the IfeREN (see Figure 2.5 and 2.6).

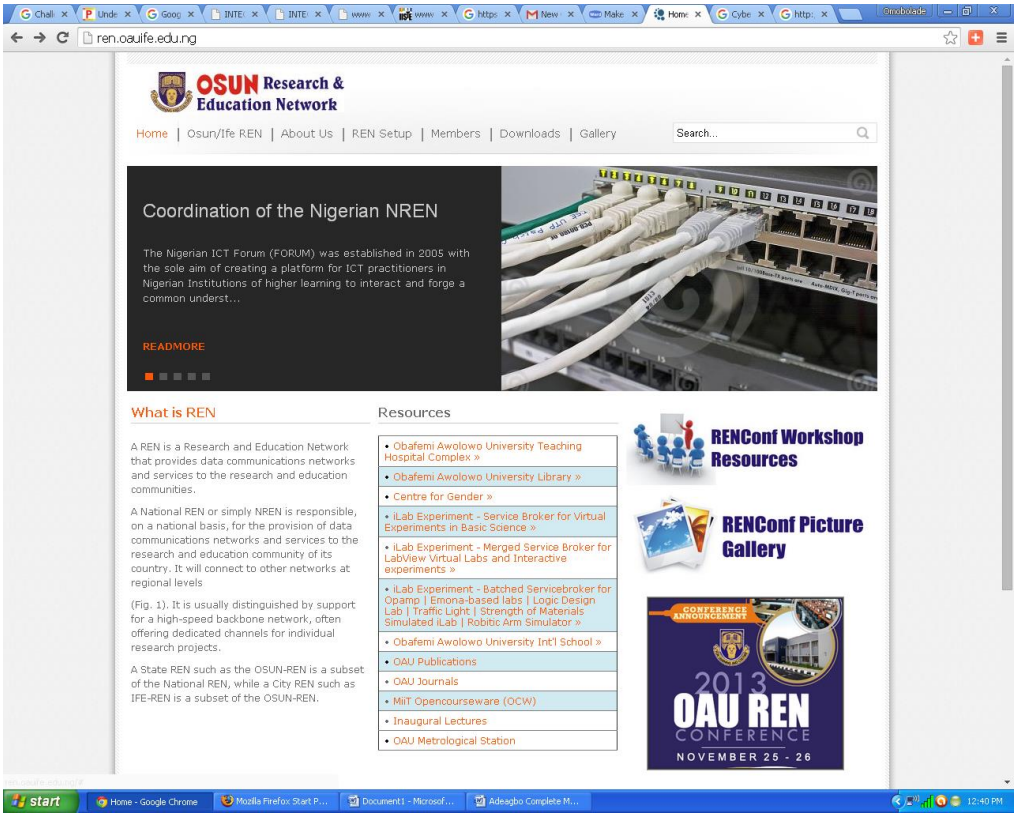

Figure 2.5 IfeREN website

(Source: http://ren.oauife.edu.ng/)

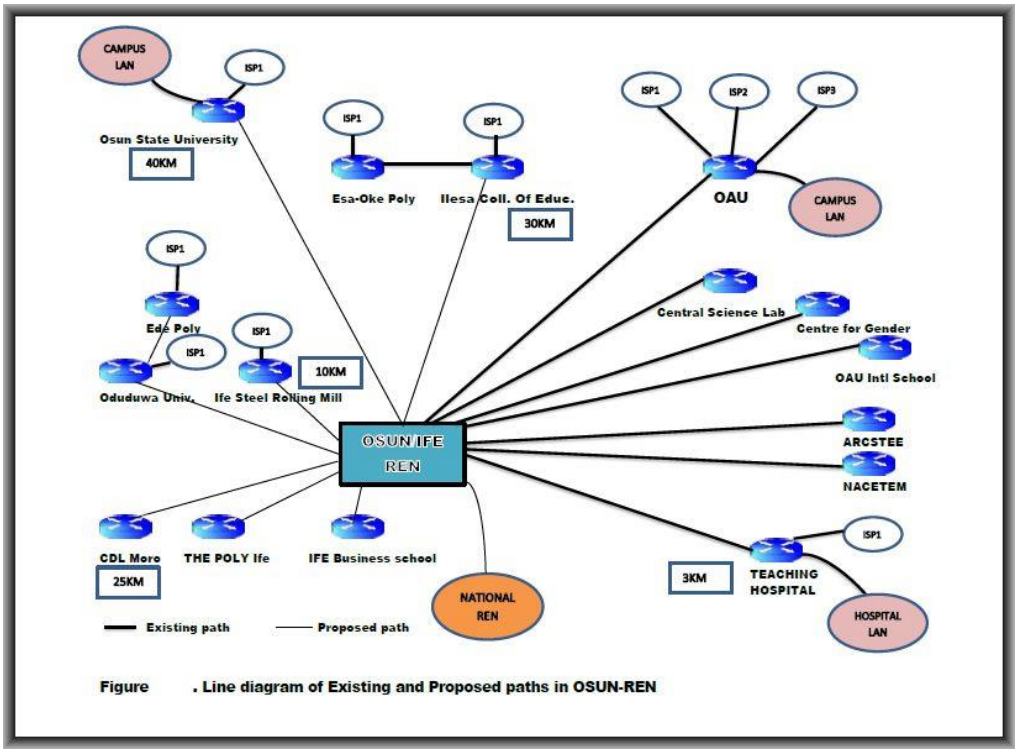

Figure 2.6 Phases of the OSUN/IFE REN

(Source: http://ren.oauife.edu.ng/index.php/osun-ife-ren/phases)

It is worth noting then that the Federal Government (FG) has been making efforts to redeem the situation. According to the executive secretary of the National Universities Commissions (NUC), Prof. Julius Okojie, the FG recently approved a sum of three billion naira for research project activities (Okojie 2012). Also, the Tertiary and Education Trust Fund (TETFund) provides funds for staff training in Nigerian tertiary institutions.

He states further;

> *"What we are trying to do is to ensure that we intervene through diverse means by ensuring we build capacity of our academics, build infrastructure on ICT to accommodate diverse research methodologies such as video conferencing, teleconferencing, that would bring faster results for collaborative learning between educational institutions within and outside the country,"* (Okunlola 2015)

Okunlola (2015) attests to this in his report stating that 27 Nigerian universities are now connected to share 10GB core high speed and online resources to improve research activities in tertiary institutions. The focus of the NgREN, according to the NUC executive secretary is *"to enable online researches in universities and offer efficiencies of unified communications and consolidation of digital content in research and development in line with global demands."*

2.4 The impact of eResearch on University libraries

eResearch is basically the incorporation of ICT into traditional research practices. This initiative has paved the way for a collaborative arrangement between the library, information technology and the research units of universities (Heijne 2009; McAlpine & McIntosh 2014). Studies have elucidated the new roles created by eResearch and highlighted new services for the library (Gold 2007; Luce 2008; Heijne 2009; Bryne, McKenzie & Frances 2012). Furthermore, eResearch has led to different ways of exchanging knowledge through open access publications, access to large datasets thus creating new roles for the library to facilitate computing resources, data curation, naming conventions and metadata. New services from the library would include research data management, data mining, data retrieval, access to knowledge and ensuring data quality. The library has no choice but to key into these new roles and services created by eResearch. Specifically, one of the fundamental roles of the library that has been greatly impacted by eResearch is knowledge preservation. Rising to this challenge, Luce (2008), suggested that libraries must be positioned to ensure the curation and quality of digital information, sustain services in digital environments, bridge and connect disciplines and archive research data to support eResearch in the preservation knowledge.

Allusions have also been made to the fact that, researchers are enabled to perform new forms of collaborative research activities irrespective of time and location, by the emerging technologies which have compelled new services for libraries (Sargent 2007; COAR 2013). Some of these services according to COAR (2013) include “development of research data management plans, hosting collaborative virtual research environments, managing institutional repositories, and disseminating research outputs through open access mechanisms”

Heijne (2009) however argues that libraries need to support eResearch for the following reasons:

- Information and data management involving providing access, creating metadata, reusing, storing and preserving information and data.
- Teaching experiences on academic skills needed for research.
- Knowledge and research management support.
- Organization of research outputs and the underlying data.
- Providing and maintaining links to research outputs and data.

Moreover, Thomas (2011, pp. 38-39) and McAlpine & McIntosh (2014) stated the core components of eResearch to be supported by academic libraries as research data management (RDM), high performance computing (HPC), scholarly communications, collaborative tools, data collection and analysis. Generally, libraries are primarily focused on operating within the space of RDM which specifies the policy, practices and services to sustain data in various formats. The volume of data being created through research projects based in universities necessitate the need to define how to manage all the datasets, especially the small ones acknowledging the fact that projects with big datasets have support framework for data collection and preservation. The library must work with researchers to provide support for small datasets, the volume of which must be specified. Martin (2014) suggested that collection, preservation and consultation of data should be seen as an extension of library services.

Leiss and Lockhart (2015) strongly believe that academic libraries plan to support eResearch and RDM while some are already doing so based on the available ICT infrastructure. They stated further that this support has created three major roles for the library; RDM support skills, eResearch support skills and staff development (see Figure 2.7)

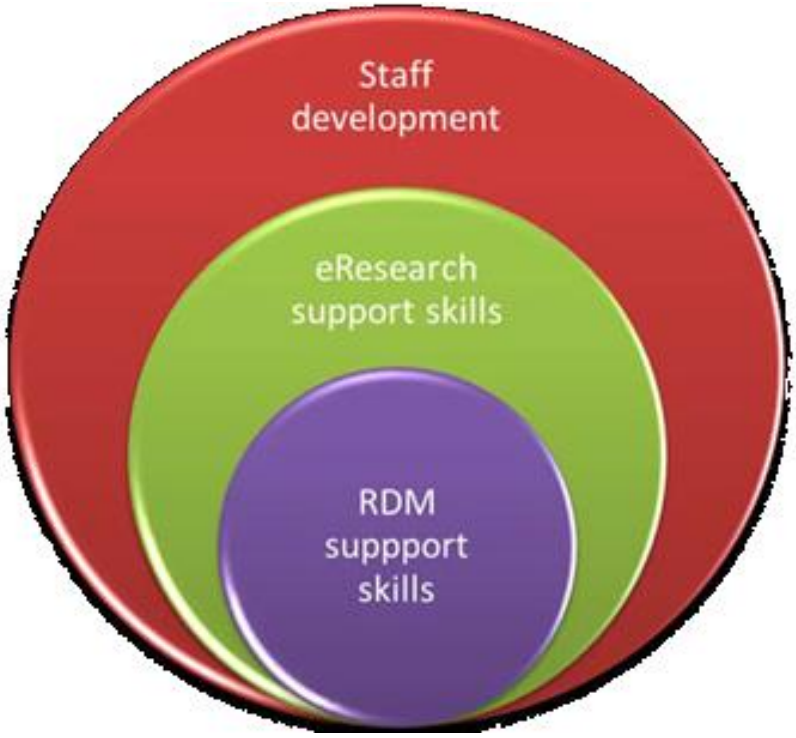

Figure 2.7 New roles for libraries
(Source: Leiss & Lockhart 2015)

Research data are generated as primary sources of information for the research projects which are required to validate research findings (Thomas 2011:38).An earlier study has highlighted the need for awareness of data stewardship, a role that must be taken seriously by the library (Shearer, Argáez, & Swanson 2010). The library could collaborate with the researchers in RDM process to archive research data (MacColl & Michael 2011). According to Heijne 2009, Leggott, Moses and Hooper 2014, the library needs to explore new services, roles, research support/partnerships and work collaboratively with the researchers. In all, librarians need to know more about eResearch (Simons & Searie 2014).

HPC has drastically reduced limitations on computational processes and data visualization in research, giving rise to activities like coding, supercomputing, support for programming, data collection, datasets comparison, tracking and analysis. Knowledge distribution is now more effective through electronic publishing, creative commons, institutional repositories and software for referencing (Gold 2007; Thomas 2011, p. 38). eResearch also affords researchers technologies like video/audio conferencing, wikis, SharePoint, project dedicated websites and workflow tools online that facilitate collaboration and communication regardless of the researchers locations (Thomas 2011, p. 37).

Simons and Searle (2014) strongly believe that university libraries are developing new infrastructure to support online resources and research activities in digital environments, in response to the changes brought about by the new technologies and their use by the academic community. They however argued that libraries must be actively involved in the professional development and the general education of library staff and other support units since there is no clear career specification into eResearch. An earlier study by Susan and Baby (2012) on developing technology skills for academic librarians, suggested organizing trainings and workshops by the University and the libraries as a means of equipping the professionals with the needed skills and the restructuring of the curriculum of library schools to accommodate these changes.

Research practices and dynamics are changing due to eResearch and the internet has provided a networked infrastructure for collaborative technologies to be used by researchers to communicate with each other (Harley & Blismas 2010). An earlier study has confirmed the positive attitude of researchers to eResearch and the use of online tools (Arcila, Piñuel & Calderín 2013). eResearch is adopted by researchers involved in collaborative research projects because they often use collaboration tools enhanced by ICT, share data and disseminate results through digital means (Markauskaite, Kennan, Richardson, Aditomo, & Hellmers 2012). Although developing these online collaborative practices is not an easy task, studies by (Olson, Zimmerman &Bos 2008; Markauskaite et al. 2012) note that researchers grow into these practices and develop the skills over the years.

Whitmire (2013) argues that the different terminologies used for research in an online environment might not be helpful if they are not understood by the various stakeholders involved. This might impede library services that are to support the various eResearch activities if the term is not well understood by the researchers. However, studies indicate that there is a general awareness of eResearch notwithstanding the terminologies used (Markauskaite et al. 2012, Markauskaite 2011; Simons & Searie 2014). Khatibi and Montazer (2012, p. 65) report that this might be due to the fact that researchers are aware of the full potential of ICT and how it can enhance research activities in online digital environments.

Researchers prefer using non-commercial tools to the open/free source to ensure data security. This is because most of the free/open source software are still in various stages of development and their credibility cannot be guaranteed. Markauskaite et al. (2012) however opine that researchers involved in experimental based disciplines tend to collaborate more than those in theoretical based disciplines. In addition, researchers have structured ways of sharing research data generated or collected. It has been noted that sharing data is the core of eResearch collaboration (Markauskaite et al. 2012). Wolski and Richardson (2015) assert that most researchers exercise good practices in research data management because they make use of the tools and technologies that are readily available for their research discipline through the internet. The web-based bibliographic tools used by researchers to maintain reference lists and items to read also allow them to share resources and references online (Brunvand & Duran 2010).

The research information management programme (MacColl & Jubb 2011) notes that researchers are at the middle of research environments and thus, seek to analyse the role of the library as service provider as shown Figure 2. 8.

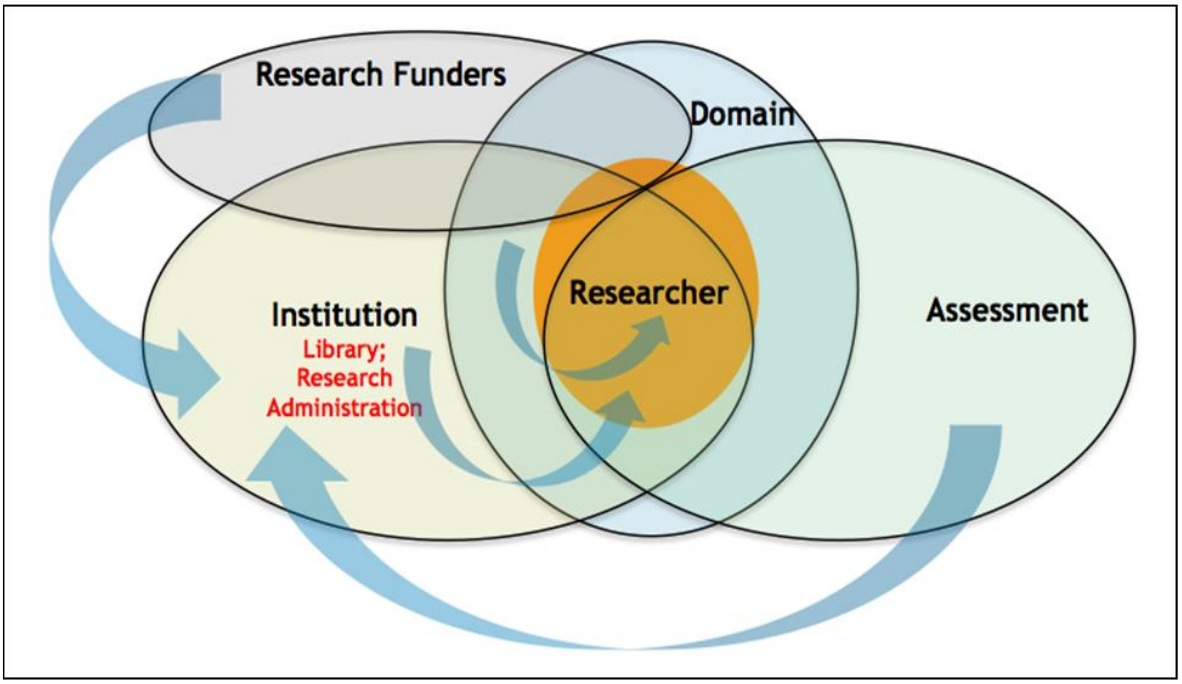

Figure 2.8 Research environments and impact dynamics

(Source: MacColl and Jubb 2011)

MacColl and Jubb (2011) explain that disciplines domain impact directly on the researcher while assessment and funding environments impact the institution. Institution act on the requirements of the researchers through the research administration and the library.

Providing insights on how university libraries could initiate collaborations that lead to eResearch, Brandt (2007, p. 367) using Purdue University Library as an example highlights the following:

- Library heads to interact and converse with Deans of Faculties and Heads of Departments with the aim of informing them on what the library has been doing, what the library can do and the available facilities that support research.
- The librarians should attend grant call outs, workshops, seminars and trainings within the University using the platforms as opportunity to create awareness for the library.
- Early involvement of the librarians in the organization and the descriptions of digital objects in eResearch spectrum.
- University libraries should have curation centres that could investigate and address the data needs and problems of eResearchers.

Heijne (2009) asserts that in the e-science/eResearch environment, “data become a valuable asset to the institution - the researcher is the driving force, the library should claim and prove its role in ‘Data management’, in close collaboration with parties for maintaining infrastructure and (technical) development”. Open access policy recently launched by Bill and Melinda Gate Foundation in 2014 is yet another way in which the impact of eResearch is pronounced. The policy requires that “data underlying published research results will be accessible and open immediately” (Bill and Melinda Gate Foundation 2014). The impact this will have on the library will include provision of resources that enable data sharing and data citation. However, how researchers will respond to this is yet to be seen. Thus, university libraries must empower eResearch by providing e-resources, incorporating the teaching of information literacy skills towards eResearch in the library instructional programmes for students as well as researchers, providing support for scholarly communications and for a for real time interaction to answer researchers questions (Lehto et al. 2010).

2.5 Theoretical Framework

This study is based on Fernihough eResearch Implementation Framework in section 2.3.3 and the collaboration theory in section 2.5.1. The collaboration theory was reviewed by Harley and Blismas (2010) as it applies to the online environment.

2.5.1 The Collaboration Theory

The advent of internet has drastically changed the way people communicate and interact. These innovations have broken barriers of communication in pre-internet times and have provided technological environment in which transcontinental and intercontinental communication can exist (NECTAR 2007). The exponential increase in connectivity to

internet and influence of the World Wide Web (www) has made multiuse computer systems (groupware) within the complex widely distributed organization a common phenomenon (Gutwin & Greenberg 2000). This web-enabled technology has flowed through to the research environment and has expanded the contemporary research environment allowing several teams at different sites to benefit from a tool that support them in their research. These online collaborative toolsets (OCTs) or groupware, enabled people to work together despite the barrier of location and distance (Foraker Design 2007; Gutwin & Greenberg 2000; McDonald 2003; Tech Target 2007). There are ranges of resources OCT can provide; it can be as simple as making an online space available for community engagement to more complex innovative workflow and information technology solutions.

However, the use of these tools does not necessarily mean that users develop collaboration amongst team members, or specific collaborative attitudes are invoked. Therefore, to appreciate and understand the factors guiding the use of online technologies in the eResearch environment, it will be important to understand the concept of collaboration within the e-environment and how it differs from cooperation and coordination. Cooperation and coordination had been used interchangeably with collaboration (Fitzek & Katz 2006; Mattessich, Murray-Close & Monsey 2001; Harley & Blismas 2010). However, these authors pointed out the distinct differences in these terms.

2.5.1.1 Cooperation

Cooperation is usually identified as informal relationships that exist without a prior defined mission, structure, or planning effort. In this relationship, information is shared as needed; each entity retains authority, and ensures that resources and rewards are separated (as cited in Harley & Blismas 2010). In his own view, Pearsall sees cooperation as the “action or process of working jointly towards the same end” (Pearsall 1999). Argyle (1991) also defines cooperation as acting together in a coordinated way at work, leisure, or in social relationships, in the pursuit of shared goals, the enjoyment of joint activity, or simply to further the relationship. Cooperation can also be understood as joint action for mutual benefit, and is the strategy of a group of entities working together to achieve a common or individual goal (Fitzek & Katz 2006). However, Schermerhorn has a different view of cooperation, and he defined it “as deliberate relations between otherwise autonomous organisations for the joint accomplishment of individual operating goals” (Schermerhorn 1975). It is clear that cooperation can also be seen to take place on a small or large scale with few or many collaborating entities (Fitzek & Katz 2006).

2.5.1.2 Coordination

Several scholars had put up many definitions for coordination, however with inconsistencies; therefore practitioners have been cautioned to be wary of applications developed for this use (Rogers & Whetten 1982). This term has been used synonymously or confused with a variety of related concepts including cooperation. Pearsall 1999 defined coordination "as the action or process of bringing different elements of a complex activity or organisation into a harmonious or efficient relationship" (Pearsall, 1999). Moreover, it is noted to be characterised by relationships that are more formalized which have an understanding of compatible missions. Mattessich et al. (2001) also noted that "some planning and division of roles are required, and communication channels are established" but authority still rests with the individual organisations with some increased risk to all participants. In their own contribution, Rogers and Whetten (1982) see coordination existing across two or more organisations, so they linked it with intra and inter-organisation coordination and defined inter-organisational coordination as "the process whereby two or more organisations create and/or use existing decision rules that have been established to deal collectively with their shared task environment". Another school of thought Warren, Rose,& Bergunder (1974 as cited in Harley and Blismas 2010, p. 17) conceptualised coordination as "a structure or process of concerted decision-making or action wherein the decisions or action of two or more organisations are made simultaneously, in part or in whole, with some deliberate degree of adjustment to each other".

2.5.1.3 Collaboration

Collaboration has been considered by some as a process that embraces ability of two or more people or groups to transfer data and information online (Breite & Vanharanta 2003), while some see it as being simply equal to participation (Romano, Chen & Nunamaker. 2002). However, an earlier study considered collaboration to be "the capacity to bring previously separated organisations into a new structure with full commitment to a common mission" (Mattessich et al. 2001). The belief that such relationships must require comprehensive planning and well-defined communication channels operating on many levels and that authority is determined by the collaborative structure and risk is much greater because each member of the collaboration contributes its own resources and reputation. According to this view, resources are pooled or jointly secured, and the products are shared (Harley & Blismas 2010). Mattessich et al. (2001) also noted that the collaborative environment includes a commitment to mutual relationships and goals; a jointly developed structure and shared responsibility; mutual authority and accountability for success; and sharing of resources and rewards. Pearsall (1999) finds it difficult to see any difference between the terms cooperation and collaboration, noting that collaboration is "an act of

working jointly on an activity or project" whereas Schrage (1990) notes that collaboration is the "act of constructing relevant meanings that are shared by all parties involved to achieve congruent goals".

Several factors had also been identified to contribute to collaboration being present in a specific environment. These include communication, trust and respect, equality and power, strategic alliances or partnerships, incentives, negotiation, and inter-organisational knowledge sharing.

2.5.1.4 Models to distinguish Cooperation, Coordination and Collaboration

In order to understand and compare these terms, Mattessich et al. (2001) proposed four key categories that present a series of elements that has a varying or gradated relevance to the three terms. These categories are:

- Vision and Relationships: the elements are relationships, missions and goals, and interaction.
- Structure, Responsibilities and Communication: the elements are roles, planning and communication.
- Authority and Accountability: the elements are authority, leadership and risk.
- Resources and Rewards: the elements are resources and rewards.

In their assessment, in most instances, these elements apply less to cooperation and more to collaboration, with coordination occupying the middle ground. However, Rogers and Whetten (1982) had earlier listed five criteria with which we can make distinctions between cooperation and coordination. These criteria include:

- Rules and formality;
- Goals and activities;
- Implications for vertical or horizontal linkages;
- Personnel resources and
- Threat to autonomy.

In their own view, cooperation and coordination are differentiated by the degree to which they are relevant to the specific criteria. In the first of the criterion, they differentiated between the two terms by observing the way formal rules are managed. In cooperation, few formal rules are involved while greater use of decision rules is required in coordination. In the second criterion, type of goals emphasised is determined by the individual organisation's goals and activities but coordination is determined by joint goals and activities. The third criterion necessitates the extent of inter-organisational linkages. Cooperation is usually expressed within its own organisational domain but coordination could spread and link withother organisation structures. The fourth criterion examined the type of personnel involved. Cooperation has few members drawn from lower positions within the organisation while coordination will require resources, commitment and involvement from senior members of the organisation. The fifth criterion looks at the autonomy of the organisations and notes that cooperative organisation will have little autonomy threat but within coordinative organisation, the threat to autonomy increases within.

Argyle (1991) observes that cooperation is usually needed to implement tasks, to sustain basic social relationships and working environments. He identified communication and interaction as drivers of successful cooperation. Argyle also noted that cooperation within the working environment can take several forms. The first form is where a worker undertakes a task independently or in partnership with other workers, the second form is a supervisory relationship where a person is responsible for ensuring that other people performed the task correctly, the third form includes other social relationships found in working environments such as information sharing, discussions, negotiations and expert advice provision (Argyle 1991).

Fitzek and Katz (2006) also describe cooperation as any action and relationship that enable participants' contributions in order to gain through giving and sharing. Cooperation can encourage specialization and differing competencies while the rules within the cooperative environment can be enforced through rewards and incentives (Harley & Blismas 2010, p. 28). The condition of cooperation is however based on the assumption that each of the participating members is gaining more by cooperating than operating alone or independently. Coordination also has a mechanism to plan an action between organizations which can be for individual purposes (Rogers & Whetten 1982). Figure 2.9 exemplifies the model of juxtaposition of cooperation and coordination outcomes by Rogers and Whetten (1982).

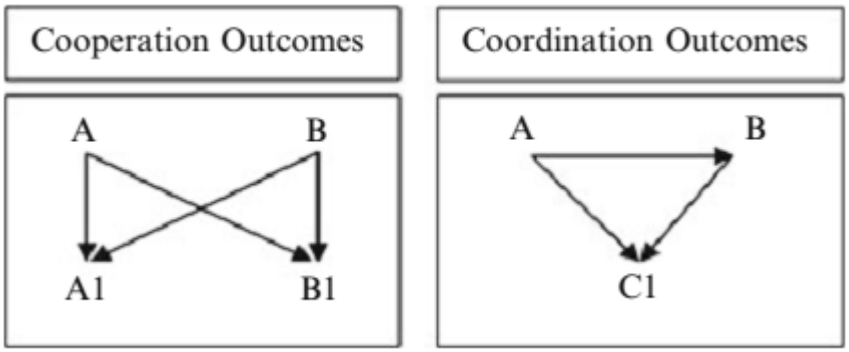

Figure 2.9 Juxtaposition of cooperation and coordination outcomes
(Source: Harley & Blismas 2010, p. 29)

In the cooperation model, organisations A and B relate with each other in order to accomplish their respective goals. In the coordination model, the outcomes created may be different from the respective goals and preferred outcomes (Rogers & Whetten 1982). Coordination involves undertaking tasks within the shared organisational environments without an authority structure in place. As the application of coordination across organisations increases, emphasis will shift from managing internal activities and external constraints resource control (Thompson 1967 as cited in Harley & Blismas 2010, p. 29). It is therefore more difficult to successfully manage an inter-organisational coordination than interdepartmental coordination (Harley & Blismas 2010, p. 29).

2.5.1.4 Collaboration and eResearch

Several models and applications have been presented for the terms cooperation, coordination and collaboration, however there are slight variations as a result of the environment or circumstances for which it is intended (Harley & Blismas 2010, p. 30). It is clear from the forgoing that the elements identified can be understood depending on whether

it isbeing applied to cooperation, coordination or collaboration. It has also been established that description of each term is relative to each other. This means that each element exists along a progression or scale with cooperation at the start of the scale, coordination occupying the middle ground and collaboration being described as high or complex involvement of the particular element. This analysis of collaboration identifies the scale, and highlights the degree to which the elements must be present in order for collaboration to occur. Harley and Blismas (2010) presented an alternative way of understanding collaboration and the degree to which it occurs within the eResearch environment by amending the model by Rogers and Whetten (1982). They describe collaboration as “a complex interaction of intra/inter-organisational linkages and connections with cooperation as the entry point in this interaction, progressing through coordination, and reaching maturity

at the collaboration stage" as shown in Figure 2.10

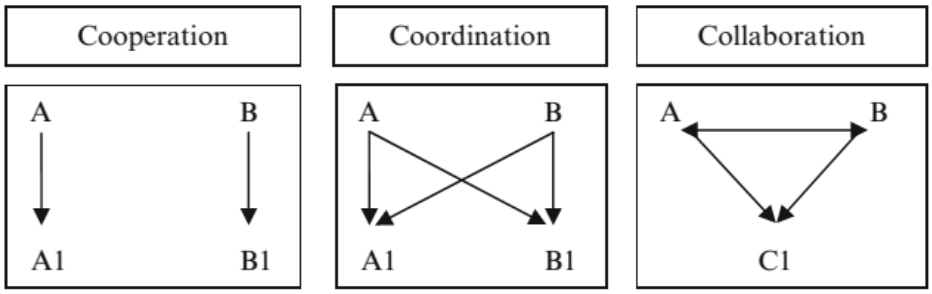

Figure 2.10 Amended juxtaposition of cooperation, coordination and collaboration outcomes

(Source: Harley & Blismas 2010, p. 32)

In this model as shown in Figure 2.4 above, collaboration is seen as an amalgam of the three terms (Harley & Blismas 2010, p. 30). Each term can also play a role in the eResearch environment if viewed singly. A greater understanding of how online tools can contribute to the eResearch environment is enabled by this conceptual framework. Different elements can be identified within collaboration, which in turn identify different approaches and functions in eResearch activities. The authors in their submissions argued that "collaboration is the result of mature manifestations of these elements, not all of which may be required within a particular collaborative engagement, nor be required to exist or operate at equivalent mature levels" (Harley & Blismas 2010). For instance, it was noted that eResearch team will benefit from cooperative activities but may still require coordination of processes and may not require collaboration in all activities. However, the impact of collaboration on the use of the online tool will require a more complex interaction, as opposed to cooperation or coordination that will require simple transmission of information or just a meeting. This view highlights many possibilities for investigating the eResearch environment and how to measure the associated activities. Harley and Blismas (2010) strongly believe that using online tools in the eResearch environment will "develop and nurture strong social/research/academic networks that are essential to the health and longevity of research practices" as well as contribute to the attainment of the research objectives.

Finally, this theory gave an understanding of the constituents of collaborative online research activities. The emerging online toolsets to facilitate and manage collaborative research environments further add to the opportunities resulting from the social aspects of collaboration, which is evident in the geographical spread of the research team and the need for them to access distributed information and data. This theory has proved that collaboration within eResearch environment involves activities that cut across cooperation,

coordination and collaboration. Having an understanding of the terms and their elements will therefore guide the user in the use of online technologies in eResearch environments.

2.6 The Obafemi Awolowo University library.

The University library commenced operation in 1962, the year Obafemi Awolowo University, formerly University of Ife, was established. The library collection covered all the courses taught by the University even though the library was housed in a temporary location not well equipped for the library operations (HOL 2013). Owing to the priority accorded by the University authority to the library, the library moved to the permanent site in October, 1969, a four storey building covering 42,000sq.ft designed to accommodate 250,000 volumes with 800 sitting facilities. In 1980, due to rapidly increasing students' admissions, an extension was added doubling the volume and bringing the sitting capacity to 2,500. The library was also named Hezekiah Oluwasanmi Library (HOL) the same year in honour of Professor Hezekiah Oluwasanmi, the Vice Chancellor of the University, 1966-1975.

HOL is the major repository of all academic resources which serve the needs of the staff and students as well as other external users. The library is an important unit in the execution of the University primary functions of teaching, learning, research and community service (Library Handbook 2012). HOL presently has four departments which are further divided into sections and units namely:

- Collection development: The sections in this department are Serials and Orders;
- Readers' Services: The sections in this department are Circulation, Reference and the Faculty Libraries;
- Technical Services: The sections in this department are Cataloguing, ICT and Reprography;
- Research Development: The sections in this department are Africana, Government Documents and the University Archives.

The library opens Monday to Sunday at specified times and the e-resources are accessible to all users through the library website.

2.6.1 General description

HOL building consists of two wings, North and South, connected by walkways on two levels. The south wing consists of the following:

- Lower ground floor (meant for staff only) – on the east, reprography unit and the board room and on the west, bindery and conservation.

- Ground floor – on the east, reference room (reading room A), an exhibition hall and on the west, circulation desk, Online Public Access Catalogue (OPAC), orders/acquisition and the cataloguing unit.
- First floor – on the east, university archives, university librarian's office and on the west, reading room B.
- Second floor – on the east, back files journals and on the west, reading room C.

The north wing consists of the following:

- Lower ground floor – stack room (not opened to users).
- Ground floor – on the east, document section and on the west, reading room E.
- First floor – on the east, bibliography room, deputy university librarian's office (technical services), bar-coding room, e-Library (Universal Service Provision Fund, USPF), current periodicals, serials workroom and on the west, back files of journals (post 1975).
- Second floor- on the east, deputy university librarian's office (readers' services), deputy university librarian's office (research development), Africana section, e-Library, ICT unit, and on the west, reading room F.
- Third floor – on the east, general office, reserved books room and on the west, law library.

The catalogue hall is located on the lower walkway while the upper walkway serves as another exhibition hall.

2.6.2 Products and services provided for researchers and lecturing staff

Presently, the library holds over 700,000 volumes which spread across textbooks for different disciplines, journals and special collections. The special collections include the following:

- Africana special collections: collections of rare books in the field of African studies written by Africans, OAU staff publications, postgraduate thesis of the University and those of other Universities, and OAU publications
- Documents collections: these collections include official publications of the Federal and State governments of Nigeria like Central Bank of Nigeria (CBN) publications, National Population Commission (NPC) and other African government publications. The library is also a depository for international agencies such as World Fertility Survey (WFS), United Nations Organisation (UNO), General Agreement on Tariffs and Trade (GATT), United Nations Economic Communities of Africa (UNECA),

African Union (AU), World Health Organisation (WHO) and the World Bank.

- Reference special collections: these include dictionaries, encyclopaedias, handbooks, directories, atlases, University calendars, bibliographies, indexes and abstracts. Nigerian newspapers from 1962 to date, newspaper clippings files (post October, 1985), vertical files of reprints and pamphlets are also part of the reference special collections and the Old Western Region Customary Court proceedings from 1900-1960 (Hand written).
- Serials special collections: these include both current and back files of journals.
- Reserve collections: these include past question papers and, multiple copies of textbooks especially those placed on reserve by users or the lecturers for students.
- Recent accessions: these include a selection of the library's new stock displayed for several days before they are added to the main collection on the shelves.

HOL also assures availability and accessibility to local content and promotes dissemination and utilization of knowledge through initiatives like raising awareness on the benefits of open access in the international research communities. Presently, the library is creating awareness through workshops within the University on the role of the library in enhancing the availability of local content online (Asubiojo 2015). As part of services to the academic community, HOL digitizes and uploads local contents for online access. The local content at OAU as specified by the library include published books, theses and dissertations, journal articles, inaugural lectures, seminar papers, newsletters, conference proceedings, convocation lectures, working papers, datasets, past question papers, inventions, annual reports and any other OAU publications.

HOL currently provides online access to the local content through:

- the library website,
- the Institutional Repository (IR), and
- Databases of African Theses and Dissertations (DATAD)

Furthermore, HOL provides services like interlibrary loan, reference and Information services, Current Awareness Services (CAS), Selective Dissemination of Information (SDI), user-education, literature searching, bibliographies compilation, indexing and abstracting, knowledge management, preservation and conservation, bindery, information literacy, internet and archiving. Others include consultancy services like reprography, publication of guides to the library, statistics compilation and maintenance, e-libraries, translations and book editing. HOL is also engaged in several activities to promote library resources and use. Some of these activities include exhibitions, library tours, orientation and library instructional

programmes for students, new arrivals display, library self guides and advocacy.

2.6.3 Library infrastructure

The library has facilities that provide access to learning and research materials in the e-format. HOL subscribes to databases which provide access to eBooks, journal articles, newspapers, scientific and business information. Some of the online databases include SAGE, AJOL, Science Direct, Scopus, OARE, AGORA, JSTOR, BIONE, DATAD and other academic links Directory of Open Access Journals (DOAJ), Pubmed Central, Free articles, Free full texts among others.

HOL has a website which can be accessed through www.library.oauife.edu.ng. The website has links to the various electronic resources. The library has e-Libraries with internet facilities and Wi-Fi for wireless connection to the internet within the library thus providing round the clock access to the e-resources. The library also operates an OPAC, a bibliographic database of the books and other materials available in the library. The OPAC can be accessed directly on the library's website. The IR is also hosted on the library's website. Other infrastructures include audiovisual materials like projectors and digital cameras, photocopying machines, scanning machines, printers, a bindery, and a canteen. There are research commons available only to staff and postgraduate students.

2.6.4 Library staffing

HOL has a mix of relevant personnel for effective and efficient library operations and service delivery. The library personnel are made up of the academic librarians, para-professionals and support staff consisting of technical staff, clerical staff, library assistants and others. The

Librarians' Registration Council of Nigeria (LRCN) requires that the composition of an academic library staff must correspond with the academic programmes offered by the University, the University population, the number of service points and the number of hours services are rendered (LRCN 2014). Based on this, the library staffing includes:

- Academic librarians -23
- Para-professionals – 10
- Other support staff –145

2.7 Concluding remarks

This chapter has presented the review of literature on the concept of eResearch, eResearch components, its implementation in African institutions, challenges of eResearch in Nigeria, the research lifecycle, VREs, an overview of the Fernihough eResearch implementation framework, impact of eResearch on University libraries, collaboration theory and the OAU library to give a better understanding of the research. Research gaps were identified showing the need for guidelines for university libraries to effectively support in eResearch activities. The next chapter discusses the methodology used in this study.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The previous chapters defined the concept of eResearch, its components and the value of adopting eResearch framework in African institutions. The literature review provided information on eResearch and its implementation, challenges of eResearch in Nigerian universities, the research life-cycle, Virtual Research Environments, the theoretical framework for the study and a general overview of the University library in African institutions. This chapter describes the research design and the procedures employed for the study under the following sub-headings:

- Research paradigm
- Research design
- Data collection method
- Data collection tools
- Target population
- Sampling
- Method of data analysis
- Ethical Concerns
- Conclusion/In summary

3.2 Research paradigms

Research paradigms are the different approaches applied to research. According to Rossman and Rallis (1998), research paradigm is a “shared understanding of reality” or an assumption of how things work. The two main approaches to research methodology are quantitative and qualitative but recently, a mixed methods approach emerged when both qualitative and quantitative methods are used (Kumar 2014, p. 30).

A quantitative approach to research involves collection of data that can be quantified or counted through structured and predetermined set of procedures using closed ended survey questionnaire, experiments or structured interviews. It is rooted in the philosophy of rationalism (Kumar 2014, p. 14). The participants have little or no contact with the researcher, emphasis is on the measurement of variables and the objectives of the research, large sample size, validity and reliability of findings, analysis of findings, conclusion and inferences drawn are generalized (Kumar 2014, p. 14; Rossman & Rallis 1998). The approach is used to quantify the effect or systematic variation of one or more variables, known as independent variables, on other variables, known as dependent variables (Ajewole

& Odaibo 2014, p. 59).

The important questions answered by quantitative approach are ‘how many’, ‘how often’ or ‘how significant’.

The use of a quantitative approach in research projects has both advantages and disadvantages (ACET 2013; Kumar 2014, p. 18). Some of the advantages are:

- It is an efficient way of gathering information from a large group.
- Used to quantify extent of variation in a situation.
- Less expensive for large samples.
- Subject variables to statistical procedures.

Some of the disadvantages include:

- Narrow focus in terms of extent of enquiry.
- Respondents are limited to a set of options.
- Uses a rigid or predetermined methodology.

A qualitative approach to research involves the identification and exploration of mutually related variables that give insight into human behaviour, nature, causes of particular problems and the consequences for those affected (Ajewole & Odaibo 2014, p.59). A qualitative approach usually gathers non-numerical information using structured, semi-structured or unstructured interviews or questionnaires often containing open-ended survey questions. Typically the researcher would use discussion groups, observations, personal or focus group interviews, but collecting brainstormed ideas from a group is also used at times (ACET 2013). According to Rossman and Rallis (1998), the hallmark of qualitative research is the in-depth interview where the researcher is interacting face-to-face with the research participants. The emphasis is on a description and narration of feelings, experiences and perceptions rather than measurement. A qualitative approach to research is rooted in the philosophy of empiricism which follows an unstructured approach to research, explores diversity, emphasises a description of feelings, perceptions and experiences and communicates results or findings in a descriptive or narrative manner Kumar (2014, p.14).

Qualitative research generates rich information that encompasses a wide range of philosophical positions, methodological strategies and analytical procedures. In qualitative research, raw data is considered, examined and reformulated to become a research product. Qualitative data include transcripts of interviews, field notes, copies of documents, audio/video recordings, photos and so on. The instruments for qualitative data collection

could be structured or unstructured but the purpose of a qualitative approach is to describe a situation (Archie 2015).

Qualitative approach is good to use when little is known about a situation. Qualitative methods answer the 'what', 'how' or 'why' of a phenomenon. This method can help in generating hypothesis that can be tested by quantitative methods (Brikci & Green 2007).

Using a qualitative approach has some advantages and disadvantages. Some of the advantages of the qualitative approach according to ACET (2013) are:

- Contextual information is gathered during data collection.
- In-depth assessment of the phenomena or situation.
- Respondents can answer the questions freely.
- Examines complex questions.
- Explores new areas of research and generates new theories.

Disadvantages of the qualitative approach include:

- It is more time consuming to schedule interviews, transcribe, analyse and summarise data.
- It is more expensive and labour intensive.
- Open ended questions often generate more data to analyse.

The mixed methods approach is embedded in the strength of both quantitative and qualitative research based upon the fact that some research studies will require combining the two approaches or two or more methods (Kumar 2014, p. 14). Johnson, Onwuegbuzie and Turner (2007, p. 113) defined mixed methods approach to research as

> *"the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes, breadth, depth of understanding and corroboration".*

According to Creswell and Clark (2007, p. 5) combining the use of quantitative and qualitative approaches provides a better understanding of the problem than the use of only one. The mixed methods approach combines the attributes of the qualitative and the quantitative approaches to enhance accuracy. Mixed methods approach is rooted in the belief that the use of more than one method will provide a better and more complete picture of the situation being studied and the ability to provide accurate answers to the research

questions (Kumar 2014, p. 25).

There are advantages and disadvantages of using mixed methods in a research (ACET 2013; Kumar 2014, pp. 28-29). Some of the advantages of using mixed methods approach include:

- Efficiently combines data collection and analysis to provide rich data.
- Less expensive than in-depth qualitative research.
- Better to use for complex research situations.
- Enhances research possibilities.
- Additional research evidence can be collected.

The disadvantages of using mixed methods approach include:

- How to ensure the methods combined complement and not duplicate each other.
- Using more data collection methods imply more work.
- Additional skills are needed.

Research is a search for knowledge, a way of thinking, questioning what is observed, attempting to explore, understanding and explaining observations and finally, drawing conclusions and inferences to enhance practices and the knowledge base (Kothari 2004, p. 18; Kumar 2014, p.2). The view of this study is to establish eResearch activities in the University and propose a guideline for effective library support. It is an imperative to use a research approach and design that is appropriate for the study (Kumar 2014, p. 38).

For this work, it appears that qualitative research is the most appropriate approach to follow. This will enable the researcher to gain a deeper understanding of the field of study, provide more accurate information and ensure the reliability of the findings within the context that the research will be conducted.

3.3 Research Design

According to Thyer (1993, p. 94) and Kumar (2014, p. 123), a research design is a blueprint of the study design to use, how data will be collected, selection of the respondents, analysis of data and how the research findings will be communicated. When following a qualitative research approach, research designs are better used for exploring variations and diversity of social life (Kumar 2014, p. 133). Simply put, a research design is basic plan for empirical research (Bamgboye & Okoruwa 2014, p. 35). The most important research designs available to empirical research are experiments, quasi-experiments, surveys and case studies (Pienaar & van Deventer 2009; Bamgboye & Okoruwa 2014, p. 35).

Experimental study design provides the best way in understanding a problem. An experimental study design always has a control, an experimental group, experimental units for manipulation and interventions or treatments of units by the researcher (Bamgboye & Okoruwa 2014, p. 35). Experimental designs include the after-only experimental design; the before and after experimental design; the control group design; the comparative design; the matched control experimental design; and the placebo design (Kumar 2014, p. 143). Most of these experimental designs are commonly use in the social sciences, humanities, education among others.

Quasi-experiment is similar to experiments but lack some essential features of a real experimental study design (Bamgboye & Okoruwa 2014, p. 38). There are either no control groups or treatments or absence of both. In quasi-experimental design, treatment is given to one group and the other group serves as the control group. The disadvantage of this design is that the researcher is not able to allocate units randomly to either the control or the treatment groups.

Survey design also known as *ex-post facto* design is a research design where the researcher is able to examine the relationship between variables. There is no manipulation or application of treatment because the situation must have occurred in the past hence *ex-post facto,* that is, after the fact (Bamgboye & Okoruwa 2014, p. 39). The researcher can take advantage of the fact that the situations have occurred before the research. Survey could be descriptive or analytical depending on whether the researcher is describing or explaining a situation. Survey could also be a cross-sectional study involving the researcher as a passive observer of a situation in its natural setting and reporting the findings without any treatment or manipulation on the part of the researcher. Survey designs are useful when treatments or manipulation are ethically constrained and situations where the consequences are evident (Bamgboye & Okoruwa 2014, p. 39).

A case study involves treating the total study population as an entity (Kumar 2014, p. 155). A case could be an individual, a group or a community, therefore, to qualify as a case study according to Burns (1997, p. 364) “it must be a bounded system, an entity in itself”. Case study design is based on the assumption that a case can provide insights into situations that are prevalent in the group from where the case is drawn. Case study design is very useful when the focus of a study is to explore and understand areas where little is known (Kumar 2014, p. 155). The advantage of case study is that the study can be very detailed if it is a large sample but the corresponding disadvantage is that it is often impossible to generalise findings (Gilbert 2008, p. 36). Case study provides an in-depth understanding of a case.

Case study design is regarded as the most suitable research design to answer the research questions hence will be used for this study. The researcher is aware of two current collaborative projects currently at the University. The design was considered appropriate in obtaining reliable information for the study from those involved in these two projects. More projects, apart from the two that were originally considered and that qualify as eResearch were also identified during the course of the study.

3.4 Data Collection Methods

Data collection is a crucial stage of any study. According to Ajewole and Odaibo (2014, p. 56) if data collection is superficial, biased or incomplete the data analysis becomes difficult and the research report will be inaccurate and of poor quality. Data collection methods are designed procedures to systematically gather information for the study (Ajewole & Odaibo 2014, p. 56). Information is gathered using two main approaches; primary data from primary sources and secondary data from secondary sources. Primary sources will include information received directly from people when assessing a situation while secondary data are extracted from records (Kumar 2014, pp. 171-172). The data must be collected systematically to be able to answer the research questions. Qualitative data collection methods involve generating data that are primarily in the form of words and not numbers (Brikci and Green 2007). Some common data collection methods used in qualitative research include observations, interviews (structured or semi-structured), focus group discussions and other methods e.g. rapid assessment procedure (RAP), free listing, pilot sort, ranking and life history (biography).

Observation is a way to collect primary data. Succinctly stated by Kumar (2014, p. 173), “it is a purposeful, systematic and selective way of watching and listening to an interaction or phenomenon”. The researcher may or may not take part in the observation. Observation is useful when the interest is more in behaviour and not the perception of people. Observation can give additional and more accurate information about the behaviour of people than questionnaires or interviews (Ajewole & Odaibo 2014, p. 61).

Interview is usually a face to face discussion, interaction or verbal exchange between two or more individuals with a specific purpose (Kumar 2014, pp. 176-177). According to Monette et al. (1986, p. 156), “an interview involves an interviewer reading the questions to respondents and recording their answers”. An interview allows the researcher to capture the perspectives of the project team member providing information about the project early stages, implementation and problems encountered based on the assumption that the information are meaningful and will impact the researcher’s study positively (NSF, 1997). According to Brikci and Green (2007, p. 11), an interview focuses mainly on the researcher’s

data needs and ensures that the findings reflect what the research sets out to achieve in a reproducible, systematic, credible and transparent way. There are three types of interviews: unstructured, semi-structured and structured interview (Kumar 2014, p. 117-118).

Unstructured interviews have complete freedom in terms of content, questions and structure. The researcher is free to ask any question in any format relevant to the study. Questions can be formulated and issues raised on the spur of the moment, in the context of discussion. Unstructured interviews are evolutionary, flexible and open (Kumar 2014, p. 177).

Structured and semi-structured interviews involve asking a predetermined set of questions, using the same wording and order in an interview schedule. The semi-structured interview allows some flexibility but in general an interview schedule as stated by Kumar (2014, p. 178), "is a written list of questions, open-ended or closed, thoroughly pre-tested for standardized wording, meaning and interpretation, prepared for use by an interviewer in a person to person interaction (this maybe face to face, by telephone or by other electronic media)". Structured interviews provide uniform information and require little interviewing skills compared with unstructured interviews. The three types of interview is shown in Figure 3.1 below.

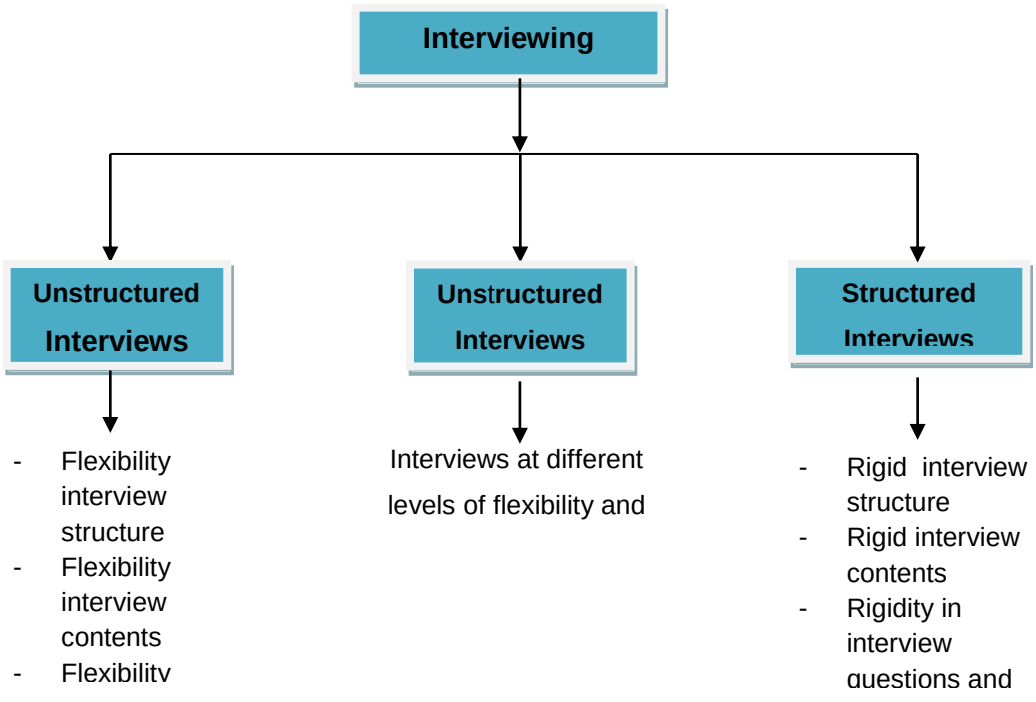

Figure 3.1 Types of interview

(Adapted from Kumar 2014)

Semi-structured interviewing is the data collection method that was employed for this study. Interview was scheduled with the coordinators and other available team members on the projects including one member of the Library Management Committee. All the respondents were contacted through phone calls or physical visits to their offices to inform them about the exercise and also, to gain their consent for the interview. Recording the data becomes necessary so as to have full transcription of the interviews. For this study, the interviews were recorded digitally. Permission to do so was sought from all the respondents at the beginning of the interviews - before the recordings took place.

3.5 Data Collection Tools

The interview schedule was structured containing predetermined questions based upon the secondary research conducted for Chapter 2 of this report. The researcher therefore had a good understanding of the appropriate questions to ask – as advised by several authors (Connaway & Powell 2010, p. 218, Kumar 2014, p. 178). The interview schedule was submitted to experts in the field and also to the Research Committee in the Department for it to be pre-tested for standardised wording, meaning and interpretation. Two interview schedules were prepared namely:

i. Interview Schedule for Researchers (see Appendix B)
ii. Interview Schedule for the Librarian (see Appendix C)

The interview for researchers was scheduled to run for a duration of sixty minutes. It has three sections;

a. eResearch Activities
b. eResearch Skills and Practices
c. Library/ Institutional Support

The interview for the Librarian was scheduled to run for duration of thirty minutes having six main questions. The interview schedule was supported with a digital recorder. This was to ensure that all the corresponding answers to the questions were captured correctly.

3.6 Target Population

The target population of this study were researchers who are involved in performing research in an online digital environment in Obafemi Awolowo University (OAU), Ile-Ife, Nigeria. The overall population of researchers in OAU comprises of one thousand, two hundred and forty-one (1241) academic staff and four thousand, three hundred and fourteen (4314) postgraduate students (OAU 2014). The distribution of the overall researchers in OAU is presented in Tables 3.1 and 3.2.

Table 3.1 Distribution of Academic Staff by Gender, OAU, Ile-Ife, Nigeria

S/N	Faculty	Prof/ Reader		Senior Lecturer/ Senior Research Fellow		Lecturer I & II / Research Fellow I & II		Asst. Lecturer/ Graduate. Asst./ Asst. Research Fellow/Junior Research Fellow		Grand Total
		M	F	M	F	M	M	M	F	
1	Administration	21	0	12	4	19	3	13	5	77
2	Agriculture	23	8	15	5	21	5	13	4	94
3	Arts	29	8	32	2	42	9	28	14	164
4	Basic Medical Sc.	13	4	13	3	20	8	2	0	63
5	Clinical Sciences	41	6	24	10	26	6	0	0	113
6	Dentistry	6	4	5	0	4	0	0	0	19
7	Education	16	6	14	4	18	12	8	7	62
8	Environmental. Design & Management	12	4	20	0	35	6	12	6	23
9	Law	8	1	9	1	12	4	1	1	95
10	Library	2	1	6	3	5	1	1	3	37
11	Pharmacy	13	3	7	1	17	8	11	6	22
12	Sciences	40	2	28	5	40	14	21	15	165
13	Social Sciences	23	8	19	2	35	7	17	11	122
14	Technology	26	3	19	2	35	7	17	11	119
Total										1 241

(Source: OAU 2014)

Table 3.2 Distribution of Post Graduate Students by Gender, OAU, Ile-Ife, Nigeria

S/N	Faculty	M	F
1	Administration	620	286
2	Agriculture	112	52
3	Arts	234	150
4	Basic Medical Science	62	53
5	Clinical Sciences	39	55
6	Dentistry	0	0

7	Education	215	215
8	Environmental Design & Management	225	72
9	Law	144	73
11	Pharmacy	53	23
12	Sciences	465	219
13	Social Sciences	326	143
14	Technology	353	125
Total		2 848	1 466
Grand Total		4 314	

(Source: OAU 2014)

The sample population for this study is only those staff and students involved in various collaborative projects that are performed in an online digital research environment. Initially only two such projects were identified (see 1 and 2 in the Table 3.3) but six more were revealed as the research was conducted. The collaborative projects identified during the course of the study and the various departments involved are shown in Table 3.3.

Table 3.3 Distribution of Identified Collaborative Projects and Departments

S/N	Collaborative Projects	Departments
1	African Chicken Genetic Gains (ACGG)	Animal Science
2	OAU iLab	Electronics and Electrical
3	Dynamics-aerosol-chemistry-cloud interactions in West Africa (DACCIWA)	African Institute for Social Policy Innovation (AISPI)
4	Pharmacometrics	Pharmaceutical Chemistry
5	Scale-up Production and Consumption of Under-Utilised Indigenous Vegetables (UIVs) in West Africa	Soil Science, Agricultural Extension and Management and Sociology
6	Indigenous Livestock Innovation in Africa (ILINOVA)	Animal Science
7	Dairy Chain	Animal Science
8	Global Early Adolescent Study	Institute of Public Health and Sociology

3.7 Sampling

Selecting a sample in a qualitative research is guided by a number of considerations. According to Kumar (2014, p. 228) these would include the ease of accessing potential respondents and whether the respondents could provide the needed information. Sampling is usually defined by the purpose of the research. Qualitative research involves exploring diversity and therefore mostly uses non-probability sampling designs which include purposive or judgemental, expert, accidental and snowball (Kumar 2014, p. 247). To avoid bias and to attain maximum precision (Kumar 2014, p. 40) and since the researcher was not sure of the sample size, two non-probability sampling techniques namely, purposive and snowball sampling were employed for this study.

Purposive sampling is used to describe a phenomena about which little is known and when it involves inter-relationship between variables in a case study (Bamgboye & Okoruwa 2014, p. 52; Kumar 2014, p. 244). It is also known as judgemental sampling is based on the researchers' judgement to choose who best can provide the needed information to achieve the objectives of the study (Bamgboye & Okoruwa 2014, p. 52; Kumar 2014, p. 244). Sampling techniques in qualitative research are mostly purposive (Brikci and Green 2007; Kumar 2014, p. 244). The respondents are chosen because they are likely to generate meaningful information for the particular study. Therefore, the two collaborative projects in the University that the researcher was aware of were selected purposively. A member of the Library Management Committee was also purposively selected. The projects selected were:

- African Chicken Genetic Gains (ACGG)
- OAU iLab

However, in the process of interviewing the respondents involved in those two projects, the researcher was able to use the snowball technique to get information about similar projects and links to some of the people involved with these projects in the University. Snowball sampling technique, which was used in selecting the other projects and respondents for this study according to Kumar (2014, p. 244), is a process of selecting a sample using networks. The contacted respondents were asked if they were aware of any other researchers involve in such projects, these researchers were selected and they became part of the sample. Information was collected from them and they were also asked to identify people on similar projects. This was done until no further projects were identified. This was used in creating network contacts.

It was necessary to use this technique because little was known about the various collaborative projects going on in the University and the fact that the sample was small made it useful. Snowballing is not ideal for large samples (Kumar 2014, p. 244).

3.7 Sample size

The network of contacts created through purposive selection and snowballing made up the sample size for this study. The sample size includes representatives from all the research projects identified. This gave a total of 17 respondents and 1 Library Administrator. The distribution of the sample size is shown in Table 3. 4.

Table 3.4 Distribution of the Sample Size

S/N	Collaborative Projects	Departments	Researchers	
			M	F
1	African Chicken Genetic Gains (ACGG)	Animal Science	3	-
2	OAU iLab	Electronics and Electrical	3	-
3	Dynamics-aerosol-chemistry-cloud interactions in West Africa (DACCIWA)	AISPI	4	-
4	Pharmacometrics	Pharmaceutical Chemistry	1	-
5	Scale-up Production and Consumption of Under-Utilised Indigenous Vegetables (UIVs) in West Africa	Soil Science, Agricultural Extension and Management and Sociology	2	1
6	Indigenous Livestock Innovation in Africa (ILINOVA)	Animal Science	1	-
7	Dairy Chain	Animal Science		
8	Global Early Adolescent Study	Institute of Public Health and Sociology	2	-
9	University Library		-	1

3.8 Method of Data Analysis

The analysis of qualitative data can be done using thematic analysis, descriptive analysis or an in-depth method (Brikci & Green 2007). Qualitative data analysis is based on interpretative philosophy (Archie 2015). It examines the meaningful and symbolic content of the qualitative data. Descriptive analyses range the responses in categories depending on the research questions for which the findings form the basis of interpretation.

Content analysis is used when qualitative data is collected through interview, focus group, observation or document analysis. Content analysis is "...*a procedure for the categorisation of verbal or behavioural data, for purposes of classification, summarisation and tabulation*" (Risenga & Lebese 2014).

Content analysis can be done at a basic level, that is, a descriptive account of what was said with no comments or theories or at an advanced level, that is, an interpretive analysis concerned with what is said as well as the inferences or implications (Risenga & Lebese 2014). For descriptive research, content analysis involves identifying the themes that emerge from the information given by the respondents. This can be done by reporting the responses verbatim and then integrating them into the report to support or contradict the phenomenon under study (Kumar2014, p. 297-298). Another way is to assign codes to the themes and count their frequencies of occurrence. The last way to treat the themes is to combine the former two methods in communicating the findings.

Data gathered through interview for this study was transcribed using the Listen N Write freeware and Microsoft Word. Since editing is not appropriate in qualitative research (Kumar 2014, p. 317), the information gathered was transcribed as they were given by the respondents. These transcriptions were shared with some of the respondents for validation of information to ensure accuracy. Content analysis was used in analysing the research data. The contents of the interview were analysed based on the research questions. Microsoft Office Excel was used for tabulation. Responses of all the respondents were analysed. Inferences were drawn from the analyses and recommendations were made.

The ethical concerns for this study will be addressed as stated in Section 3.9.

3.9 Ethical Concerns

According to Brikci and Green (2007, p. 5), there are four key principles of ethical concern that must be considered:

- Autonomy – respecting the right of others
- Beneficence – doing something good for others

- Non-maleficence –avoid causing harm to others
- Justice – to be fair.

The two ethical issues namely, consent and confidentiality must also be put into consideration (Brikci and Green 2007, p. 5, Kumar 2014, pp. 285-286). Respondents who take part in a study must not be coerced but freely consent to participation.

For this study therefore, the researcher applied for an ethical clearance from the Research Committee of the Department of Information Science which was approved (see Appendix A) and thus, granted permission to collect data for the study from the appropriate authorities. In addition to this, the respondents were contacted on phone while some were visited in their offices to inform them about the study and to schedule a time for the interview. The respondents were given an introductory message and an 'informed consent' form (see Appendices B &C) which they read through and signed at the beginning of each interview. The informed consent form and the introductory message were needed to show the relevance and usefulness of the study to the researchers and to assure them of harmless involvement (Kumar 2014, p. 285). Moreover, the researcher asked and gained the permission of all the respondents to record the interviews with a digital recording device. The confidentiality rather than anonymity of the respondents will be ensured in the course of this study. Since it is unethical to identify individual respondents and the information provided (Kumar 2014, p. 286), no name will be mentioned in the course of this study.

Furthermore, the researcher ensured that appropriate research methodology was used in conducting this study. To be biased is unethical (Kumar 2014, p. 286) therefore to avoid being biased in interpreting the data gathered and reporting the findings; the researcher did not alter any of the information provided and took special care in reporting the responses correctly. Finally, the researcher will ensure that all the information provided by the respondents is used solely for scholarship.

3.10 Conclusion/ In summary

The research approach, research design, data collection methods, data collection tools, target population, sampling, sampling size, method of data analysis and ethical consideration were described in this presentation. The data analysis and findings will be discussed in Chapter 4.

CHAPTER 4: PRESENTATION OF RESEARCH FINDINGS AND DISCUSSION

4.1 Introduction

The research paradigm, research design, data collection method, data collection tools, target population, sampling technique, sample size, method of data analysis and ethical concern adopted for this study were discussed in the previous chapter. Chapter 4 gives the research findings and discussion of the results from the analysis. Findings were grouped in two categories: (1) the point of view of researchers and (2) the point of view of the librarian.

The research findings are presented and discussed based on the research questions and sub-questions as stated in chapter one, section 1.3 of this report.

As mentioned above, the findings are presented and discussed according to the research sub-questions. Specific themes developed to address research questions were logically related to the questions (see Table 4.1). The findings are presented and discussed under the following headings:

- description of the participants,
- eResearch activities in Obafemi Awolowo University,
- skills/practices and the difficulties faced by researchers in Obafemi Awolowo University
- extent of collaboration of researchers in Obafemi Awolowo University with researchers outside Nigeria and resource sharing,
- level of knowledge of eResearch in the library; and finally
- guidelines to develop a plan of action that will ensure effective support of eResearch in the future.

Table 4.1 Overview of the research sub-questions and research findings

S/N	Research Sub-Questions	Research findings reported
1	Are researchers in Obafemi Awolowo University practicing these eResearch activities?	Description of the participants and eResearch activities in Obafemi Awolowo University – Section 4.2 and 4.3
2	What are the eResearch skills possessed by researchers in Obafemi Awolowo University and where are they having difficulties?	Skills/practices of researchers and the challenges faced – Section 4.4
3	To what extent are researchers collaborating with researchers outside Nigeria and how do these collaborations deal with the sharing of resources (e.g. their data and access to literature and equipment)?	Extent of collaboration of researchers in Obafemi Awolowo University with researchers outside Nigeria and resource sharing – Section 4.5
4	What is the level of knowledge, regarding eResearch, in the library?	Level of knowledge of eResearch in the library – Section 4.6
5	What guidelines could be put in place to develop a plan of action that will ensure effective support of eResearch in the future?	Guidelines to be put in place in the library to develop a plan of action that will ensure effective support of eResearch in the future – Section 4.7

4.2 Description of the participants

A total of 16 participants were interviewed for this empirical study. These participants were drawn from University Library, an Institute and six (6) Departments cutting across four (4) Faculties out of the 13 University Faculties. One librarian, a member of the Library Management Committee, was purposively selected for this study and interviewed. The distribution of the participants for the study is shown in Figure 4.1.

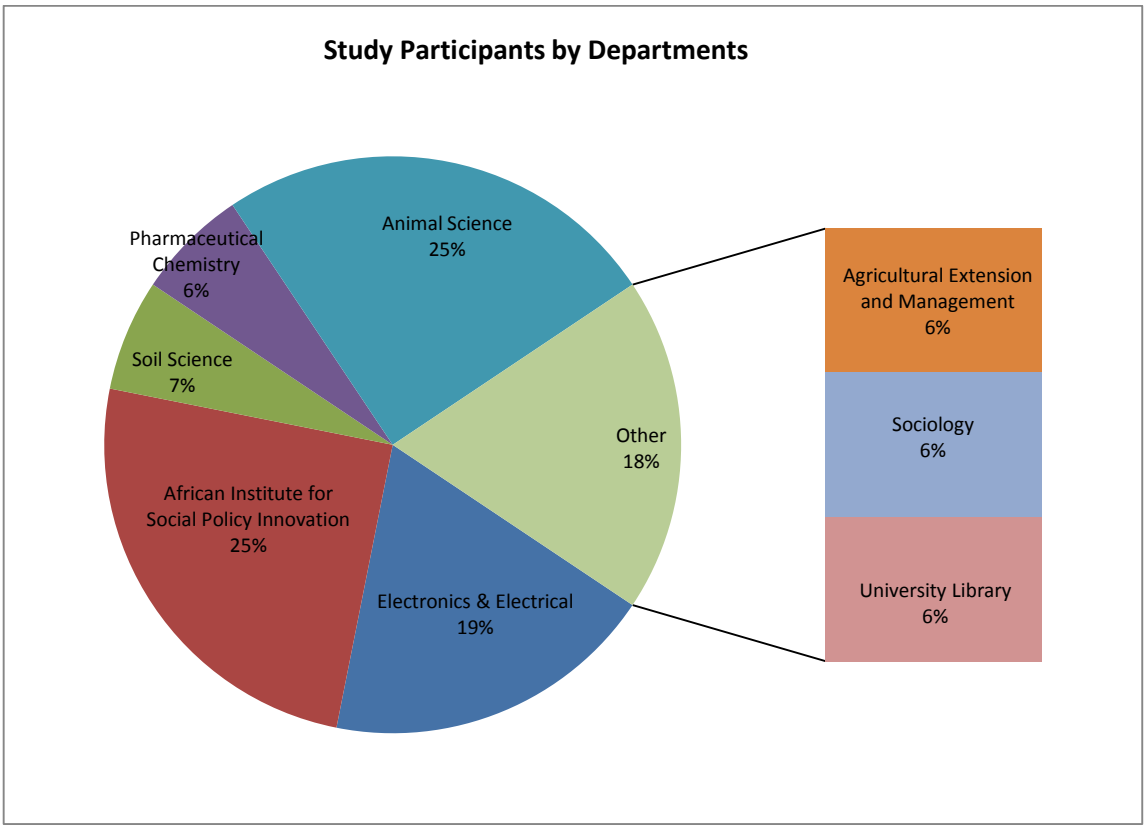

Figure 4.1 Distribution of study participants by departments

The largest number of participants (25% or three respondents each) are associated with the Animal Science department and African Institute of Social Policy Innovation (AISP) while Soil Science, Pharmaceutical Chemistry, Agricultural Extension and Management, Sociology and the library each provided one respondent. Electronics and Electrical Engineering (EEE) Department was represented by two respondents.

The next section will specifically address the research activities reported by the respondents.

4.3 eResearch activities in Obafemi Awolowo University

Eight eResearch activities were identified during the course of this study. These were initially identified through purposive sampling of two (African Chicken Genetic Gains (ACGG) and Obafemi Awolowo University (OAU) iLab) projects. With the assistance of the respondents and using the snowball sampling technique it was then possible to identify six other projects (Dynamics-aerosol-chemistry-cloud interactions in West Africa (DACCIWA), Pharmacometrics, Scale-up Production and Consumption of Under-Utilised Indigenous Vegetables (UIVs) in West Africa, Indigenous Livestock Innovation in Africa (ILINOVA), Dairy Chain and Global Early Adolescent Study). The interviews with the participants showed that these projects were based within the University community as the vast majority of the project participants were from the academic sector.

4.3.1 Knowledge and explanation of eResearch by researchers

Majority (80%) of the researchers have heard the terms 'eResearch' or 'e-Science' or 'Virtual Research' or 'Open Science' before the survey and had a very good understanding of what eResearch is, while the rest did not have prior exposure to the terms before the survey, but really had understanding of what 'e' connotes (electronics), that is, online research. The evidence of this could be seen in the verbatim responses of the researchers:

> *"Yes, e-research is basically when you have a platform somewhere over the Internet, which facilitates some sort of collaboration between researchers".*

> *"No, but I know It means any research that is heavily dependent on internet."*

> *"Yes, opportunity to collaborate, bridging the gap and virtually connecting to do joint projects with colleagues in foreign universities even seminars. Doing experiment remotely for teaching. They can be done online."*

> *"Yes, online research either using virtual resources online to conduct research or by data mining."*

> *"Yes, research interactions that are not face to face but through wireless and technological communication media that may not permit you to see the person you are communicating with."*

> *"Yes, use of ICT facility for doing research involving collaboration and conferences."*

"Yes and no. I may not understand what all of them means but I know 'e' means electronic."

"Yes, synonymous to virtual research, searching or queries done using software or programmes."

"Yes, eResearch or e-Collaboration provides a platform to use the most recent ICT for networking and for collaboration in respect of the science and research agenda."

4.3.1.1Knowledge and explanation of eResearch by the librarian

From the interview with the librarian, it is evident that she understood the terms 'eResearch' or 'e-Science' or 'Virtual Research' or 'Open Science' before this study, however the librarian narrowed eResearch down to include only the library's electronic products. Therefore, there is a need to give library staff more exposure to the concepts and the opportunities created by eResearch. Furthermore, it is also clear from the librarian's response that there the projects themselves have not created any awareness within the University – there is very little awareness of any e-Research activities going on in the University as indicative in the verbatim responses below.

"Yes. Doing research online, using electronic resources or contacting people though electronic resources."

"Not particularly but I know it's been going on. I know the University is ICT-compliant".

The next section addresses the collaborative research projects embarked on by the respondents.

4.3.2 Research projects

All the researchers interviewed were involved in collaborative research project(s) with researchers from Africa and beyond. These collaboration research projects were mostly online-based. At least 50% of these projects were agricultural based, 25% were human and health related while the rest were in the basic sciences (Figure 4.2).

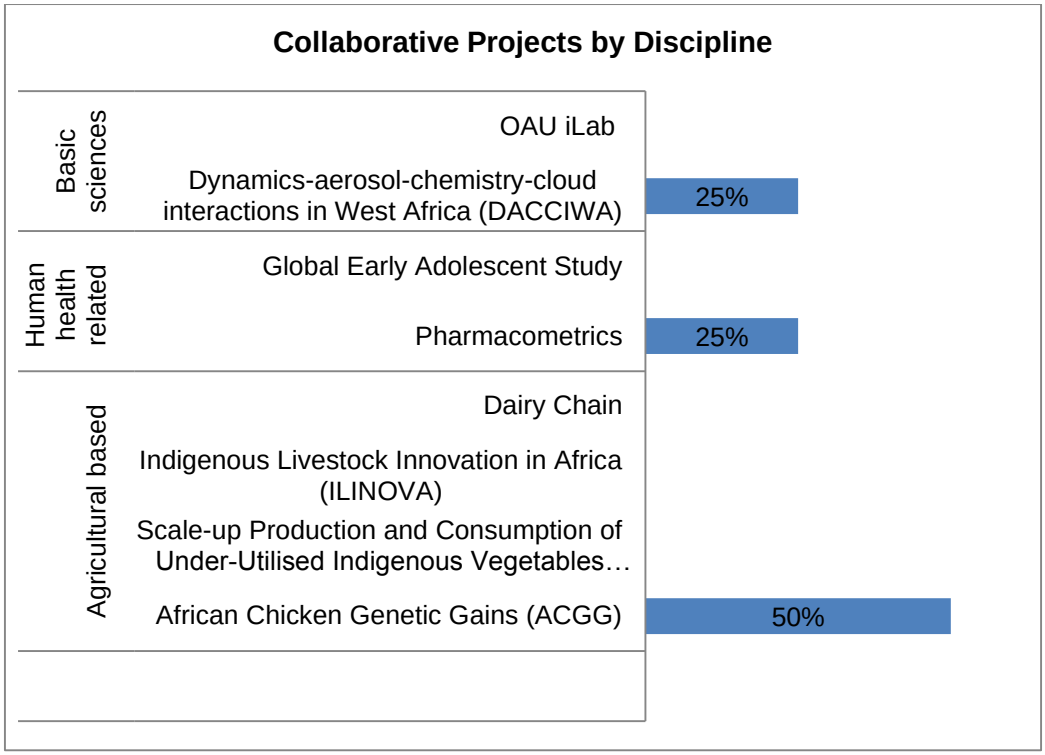

Figure 4.2 Collaborative projects in OAU

More detail, about each of these, is provided below.

4.3.2.1 Obafemi Awolowo University iLab (OAU iLab) project

The Obafemi Awolowo University (OAU) iLab was a collaborative project between Obafemi Awolowo University, Nigeria, a unit in MIT, United States, University of Dar es Salam, Tanzania, University of Makarere, Uganda and Telecom University, Ghana. OAU iLab was sponsored by Carnegie but the lifetime of the project had lapsed. It was sponsored for six years by Carnegies and one year extra support by another organization. Presently there is no external funding but the project continues with team members based at Makarere University, Uganda, the University of Dar es Salam, Tanzania and OAU, Nigeria. An iLab is a system that uses internet to allow students to remotely access laboratory equipment online. The purpose of the project is to allow students to have access to expensive (but also less expensive) equipment online throughout the day. OAU iLab is hosted on the Electronics/Electrical Engineering (EEE) OAU website. OAU iLab was vividly explained in the response from one of the team members;

"An iLab uses the internet to allow students to remotely access laboratory equipment online. One could set up an experiment in OAU and students in University of Lagos could access the results. The internet is a technical aspect of the project. The initial idea was to allow students to have remote access 24/7 to expensive hardware/equipment that was not available in their own environment. For example a Nuclear Physics student in this University could have access to nuclear reactor which is not available in Nigeria. The idea of iLab was initially conceptualized to give students access to expensive equipment that are not available in the University. However, we have expanded the concepts to equipment that may not be expensive but it just is not available. When placed online the equipment is available to students to use at any time of the day for their experiments".

Figure 4.3 OAU iLab hosted on Electronics/Electrical Engineering (EEE) OAU website (Source: http://eee.oauife.edu.ng/)

4.3.2.2 Dynamics aerosol chemistry clouds interactions in West Africa

Dynamics aerosol chemistry clouds interactions in West Africa (DACCIWA) is an experimental project to study the weather system over West Africa. The team members were from 15 institutions -some of which are: Karlsruhe Institute of Technology and the German Space Centre in Germany, Kwame Nkrumah University in Ghana, University of Leads, University of York, University of Reading, Manchester University in the United Kingdom and Obafemi Awolowo University, Nigeria. According to the researchers involved in the project, they were also aware of other members who are from Paris, France and institutions in the

United State of America.

> *"The project is purely an experimental one. We want to study the weather system over West Africa. But basically we are looking at weather systems and pollution. The fact that we are domicile within the region makes us a primary candidate for embarking on these studies."*

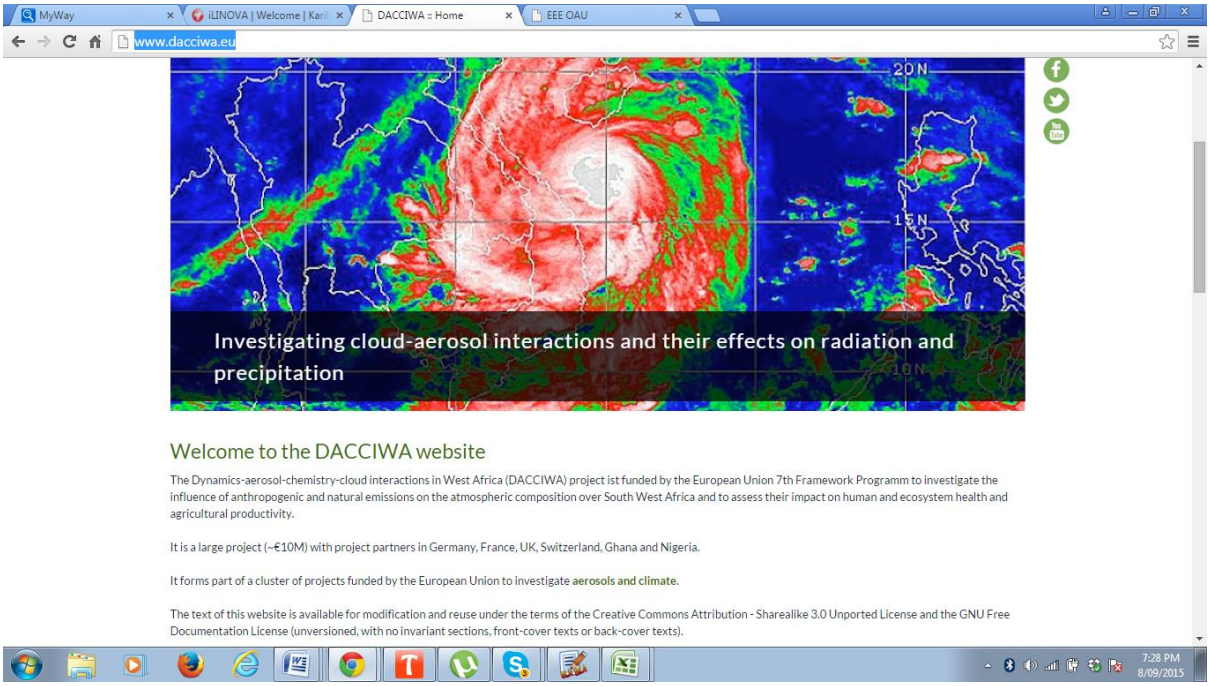

Figure 4.4 DACCIWA website

(Source: http://www.dacciwa.eu/)

4.3.2.3 Scale-up production and consumption of under-utilised indigenous vegetables in West Africa

The project, an international consortium research, is investigating the use of micro-dosing fertilizer to enhance the cultivation of under-utilised indigenous vegetables. The partnership is with OAU, Osun State University, Nigeria, University of Parakou, Benin, University of Manitoba and University of Saskatchewan, Canada. The aim of this consortium research is to bring these vegetables back to the market and thereby empower women and small scale farmers. One special thing about this project is that it has a gender specific focus as is reflected in a team member's response:

"We are collecting some indigenous vegetables in South-Western, Nigeria. We are trying to get them back onto the table, develop agronomy practices and also look for marketing channels, post-harvest and processing techniques for these indigenous vegetables that have almost gone into extinction. Our hope is that the vegetables will come back to the table. We are also trying to use it as a means of empowering women and farmers who dwell in the rural areas, who are engaged in gathering the vegetables and selling them on the farm."

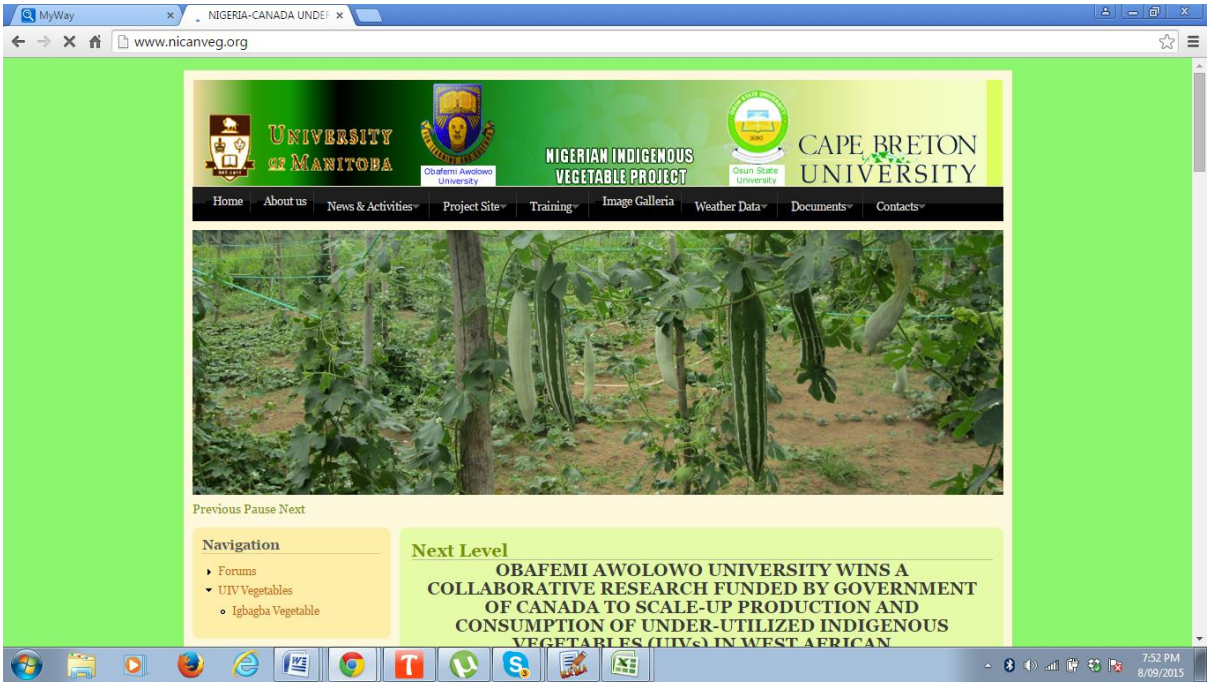

Figure 4.5 UIVs website

(Source: http://www.nicanveg.org/)

4.3.2.4 Global early adolescent study

Global early adolescent study (GEAS) is a partnership between the Johns Hopkins Bloomberg School of Public Health, the World Health Organization (WHO), and the United Nations Population Fund (UNFPA) with researchers in various research institutions from fifteen countries. Some of these institutions include African Population and Health Research Centre (APHRC), Nairobi, Kenya, Assiut University, Assiut, Egypt, Ghent University, International Centre for Reproductive Health, Ghent and Antwerp, Belgium, Obafemi Awolowo University (OAU), Ile-Ife, Nigeria, Population Council, New Delhi, India, Shanghai Institute of Planned Parenthood Research (SIPPR), Shanghai, China, University of Malawi, Blantyre, Malawi, University of St. Andrews, Child and Adolescent Health Research Unit, St. Andrews, Scotland, and University of the Western Cape, Cape Town, South Africa. The goal of GEAS as stated by the researcher is:

"To understand the factors that influence sexual health risks in young people thereafter promoting healthy sexual life with the aim of providing the needed information to promote sexual and reproductive well-being. We hold online bi-weekly meetings to discuss the way forward. It is still at the early stage."

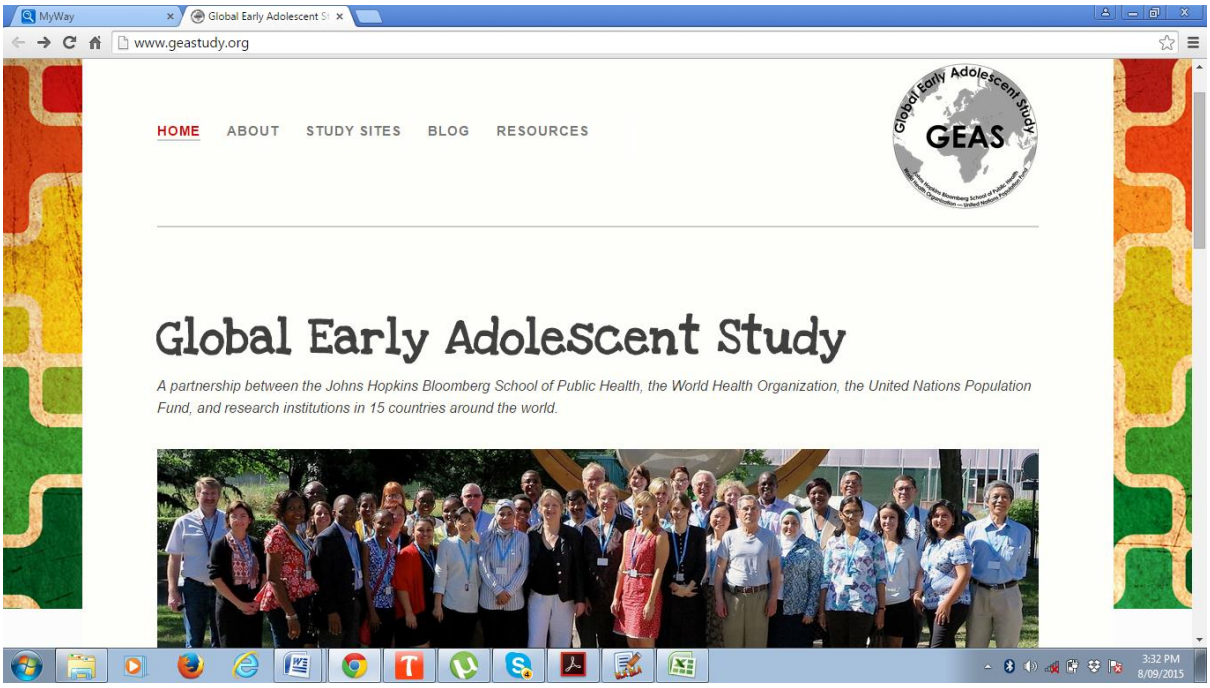

Figure 4.6 GEAS website

(Source: http://www.geastudy.org/)

4.3.2.5 Pharmacometrics

The respondent reported that he collaborates with researchers in University of Manchester and University of Cape Town, South Africa to use the Pharmacometrics method for the quantitative analysis of interactions between drugs and patients. According to the respondent:

"Pharmacometrics is a growing field in Pharmaceutical Sciences. It is concerned with mathematical models and physiology to describe and quantify interactions between xenobiotics and patients. These effects are either good or bad. This technology is new and is not available in Nigeria. I got in contact with my collaborators through a conference. I make use of my collaborators' software cloud and we also interact and exchange ideas on the design of experiments. I interact with them when I want to do analysis."

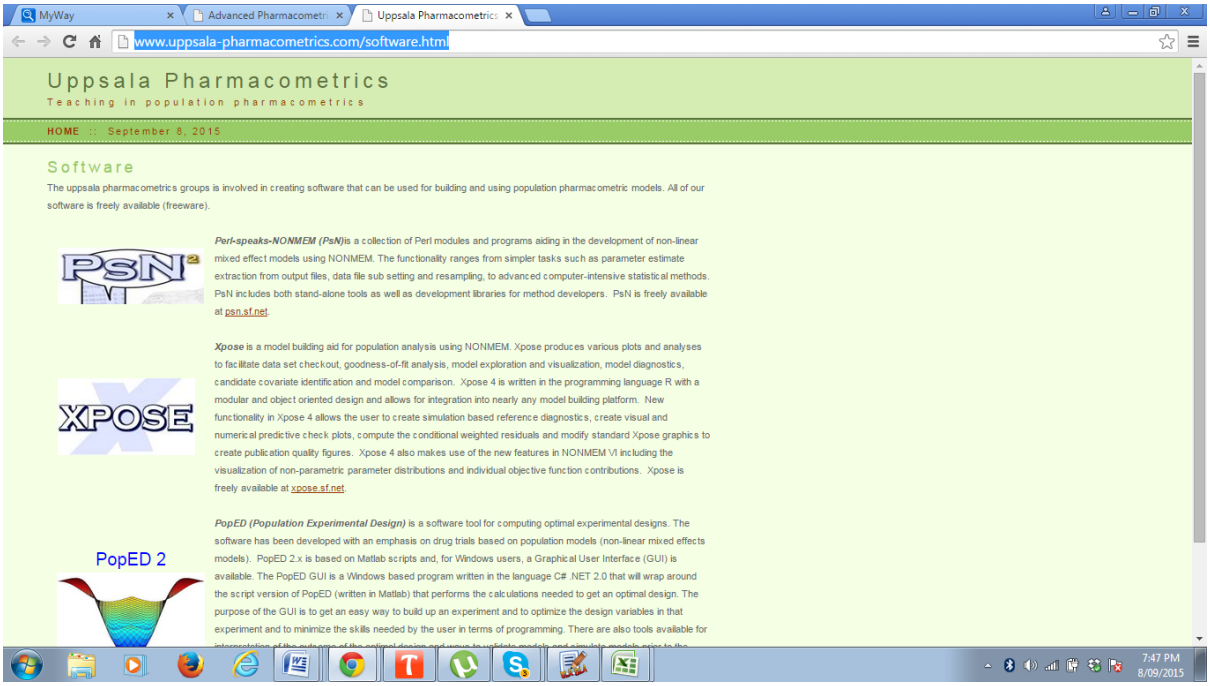

Figure 4.7 Freeware website used by one of the researchers

(Source: http://www.uppsala-pharmacometrics.com/software.html)

At this stage the eResearch project work is still in the infancy stage but it has the potential to grow.

4.3.2.6 African chicken genetic gains

African Chicken Genetic Gains (ACGG) is a 5-year research-for-development (R4D) project with the aim of developing public-private partnerships to deliver genetically improved chickens for smallholders and women in particular. The programme was implemented in Ethiopia in partnership with Nigeria and Tanzania by the International Livestock Research Institute (ILRI). The institutions involved are Ethiopian Institute of Agricultural Research, Ethiopia, Obafemi Awolowo University (OAU), Nigeria, Tanzania Livestock Research Institute, Tanzania, Wageningen University, Netherlands, PICO-Eastern Africa and Koepon. PICO Eastern Africa, Nairobi, Kenya, a non-profit organization, specialises in the provision of quality services for projects funded by organizations like ILRI while Koepon, a Foundation established in 1997 (Koepon 2011) supports various activities of organizations in less developed countries. According to the respondent:

"African Chicken Genetic Gains (ACGG) is a 5-year research-for-development (R4D) partnership being implemented in Ethiopia, Nigeria and Tanzania by the International Livestock Research Institute (ILRI). ACGG aims to develop public-private partnerships that will deliver genetically improved chickens to smallholders, especially women. The aim is to determine the chicken breeds preferred by the women, give them access to the breed's genetic material, increase women smallholder farmers chicken value chain and ensure, at a national scale, access to genetically improved breeds by smallholder farmers."

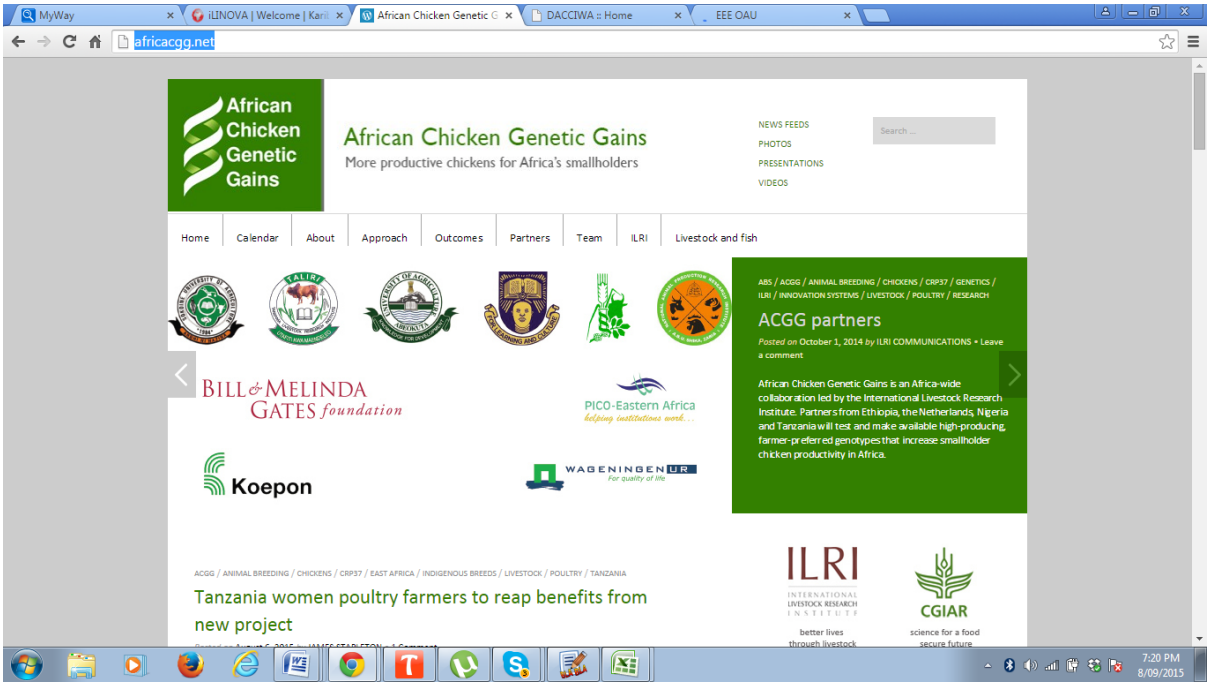

Figure 4.8 ACCG website

(Source: http://africacgg.net/)

4.3.2.7 Indigenous livestock innovation in Africa

ILINOVA project is based on building capacity for sustainable use, development and conservation of indigenous livestock in Kenya, Malawi and Nigeria using science and technology innovations (STI) to improve the management of the indigenous livestock. The programme is intended to strengthen partnership between scientists in Kenya, Malawi and Nigeria. The partners are Egerton University, Kenya, Lilongwe University of Agriculture and Natural Resources, Malawi and Obafemi Awolowo University, Nigeria. According to the respondent;

"The project is to improve the management of indigenous livestock (IL) by building capacity in the creation, update and use of innovative livestock technologies."

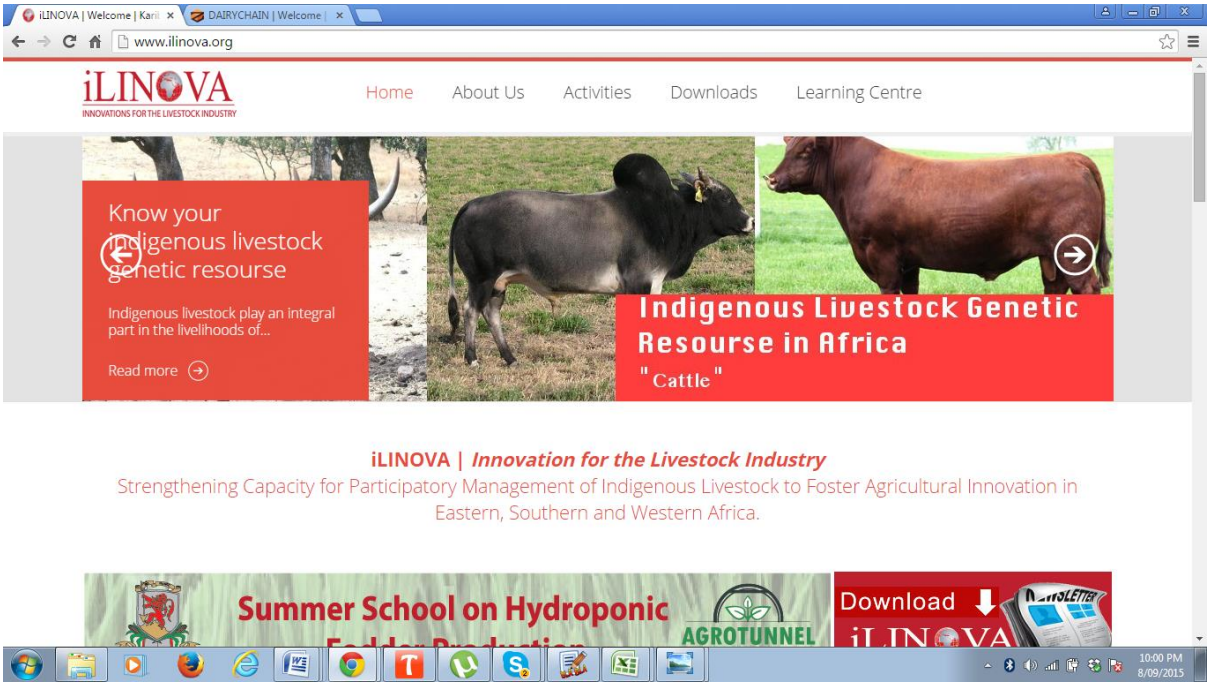

Figure 4.9 ILINOVA website

(Source: http://www.ilinova.org/)

4.3.2.8 Dairy chain

The aims of Dairy Chain programme are to contribute to poverty alleviation, provide income security for smallholders and the disadvantage in the Dairy Value Chain (DVC) and reinforce the exchange and collaborations between higher educational institutions in Eastern and Western Africa. The partners are Egerton University, Kenya, Obafemi Awolowo University and University of Education, Ghana. Explaining, the researcher stated that dairy chain-

> *"is capacity building for higher education in East and West Africa to enhance efficiency in the dairy value chain. In essence, the project looks at how to build capacity in training and in research for dairy productions, dairy and milk products and how we could promote entrepreneurship along the dairy value chain, create jobs for our graduates, create access to the dairy industries where they could have internship, mentorships and employments."*

Figure 4.10 Dairy Chain website

(Source: http://www.dairychain.org/)

From the detail above it is possible to say that Obafemi Awolowo University is involved in a research relationship network that includes 22 countries and 43 institutions. From the Table below it appears that institutions (13) in the European countries are the most active eResearch partners.

Table 4.2 OAU research networks

S/N	Countries	Institutions	Projects
1	Belgium	Ghent University	GEAS
2	Benin	University of Parakou	UIV
3	Canada	University of Manitoba	UIV
		University of Saskatchewan	UIV
4	China	Shanghai Institute of Planned Parenthood Research (SIPPR)	GEAS
5	Egypt	Assiut University	GEAS
6	Ethiopia	Ethiopian Institute of Agricultural Research (EIAR)	ACGG
7	European States	European Centre for Medium-Range Weather Forecasts (ECMWF)	DACCIWA
8	France	Centre National de la Recherche Scientifique (CNRS)	DACCIWA
		University Paris Diderot (UPD)	DACCIWA
		University Blaise Pascal in Clermont-Ferrand II (UBP)	DACCIWA

		University Paul Sabatier Toulouse III (UPS)	DACCIWA
		University Pierre et Marie Curie (UPMC)	DACCIWA
9	Germany	Deutsches Zentrum für Luft- und Raumfahrt (DLR)	DACCIWA
		Karlsruhe Institute of Technology (KIT)	DACCIWA
10	Ghana	University of Education	Dairy Chain
		Kwame Nkrumah University of Science and Technology (KNUST)	DACCIWA
		Telecom University	OAU iLab
11	India	Population Council	GEAS
12	Kenya	Health Research Center (APHRC)	GEAS
		Egerton University	ILINOVA Dairy Chain
		PICO-Eastern Africa, Nairobi	ACGG
13	Malawi	University for Agriculture and Natural Resources	ILINOVA
		University of Malawi	GEAS
14	Netherlands	Animal Breeding and Genomics Centre, Wageningen UR	ACGG
		Koepon Foundation	ACGG
15	Nigeria	Federal University of Agriculture in Abeokuta (FUNAAB)	ACGG
		Osun State University	UIV
16	Scotland	Child and Adolescent Health Research Unit, University of St. Andrews	GEAS
17	South Africa	University of the Western Cape	GEAS
		University of Cape Town	Pharmacometrics
18	Switzerland	Eidgenössische Technische Hochschule Zürich (ETHZ)	DACCIWA
19	Tanzania	Tanzania Livestock Research Institute	ACGG
		University of Dar es Salam	OAU iLab
20	Uganda	Makarere University, Uganda	OAU iLab
21	United Kingdom	St. Andrews University	GEAS
		University of Manchester	Pharmacometrics
		Met Office (MO)	DACCIWA
		The University of Manchester (UNIVMAN)	DACCIWA
		The University of Reading (UREAD)	DACCIWA
		University of York (UNIVYORK) UK	DACCIWA
		University of Leeds (UNIVLEEDS)	DACCIWA
22	United States	MIT	OAU iLab

The next section will address the collaborative research projects embarked on by the respondents.

4.3.3 Research funders and grant conditions

Most (87%) of the research projects were funded by international agencies like International Livestock Research Institute (ILRI), Ethiopia, International Development Research Centre (IDRC), Canada, Novartis, Sweden, World Health Organisation, and the European Union Framework Programme while only 13% were funded by internally generated funds within the University. The involvement of external funding has aided robust and quality research. All the projects funded by international agencies have the condition that the outcome of the research must be published in an open access journal with a high impact factor but still have right to data. This condition enabled the researchers to communicate their findings to a larger audience and create greater visibility for the researchers.

The next section will address the skills/practices and the challenges faced by the researchers.

4.4 Skills/practices of researchers and the challenges faced

All the participants in this study acquired the necessary skills/practices which empowered them to engage or manage this kind of research through postgraduate/post doctoral training, workshops and training sessions, continuous development programmes and personal development. Also for many of them, training on the job was a very pertinent and crucial way for them to acquire the needed skills/practices.

The challenges that the researchers face while carrying out research dependent on an online digital environment are fluctuating internet connectivity and irregular availability of electricity. Further challenges include lack of academic research understanding among the staff, lack of full access to reputable journals, cultural differences, language barriers, Institutional factors such as funding, money ceilings (policies on the amount of money that can be taken by any staff member at a time which at times might not be enough necessitating the researcher to look for an alternative until another processing can be done) and difficulty accessing the funds available for the project effectively.

The next section addresses the extent of collaboration between the researchers.

4.5 Extent of the collaboration between researchers

To understand the extent the Obafemi Awolowo researchers were collaborating with researchers outside Nigeria and to know if these collaborations deal with the sharing of resources (e.g. data, access to literature and equipment), the researchers were asked to

explain what technologies their team used to communicate with each other (4.5.1) , how the team members maintain reference lists and items to read (4.5.2), ensure that all know the deadlines for deliverables (4.5.3), share relevant new information with each other (4.5.4), data collection methods and sharing of their research data (4.5.5) and who is responsible for data analysis (4.5.6). Also, the researchers were asked if they made use of remote research instruments (4.5.7), data visualization tools (4.5.8), computational tools (4.5.9) and if they were aware of/or if the team members used any Open/Free Source software for research (4.5.10). Each of these is discussed in more detail in the following sections.

4.5.1 Technologies used by the researchers

The technologies used by the researchers to communicate with each other include emails (93%), Skype(60%), Dropbox (40%), mobile phones(40%), SharePoint, (40%), GSM network (33%), Online Forums (33%), Wikis (27%),Google drive(20%), Google Docs (20%), Video Conferencing (20%), blogs (13%), ResearchGate (13%), Whatsapp (13%), Facebook groups (7%), Google hangout (7%),Teleconference (audio and chat) (7%) and Yammer (Social Networking Site) (7%). 20% of the researchers use specialized tools peculiar to their project like e-Accounting, NONMEM version 7 and Development Environments for programming. The Virtual Research Environments (VREs) used by 20% of the researchers are established research and education networks and include Ife Research and Educational Network (IfeREN), Nigerian Research and Educational Network (NgREN) and West African Research and Educational Network (WacREN). Some made use of repositories: ILRI Repositories and the vast majority have dedicated websites for the projects. The technologies are presented in Figure 4.11.

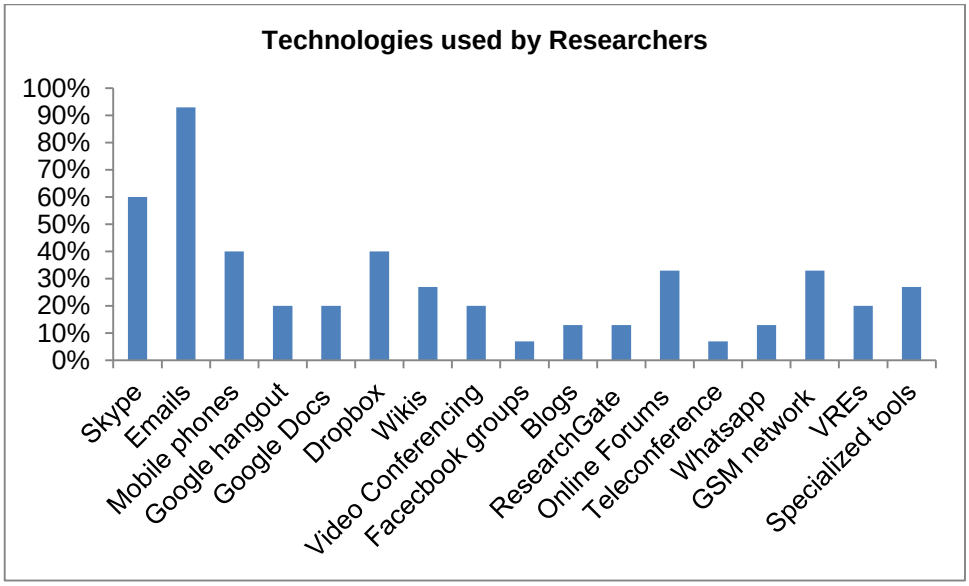

Figure 4.11 Technologies used by the researchers

The ways researchers maintained reference lists and items to read is addressed in the next section.

4.5.2 Maintenance of reference lists and items to read

Most (80%) of the researchers do not have organised ways of maintaining reference lists and items to read. About 20% of the team members maintain reference lists and items to read through dedicated websites like MIT platform, ILRI, ILINOVA and Dairy Chain, 7% use Dropbox, Microsoft Review and Email. Only 14% of the researchers have an organised way of maintaining reference lists and items to read using Mendeley. More than a quarter (27%) of the researchers depended on principal investigators, project managers or coordinators and/or postgraduate students to maintain reference lists and items to read while 14% did not have a way of maintaining reference lists and items to read. The ways researchers maintained reference lists and items to read is presented in Figure 4.12.

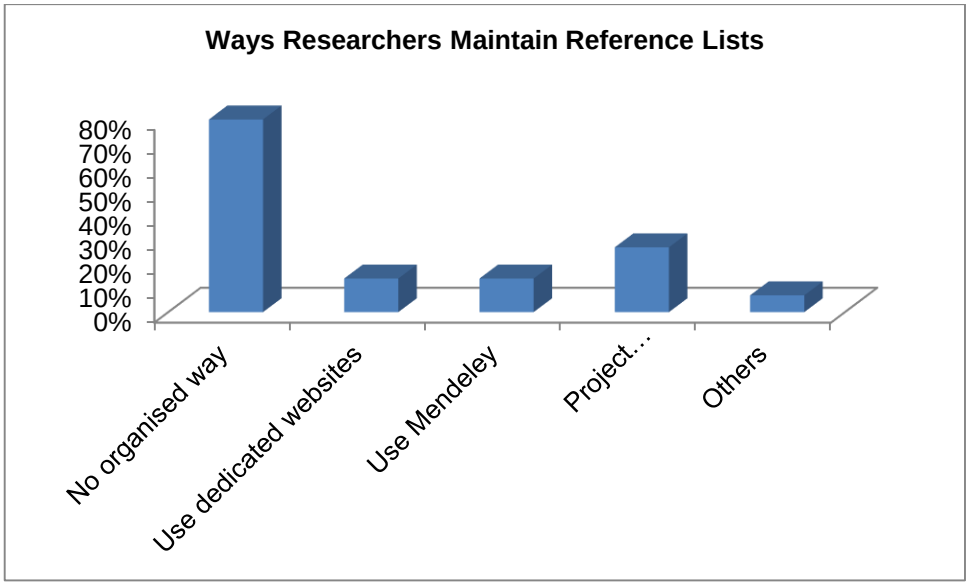

Figure 4.12 Ways researchers maintain reference lists and items to read

4.5.3 Ways of ensuring that all team members know the deadlines for deliverables

All the researchers made use of online technologies to ensure that all team members know the deadlines for deliverables. Most of the researchers used regular online meetings (80%) and a shared calendar (67%) while others used e-mails (27%), Wiki Space (20%), Whatsapp (13%), BBM (13%), Skye (13%), Online newsletters (7%), a Social Network Service (SNS) like Yammer (7%), and Video conferencing (7%) to ensure that all team members meet deadlines for deliverables. Some depended on the principal investigators (7%) and the project managers (7%) to ensure that deadlines for deliverables were met. This is presented in Figure 4.13.

Figure 4.13 Technologies used by team members to know deadline for deliverables

Word clouds visualization (see Figure 4.13) shows the graphical representation of the technologies used by team members to meet deadlines for deliverables. The frequency of use of these technologies by the researchers is shown by the sizes and colours of the words.

4.5.4 Sharing of relevant new information among team members

The respondents used collaborative technologies like group e-mails (73%), peer to peer file sharing like SharePoint (40%), Online Forum (33%), Dropbox (20%), Wiki Space (27%), and Skype (13%) for sharing relevant new information. Others used dedicated websites (7%), BBM (7%) and Whatsapp (7%) for sharing relevant new information with each other. The technologies are graphically shown in Figure 4.14.

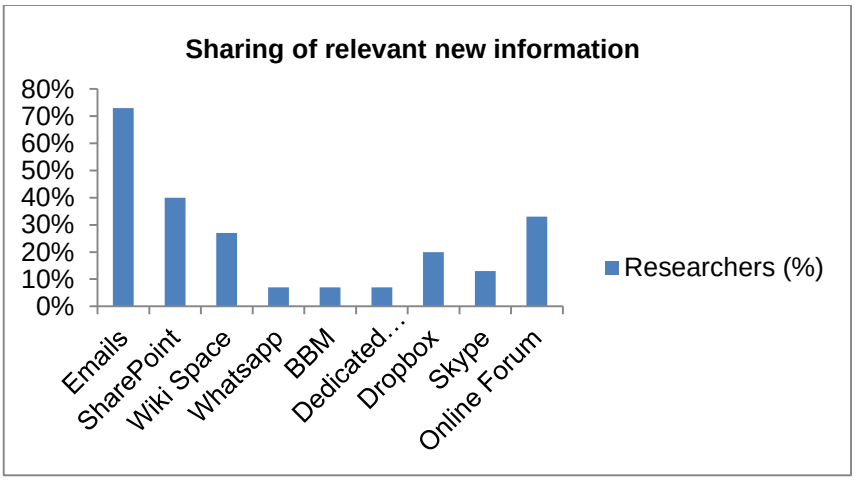

Figure 4.14 Sharing of relevant new information among team members

4.5.5 Data collection methods and sharing of research data

Nearly half (47%) of the researchers collected data face-to-face,40% used Open Data Kit (ODK), (an electronic device), 33% used questionnaires, 27% used data logger (an electronic device), 20% used systems while 7% used focus group discussion (see Figure 4.15).

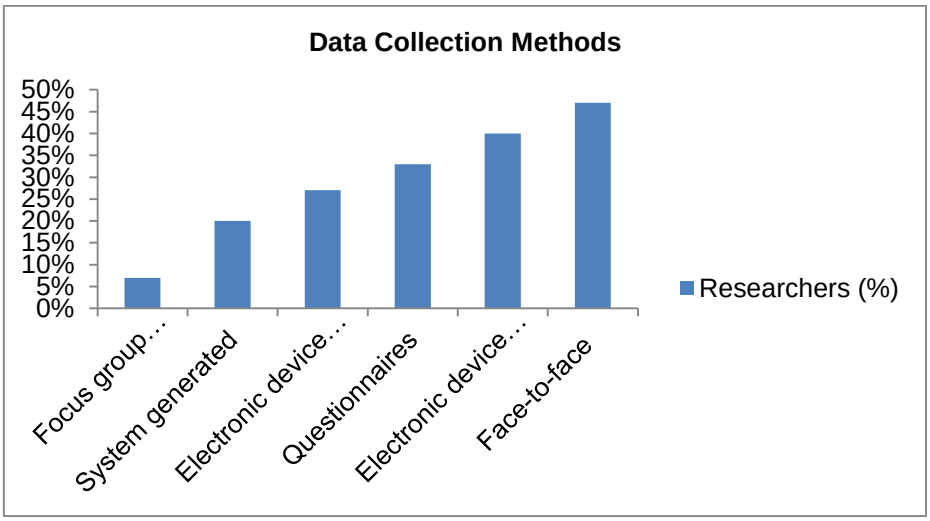

Figure 4.15 Data collection methods

4.5.5.1 Types of data collected

The types of data used by the researchers included baseline information (40%), on-station research data (40%), on-farm data atmospheric data (40%), system generated data (27%), agronomy data (20%), laboratory analysis data (7%) and blood sample (7%) (see Figure 4.16). All the respondents have documented data management practices and were responsible for the storage of their own data. Some of the data was stored on websites or making use of cloud services.

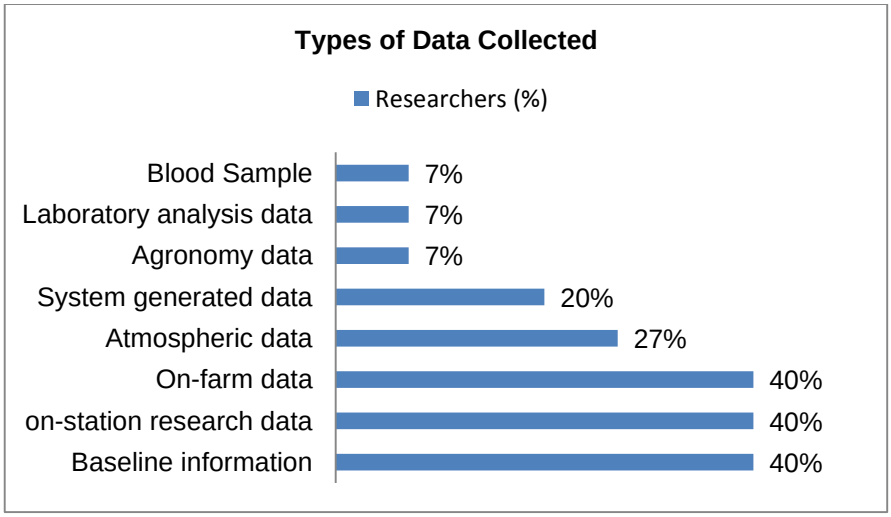

Figure 4.16 Types of data collected

4.5.5.2 Sharing of research data

Less than half (33%) of the researchers stated that the research data was personal to them but had a data sharing policy to use if there was ever a need for them to share data. 20% of the researchers uploaded their research data into a central pool, made their data available in the cloud which could be accessed and used by anyone with permission to do so or share the data using emails or MIT Wiki. Only a few (7%) of the researchers used the project website to share data (see Figure 4.17).

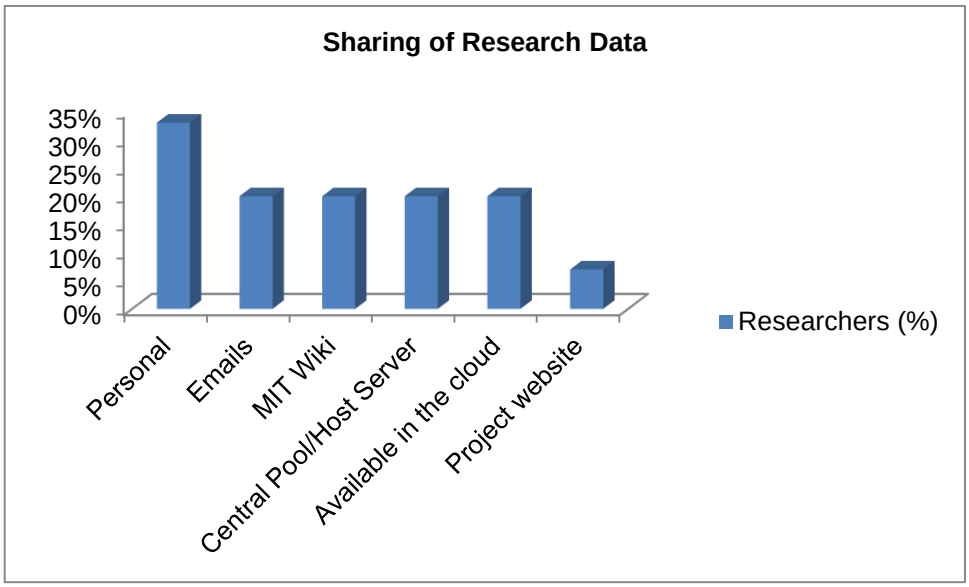

Figure 4.17 Sharing of research data

4.5.5.3 Data formats

Most (77%) of the data were collected in Microsoft Excel formats. Others are in ASCII (27%), plain text (20%), R files (13%), Maps (13%), other formats like pictures (13%) and ACCESS (7%) (see Figure 4.18).

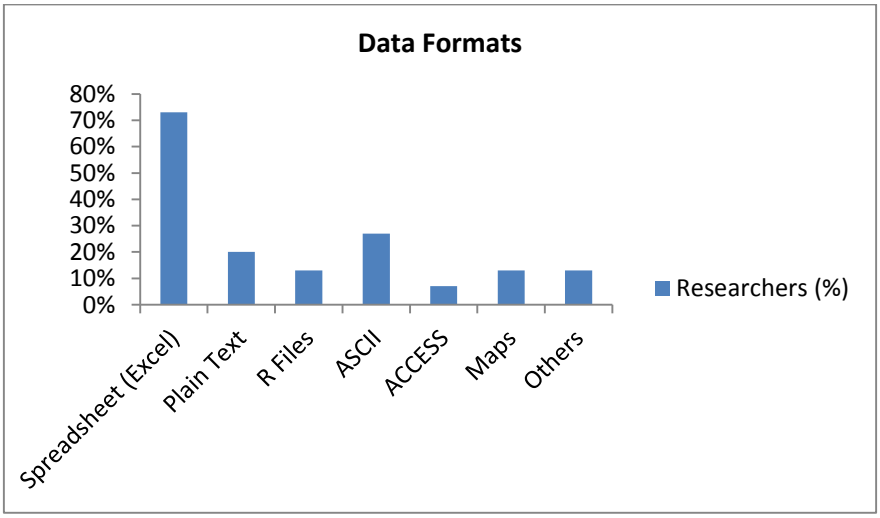

Figure 4.18 Data formats

4.5.6 Data analysis responsibility

Almost half (40%) of the researchers were personally responsible for their data analysis. Students were responsible for analysing 25% of the projects while 13% of the projects had team members dedicated to the task. Few (7%) of the researchers used Excel, 27% used SPSS, 7% used ANOVA, MATLAB and STELLA, 20% used SAS, ATLAS ti, R, STRATA and ODK for analysis. 27% used ORIGIN and 7% used NONMEM (specialized software analysis which is discipline based) and 14% used customised software for analysis because of the nature of the work they did. The library will have to look into the different tools available for data analysis since it is obvious that the researchers are all vast in the use of these tools. The library cannot ignore this fact.

4.5.7 Use of remote research instruments

More than half (53%) of the researchers made use of remote research instruments. For example, OAU iLab uses remote instrument on MIT Web Lab. The Web Lab is an online laboratory on MIT website that allows users to have access to remote instruments for analysis. MIT website has an interface for students to make use of remote instruments like the parameter analyser. The student's just need to create an account with MIT through OAU channel, click MIT link button on OAU iLab interface on the EEE website, specify the settings for the analysis and the device runs in the laboratory where it is located, generates results which are sent to the students. The results can be plotted using excel or any other application. Also, Open Data Kit (ODK) used by some of the researchers for quantitative data collection is a tool which enables the researcher to build a data collection form and collect data using mobile devices. ODK uses Global Positioning System (GPS), a space-based navigation system to provide information on location and time anywhere and in any weather conditions which enables real time uploading or corrections to be made on data. The collected data is sent to a server where it is aggregated into useful formats.

4.5.8 Use of data visualization tools

The data visualization tools used by all the researchers included Google maps (40%), Google live (27%), within C# programme (20%),GPS on ODK (20%), Yes, but not stand alone (13%), GIS (13%), Photo editing suite (13%), Atlas ti (7%) and ADEPT (7%). ADEPT, a free visualization software from the World Bank developed in collaboration with the Bill and Melinda Gate Foundation is used for livestock production system data and also makes provision for household dynamics. Most of the statistical packages used by the researchers have options for data visualization. This implies that the library will have to do an audit of all these tools, learn about them and interact with users on how to improve on the usage of the tools.

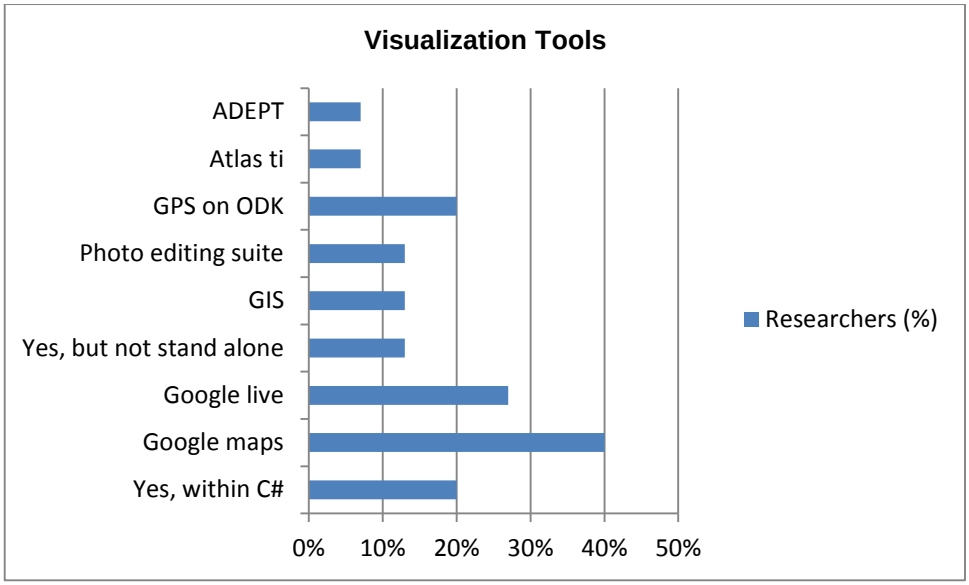

Figure 4.19 Visualization tools

4.5.9 Use of computational tools

A substantial number (53%) of the researchers made use of computational tools. ATLAS ti was used by 13% of the researcher for modelling soil and environmental quality resulting from different methods of cultivation. The outcome of this modelling assists the researchers to pick and select the best agricultural practices. MATLAB was used by some of the researchers for analysis while some of the researchers (20%) wrote programmes using FORTRAN to customise data analysis to suit the particular project. NONMEM version 7 was also used by one of the researchers as a tool that combined mathematical modelling with computational tools to elucidate pharmacokinetic parameters from sparse data. The implication of this is that the library must proactively look into all these tools to be able to provide support for the researchers.

4.5.10 Awareness of or use of open/free source software

73% of the researchers were aware of Open/Free Source software that could be used for their research. Some used open source relational database management system like MySQL, programming language like PHP, high level programming language for general purposes like Python, and R, computational software like MATLAB and OCTAVE, open/free source operating system (OS) like LINUX, and quantitative analysis software like ODK and SPSS. Most of these are linked to the various disciplines of the researchers as a preferred tool. Nevertheless, almost half (47%) of the researchers prefer proprietary software to the open/free source software explaining that most of the Open/Free Source software were still in various stages of development and therefore there was no guarantee that their data would be secured. For example, the researchers did not use the free version of ODK. This implies that

the library must be prepared to subscribe at an institutional level to this software in order to be able to support the research activities of these researchers.

4.6 Level of knowledge of eResearch in the library

To know the level of knowledge, regarding eResearch, in the library, the librarian was asked if the library was providing support in the following phases of eResearch (as described in Chapter 2, section 2.3.1). The responses were as follows:

- Planning phase - The library had trainings for staff and students

  "We had trainings for staff and students. We organised training sessions on Science Direct, SAGE, ITOCA, TEAL and AGORA"
- Data capturing/creation phase - The library has done little to support the data capturing and creation phase of eResearch.
- Data storage phase - The library does not currently provide support for the data storage phase of eResearch.
- Data management phase - Library does have support for the data management phase of eResearch. This was indicated in the respond of the respondent:

  "Yes, we did that recently. We organised trainings on Scopus and Mendeley. We have also started IR in the library and I know the University has Google Scholar."
- Data collection and analysis tools & techniques - The library does not currently provide support for data collection, analysis tools and techniques.
- Visualization of data - The library does not currently support the visualization of data process.
- Sharing data - The library is able to provide support for data sharing by curating the data and disseminating through the institutional repository.

4.7 Guidelines to ensure effective support of eResearch in the future

Seeking for inputs on the guidelines the library should put in place to develop a plan of action that will ensure effective support of eResearch in the future, the respondents were asked how they think the library could support online digital research activities, what would happen to the research data and reports after project closure and if they had asked the library for assistance for their research activities in online environments. Respondents identified four areas of interest/ support.

4.7.1 Support needed from the library for online digital research activities

The researchers mentioned the following as possible ways in which the library could support their online digital research activities: dissemination of information on eResearch resources available in the library, regular training and workshops on academic research, subscription to reputable journals, documentation of ongoing projects and links to the projects' own websites from the library's website, subscription to online communication tools and to make them available to members of staff through the library's website, develop a data storage policy for research groups, and train students and staff on how to avoid plagiarism. All the researchers agreed that it would be helpful if they could use their journal articles directly from their workspace and get assistance with information overload. The researchers also thought that guidance on predatory publishing and training on the use of online communication tools would be very useful.

4.7.2 Research data and reports after project closure

The researchers were asked what would happen to their research data and reports after project closure. All the researchers would publish their research data and reports in open access, peer reviewed journals. All of the researchers are major stakeholders in their projects, and thus the outputs of their projects will not be transferred to the funders or one of the research partners but rather, the research funders and partners would be acknowledged. However, the reports and outputs would be made available and accessible on the dedicated websites of each of the projects and through open access journals. The research data are personal to all the researchers, therefore whoever wants to use the research data from all the projects will need to ask for permission from the researchers to do so. Researchers themselves did not understand that their technology would go obsolete and their data will not be usable after a number of years if the data were not properly curated.

4.7.3 Request for library assistance

The researchers were asked if they had asked the library for assistance. Only 2(13%) of the researchers had asked the library for assistance while more than half, 9(60%) had not. 4(27%) of the researchers were preparing a summary of the research data collected over the years and were willing to give them to the library to capture as part of their online information resources. There was no certainty that the library would be able to rescue all the data! It is a concern that most of the respondents had not been to the library to ask for assistance for their research projects.

4.7.4 Library plans to support researchers in all the eResearch phases

It was stated that the library had plans to tap into new technologies, thus providing support for researchers in all the phases of eResearch. The library can effectively support online digital research activities by providing platform for e-resources and having good collaboration with the researchers. It is accepted that the library, being the heart of the University, is to provide, store and make information accessible to the research community. Library management is willing to implement a guideline for the library to effectively support eResearch activities in the University.

4.8 Discussion

This chapter has captured and analysed the findings about eResearch activities and the need for effective library support. Specifically, this chapter analysed the eResearch activities in Obafemi Awolowo University, the skills/practices of researchers and the challenges faced, the extent of collaboration of researchers in Obafemi Awolowo University with researchers outside Nigeria and resource sharing, level of knowledge of eResearch in the library and how the library can support online digital research activities in Obafemi Awolowo University.

The sample was not representative of researchers in Obafemi Awolowo University but purposively selected few based on their online research activities and therefore, the findings cannot be generalized to the entire population (Bamgboye & Okoruwa 2014, p. 52; Kumar 2014, p. 244). Notwithstanding, the sample was large for a case study and well represented the researchers that are involved in eResearch activities in Obafemi Awolowo University. Therefore, the findings of this descriptive study are primarily informative about what could be regarded as eResearch activities and how the library could effectively support and enable these activities at Obafemi Awolowo University.

Even though not all the researchers have heard about the terms ‘eResearch’, ‘e-Science’, ‘Virtual Research’ or ‘Open Science’ (section 4.3.1), they all have a good understanding of what eResearch is by practise and appear to have a full grasp of the concept. This is in line with the literature review in Chapter 2 section 2.4**.**Earlier studies (Markauskaite et al. 2012, Markauskaite 2011; Whitmire 2013; Simons & Searie 2014), indicate that there is a general awareness of eResearch notwithstanding the terminologies used. Similar to what was reported by Khatibi and Montazer (2012, p. 65), it is evident that the researchers in this study were aware of the full potential of ICT and how it can enhance research activities in online digital environments. On the other hand, the library appears to be looking at eResearch parochially, limiting it to use of electronic resources in research. This indicates that the library may have limited knowledge of the concept and it will be difficult to provide the needed support for the researchers. Therefore, the library needs to explore new services,

roles, research support/partnerships and work collaboratively with the researchers (Heijne 2009; Leggott, Moses and Hooper 2014). In summary, the librarians need to know more about eResearch (Simons & Searie 2014).

It is worthy to note that the researchers who participated in this study engaged in quality collaboration within Africa and beyond (see Table 4.2 in section 4.3). They are involved in various projects in partnership with other team members in different fields and institutions all over the world. This shows that eResearch activities are going on in OAU, thus, implementation of eResearch cannot be ignored. The online research projects are spread over various academic disciplines such as Agricultural Science, Human Health, Pharmaceutical Science, Engineering and basic sciences. This gave an indication that most of the eResearch activities going on are domiciled in natural/ physical science related disciplines. Although, it will be difficult to make such assertion with the small number of participants used in this study this finding is aligned with literature that has shown that there is more collaboration between researchers in physical sciences than between those in the social sciences and humanities (Kumar 2014, p. 244). Also, as was indicated in Chapter 2, section 2.4 - experimental based disciplines tend to collaborate more than theoretical based disciplines (Markauskaite, L., et al. 2012).

A significant proportion of the projects (section 4.3.3) were internationally funded with extensive international collaboration on the projects - indicating a breakthrough to one of the pertinent issues raised by the British Academy in 2008;

> *"International collaboration is essential to producing good research in any country; this is particularly true of Nigeria where the level of existing participation in international research is much lower. The role for donors may depend as much on creating and enabling good connections to international research networks, and encouraging the sharing of knowledge and experience, as it does on funding for research projects."* (British Academy 2008).

In addition most of the funders required the dissemination of the outputs of the research projects by publishing in reputable but open access journals to ensure accessibility. This would ensure additional exposure for the Nigerian research capability.

There is currently no structured training on the practices and principles of eResearch as presented in section 4.4. Most of the researchers gained their skills and practices through personal development while some had opportunities of going for post doctoral studies, workshops, training, continuous development programmes outside the country. This clearly shows that most of the researchers just have to pick up the skills for eResearch with practise. It is a field that is just evolving and is not included in the curriculum of the Postgraduate training. Therefore, there is the need to advocate the inclusion of eResearch methodology in the postgraduate programme and the library could assist with the training programme. The lack of training is not unique to OAU as concerns for researchers' formal training in eResearch have been raised in an earlier study (Arcila, Piñuel & Calderín 2013).

The implementation of eResearch by the researchers that were interviewed in this study was limited by various challenges (section 4.3.3). The challenges included power/ electricity, internet connectivity and funding which are not unusual in developing countries especially Nigeria where ICT and power infrastructure are major challenges (Baro & Asaba 2010; Abubakar 2011). However, the researchers devised some alternative means such as having several means for connectivity like mobile networks and Wi-Fi, use of inverter, solar power, power banks and other sources of generating electricity to mitigate these challenges. One other challenge that was also mentioned that is peculiar is the sustainability of research funding after the initial funder relationship has lapsed. There is funding gap in Nigeria and some African institutions where the governments are not funding research and universities are mostly dependent on external funders. Odia and Omofonmwan (2013) in a previous study that examined the constrains to research and development sector in Nigeria stated on a positive note that researchers in Nigeria are looking forward to a better infrastructure and research facilities that can compete with that of their international peers. Odia and Omofonmwan thus called on the government and other relevant stakeholders to attend to these aspirations so as to attain the development goals of the nation.

The researchers in this study extensively collaborated with researchers in universities and multinational organizations from other parts of the world including Africa, Canada, China, Europe, United Kingdom, and the United States of America. The collaboration was well structured and of high quality which could be seen as an indication of the level of expertise of the researchers in OAU. Although there were other communication tools, as shown in Figure 4.9, the researchers primarily made use of Emails and Skype to communicate with each other. However, there were specialized tools, typical to each discipline, which the researchers made use of. The internet provided a networked infrastructure for collaborative

technologies used by team members to communicate with each other (Harley & Blismas 2010). This trend showed that the technologies used by the researchers for eResearch activities were linked to their areas of specialization where some cut across all disciplines. Researchers in OAU made use of VRE infrastructure as identified in section 4.5.1. It was also noted that the researchers did not have organised ways of maintaining reference lists and items to read (section 4.5.2). This might be due to the fact that they did not receive any formal training in managing their reference sources. This is a matter that should definitely be addressed by librarians as this could be regarded as a standard information literacy skill. Mendeley, one of the web-based bibliographic tools used by some of the researchers to maintain reference lists and items to read, allows the researchers to share resources and references online (Brunvand & Duran 2010). The library should consider Mendeley as the standard tool to use when teaching researchers how to maintain reading lists.

The researchers made use of shared calendar, emails, wiki-space and regular online meetings as ways of ensuring that all the team members knew the deadlines for deliverables (section 4.5.3). These are necessary for effective collaboration among the team members since they are not in the same geographical locations and neither do they report into the same governance structure. The researchers also use tools like SharePoint, online forum, Dropbox, wiki space and dedicated website to share relevant information (section 4.5.4). The tools used by the researchers are among those stated by Thomas (2011, p. 38) that facilitate effective collaboration and communication among researchers irrespective of the location. Although the researchers used discipline based data analysis software like NOMEM and ORIGIN, they also used general ones like R file, STRATA, Atlas ti, ANOVA, SPSS among others (section, 4.5.6). All these tools are incorporated in Fernihough's eResearch framework (Fernihough 2011)

A few of the researchers, that made use of remote research instruments (section 4.5.7), used the instruments mainly for analysis. The collaboration service with other universities and organizations made it possible for them to have access to instruments and equipment which are too expensive for the University to purchase (Thomas 2011, p. 39). For example, as a result of this accessibility to MIT equipment, OAU researchers have been able to take giant leaps in their research activities. In addition, advanced technology like ODK used by the researchers, which according to them is only available in OAU, made data simulation possible. Data collection is done using the e-questionnaire programmed on it. ODK also enables real time communication between the researchers and research assistants collecting data on the field.

The researchers used various data visualization and computational tools (sections 4.5.8 and 4.5.9).The use of open/free source software for research was determined by their discipline. Most researchers were still sceptical regarding the use of open/free software due to the fear of loss of data to unsuspected online pirates thus preferring the proprietary software. These observations are in line with an earlier study (Arcila, Piñuel & Calderín 2013). This implies that the library must proactively look into all these tools to be able to provide support for the researchers. The library will have to carry out an audit of all these tools, learn about them and interact with users on how to improve on the usage of the tools and be prepared to subscribe to the software.

Research data management activities of the researchers (section 4.5.5) were reflected in most of the projects and data were generated through experiments, computational models, data mining, datasets, data visualization and the face-to-face collection of data. As was reported, research data are collected or generated as primary sources of information for the research projects and are also required to validate research findings (Thomas 2011, p. 38). Majority of the researchers had structured ways of sharing research data generated or collected. Sharing data is the core of eResearch collaboration (Markauskaite et al. 2012). The researchers quite understood how to store and retrieve their data. Wolski and Richardson (2015) asserts that most researchers exercise good practices in research data management because they are making use of tools and technologies that are readily available to their research discipline through the internet. However, as stated by some of the researchers, there could be improvement in the management of the data - especially in the archiving of data. There were requests made to the library by concerned researchers, to assist with the research data management process. The request is not unique to OAU - as was reported in Chapter 2, section 2.4 the library could collaborate with the researchers to archive research data (MacColl & Michael 2011). An earlier study has highlighted the need for awareness of data stewardship, a role that must be taken seriously by the library (Shearer, Argáez, & Swanson 2010).

The researchers were also involved in scholarly communications, a part of eResearch activities (section 4.7). They published their results and reports electronically in reputable open access journals. They also disseminated their outputs through the project websites and the funders' repositories. However, the researchers did not upload any of their publications to the University's institutional repository due to lack of awareness of the process to do so. Although some were in the planning process while others requested the assistance of the library.

Based on the phases of standard research process (van Deventer 2015), Hezekiah Oluwasanmi Library (HOL) did not substantially support all the phases. Interaction with the librarian revealed that the library only had support for the planning phase of eResearch. Various trainings and workshops were organised by the library in the past for the researchers. However, there are plans to expand the library support for the other phases of the eResearch process. Libraries, especially academic libraries have had it as part of their mission statement to provide support for research activities in universities (Garner 2006), therefore HOL needs to step up the eResearch support platform by providing support for the other phases.

HOL has been creating awareness about the institutional repository (IR), encouraging researchers to populate the IR by self-archiving their publications or sending the softcopy to the library. However, HOL will need to intensify the awareness to ensure positive response from the researcher. Furthermore, using the guidance provided by van Deventer (2015) HOL should provide support for;

- the discovery phase of research, by providing access to bibliographic tools and electronic journal platforms, amongst other things,
- the research in action phase, in some aspects like digitisation, information overload, data analysis and so on,
- the dissemination phase, by providing institutional repositories, peer review and journal impact factor; and lastly the project closure phase, providing advice on long term preservation, metadata and repackaging of research outputs and products for re-use.

The points above were expressed by researchers who requested HOL to have a structured eResearch support programme in the library. Disseminating information about e-resource materials in the library could be useful to online research. Also the researchers want HOL to engage them through regular training and workshops and wish for journal subscriptions that will be accessible via the library website. These aspects should be easy to address as the requirements are aligned with the existing library mandate.

Linking from the library web site to the various ongoing research projects' websites is also a relatively quick and easy task to do. The request does however need to be considered carefully as the act may set a precedent. The library should also establish a data storage policy and put storage in place for the researchers. The library should guide researchers on archiving of data after project closure for future retrieval and use.

Overall, it is evident that eResearch activities are already established at the University. According to Thomas (2011), eResearch incorporates activities and services such as collaboration technologies, research data management, scholarly communication, computation, visualization, data collection and analysis. Proof of all these activities was uncovered as part of the study.

It is of concern that the researchers have not been able to appreciate the roles that the library can play in supporting their online research activities. The researchers still look at the library from the traditional perspectives. To change this view however, the library must proactively initiate a programme to change the perceptions of the researchers. Survey of the various online research projects at the University could be engaged in to initiate an interaction forum with the researchers with the aim of seeking how best to support their research activities. The library must be prepared to meet the researchers and provide the necessary support.

4.9 Conclusion/ In summary

Storage and preservation of knowledge in various forms are valid role of the library throughout the ages. Providing support for eResearch activities however, will imply a new service role since the library will be involved in the research process itself. The study has revealed that the researchers are involved in various collaborative projects which are based in the university but with partners all over the world. All kinds of digital data are being generated by the researchers which are to be preserved. The library and the researchers need to be more aware of eResearch and the potential that new and rapidly emerging technologies hold.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter 5 will present a review of the research questions, draw up the implications, make recommendations that will guide future activities of the library and propose guidelines for the effective support of eResearch. Suggestions for further studies and conclusions will also be made.

5.2 Review of the research questions

The study was guided by two research questions and five research sub questions. The two research questions, what could be regarded as eResearch activities, and how can the library effectively support and enable these activities at Obafemi Awolowo University were addressed in chapter 2 through the literature review. The research sub questions, are researchers in Obafemi Awolowo University practising these eResearch activities, what are the eResearch skills possessed by researchers in Obafemi Awolowo University and where are they having difficulties, to what extent are researchers collaborating with researchers outside Nigeria and how do these collaborations deal with the sharing of resources and what is the level of knowledge, regarding eResearch, in the library were addressed in the chapter 4, in the research findings and discussion. The last research sub question, what guidelines could the library put in place to develop a plan of action that will ensure effective support of eResearch in the future will be addressed in this chapter by developing a proposed guideline for the library to effectively support the eResearch activities in Obafemi Awolowo University.

5.3 Implications of the study

Providing support for eResearch must be a collaborative effort within the University. The Deputy Vice-Chancellor, Academics (DVC Academics), who oversees the University Research Committee (URC) will need to muter and sanction support for eResearch. The library will have to work with the Information Technology and Communication Unit (INTECU) of the University for a successful engagement with the research community to be able to effectively support the eResearch activities of researchers and for sustainability.

Furthermore, HOL must encourage its staff to gain experience and skills in managing researchers' publications, applying metadata, management of the institutional repository, providing advice on copy-right issues and encouraging publishing of research outputs in open access journals.

The Nigerian government should be informed so that it could recognise the growth of eResearch activities and the various collaborative projects in the country. There are technological advancements in the country every day and the government must therefore encourage academics by building infrastructures that will support eResearch activities in Nigerian universities based on Fernihough's eResearch Implementation framework (Fernihough 2011). Adequate infrastructures for power and internet connectivity are also needed for smooth running of all eResearch activities. Creation of national agencies for online research activities and regulating bodies is imperative. Funding is needed for these new ways of carrying out research in online digital environments.

These three implications of this study and dependency on each other are shown in Figure 5.1

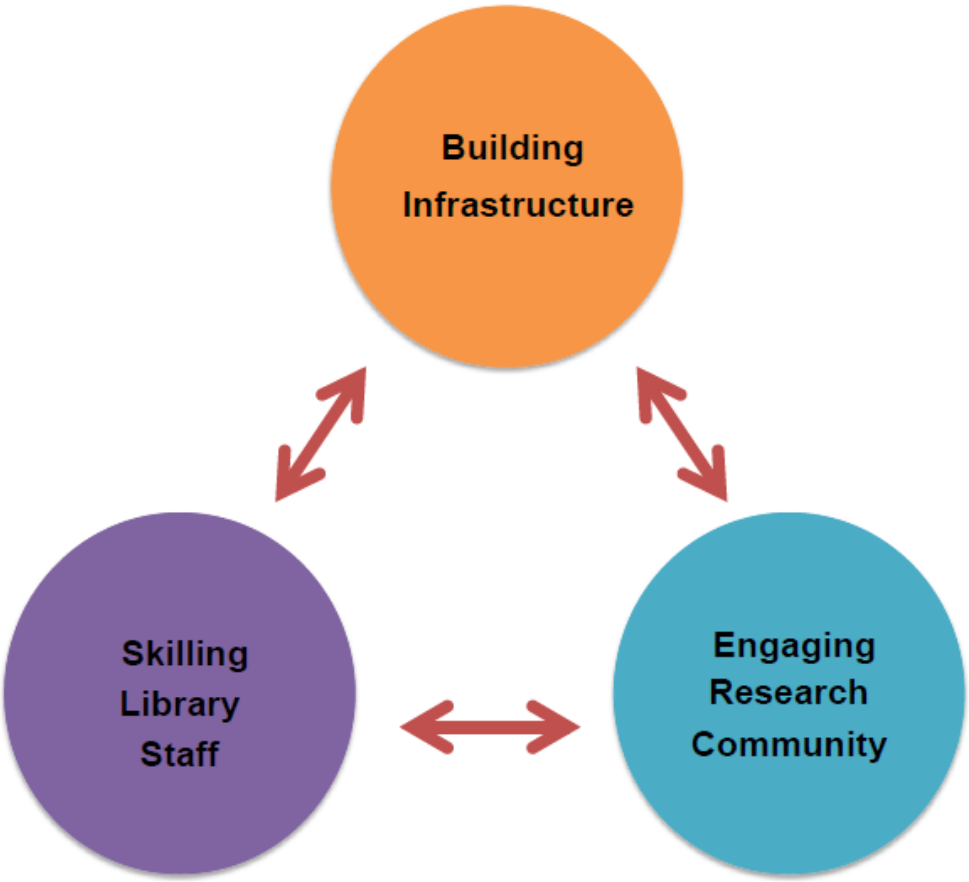

Figure 5.1 Implications of the study
(Source: Byrne et al. 2012)

5.4 Recommendations

HOL must define its role in the provision of the needed support. To stay relevant the library has no choice but to adapt and add the emerging technologies and the research environments into its services. This will entail the librarians using innovative tools, acquiring and updating of the necessary skills, changing the organizational structure of the library and forming collaborative relationships – both with other libraries and the stakeholders in the online digital environments. This however, necessitates constant and regular training/up skilling of all the stakeholders. In the light of this, an institutional framework for eResearch, with resources and adequate infrastructure, should be established by the University.

Researchers are daily generating datasets, hence, a need also for the development of a data management policy for the University. HOL must engage in promotional activities that will create more awareness on eResearch in OAU community, get the details of all the collaborative projects going on in the University from the URC and create links to them on the library's website including the contact person for each project. Adequate funding must be a priority and thus, source from both internally and externally so as to encourage growth and avoid failures.

The University and HOL need to establish relationships (collaboration agreements) with those academic institutions in Africa where the researchers are already collaborating. This kind of institutional support, as noted by some of the researchers, will aid in securing grants from notable international organisations. HOL need to subscribe to and create links on the library website to online tools that support eResearch. These tools may include Research Professional Funding, major international organizations, scholarly journals through ScholarOne, Google Scholar among others.

Another service HOL could provide is to build relationships with the libraries of the researchers' networks to create a similar library network. It may therefore be useful to investigate the facilities there further to help the librarians to also embed in the eResearch projects. HOL must raise awareness of communication tools for collaboration; have a closer look at the existing VREs and collaboration platforms to evaluate usage of tools and particular contributions.

HOL must engage in continuous training for researchers in using more efficient tools such as Endnote, Mendeley and Refworks to manage reference lists and items to read and audit the collaboration tools already in use by the researchers with the aim of learning about the tools and to provide adequate services which might include subscriptions and trainings. HOL will need to have a serious relook at how to ensure that researchers trust that the library is able to assist and enable their research. This is both a marketing/ championing challenge as well as ensuring that librarians have the necessary skills and knowhow to collaborate with the researcher as a trusted partner.

Also, the following recommendations are made specifically for the library:

1. There is a need for a guideline for the library to effectively support eResearch activities. This guideline should be developed as a matter of urgency. Some salient points to remember when developing these guidelines are provided in Figures 5.1, 5.2 and 5.3.
2. There should be more awareness on eResearch activities in the University. There is a need to assist the library staff in understanding everything about the research cycle.
3. There is a need for the library to organise workshops for librarians on how to support online digital research activities. The library needs to organise more and regular trainings for both staff and students.

The library needs to be proactive in supporting eResearch activities of the researchers in the University. This study has revealed that there are eResearch activities and collaborative projects going on in the University. Some of these projects have been in process for more than a year while some are just starting. The shortest duration of most of these projects is three (3) years. The library will therefore need to critically consider providing support for all the phases that the researchers' work go through to the completion of their projects. Sustainability of the support must be ensured through training and retraining of librarians and other supporting staff.

The issue is also for Nigerian library and information schools to train new librarians on new and emerging information management and information technology skills and the staff to update their knowledge.

5.5. Developing a proposed guideline for the library to effectively support eResearch

Some salient factors to consider when HOL develops a guideline to effectively support eResearch activities are:

i. Which staff members to involve in the activities?
ii. How to raise awareness of eResearch activities in the University community.
iii. When and how to provide a functional institutional repository.

The library in collaboration with INTECU, URC and some of the researchers already engaged in eResearch, should form a team to build eResearch support capabilities and capacity for the University. This team should be tasked with the responsibilities of:

- Training of the library staff, researchers and support staff. What capabilities and capacity of eResearch to build – in both librarians and emerging researchers. To increase awareness and to build knowledge and skills for eResearch in the University, training and workshops must be organised for the researchers, INTECU staff and the library staff who will be responsible for supporting eResearch activities. Training for the researchers could be based on the standard research life cycle displayed in Figure 5.2 and training needs and services arising from library /eResearch partnership in Figure 5.3 to include activities such as: Research data management principles, research impact services, collaborative research tools, plagiarism, copyright and intellectual property, digital library resources, bibliographic management, facilitating VREs and the use of Institutional Repository (IR), Ife Research and Educational Network (IfeREN) and Osun Research and Educational Network (OsunREN).

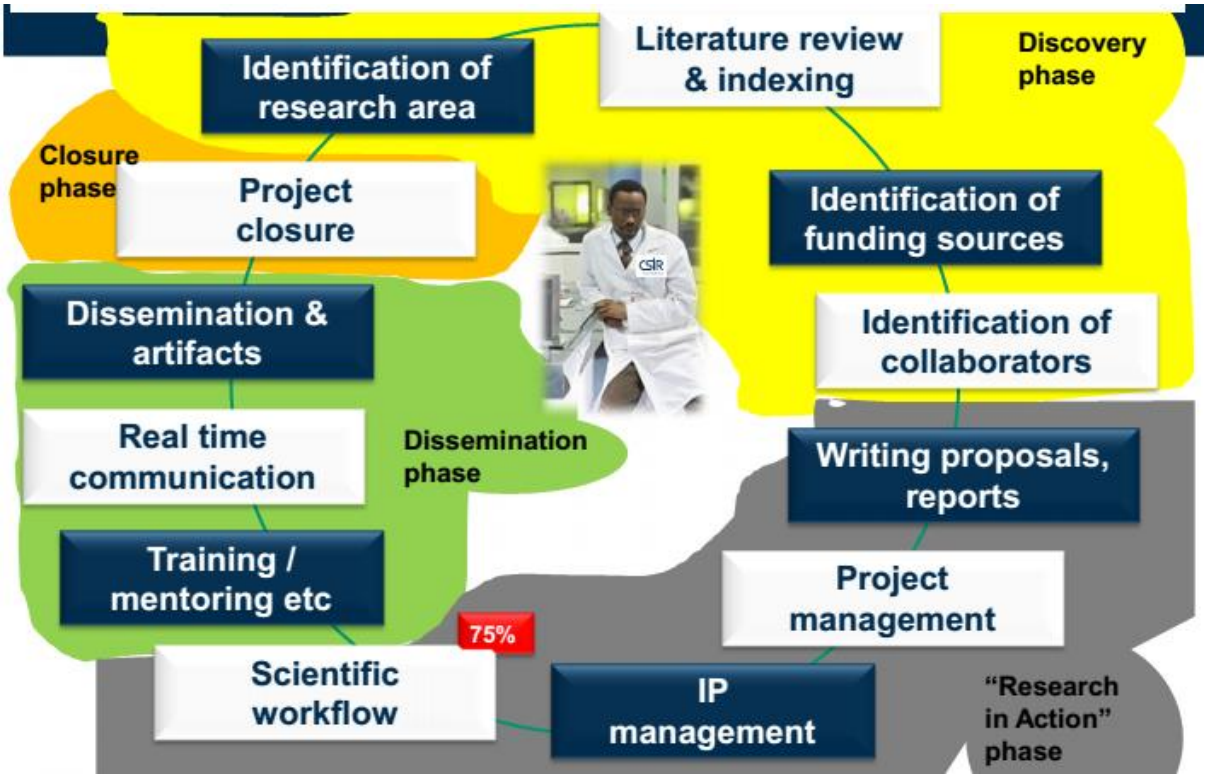

Figure 5.2 The research life cycle

(van Deventer 2015)

- How to develop a digital research data management policy and principles. Developing a data management policy, which will make it compulsory for all research data in the University to be considered as University record and thus stored, managed and made available in the institutional repository to be used by other researchers (except when there is a valid reason for not doing so), should be seen as a priority. The development of the policy will ensure that effective data management procedures are also developed by the researchers for an environment that can support online digital research. Developing research data management procedures/ guidelines for the use of existing data and new data that will be generated. Some of the things to be included in the guidelines according to Thomas (2011, p. 43) would be data ownership, copyright and intellectual property, confidentiality, data storage, data volume, metadata, length of retention and storage, access and usage after project closure.

Figure 5.3 Training needs and services arising from library/eResearch partnership
(Source: Byrne et al. 2012)

- When to create an OAU Research Website and what contributions the library should be making to ensure that its products and services are embedded in others. The creation of an OAU research support website should be linked to both the institutional and the library's websites. This will allow the library to provide seamless support for eResearch and create awareness in and outside the University. The support website for eResearch should be updated regularly with emerging new technologies and eResearch activities. This website should also contain information about the various collaborative projects based in the University that are performed in digital environments. It will be advisable that the website is interactive and dynamic so that users can easily interact with the librarians and other support staff that would be saddled with the responsibility of supporting these research activities.

- How to ensure sustainable funding for the initiative. Favourable and consistent funding conditions are needed to effectively support eResearch activities in the University. The onus lies on the University administration and Nigerian government to provide infrastructure to support the various research activities and funding that will complement the grants and funds the researchers have at their disposal for the research through collaborations with international partners.

5.6 Suggestions for further studies

In order to keep supporting research activities in online digital environments, the researcher intends to carry out a study at PhD level on how librarians can facilitate collaborative research projects. Also, an investigative research can be carried out to look into how libraries can engage and connect with researchers to form library/eResearch partnership, the challenges and benefit of such partnerships.

5.7 Conclusion/In summary

The conclusions reached, the implications and recommendations in relation to this study were made in this chapter. Accordingly, guidelines were proposed for the library to effectively support eResearch activities in Obafemi Awolowo University, Nigeria. The researcher is confident that the study has addressed the issues raised in chapter 1 using the methodology as stated in chapter 3 and thus, has contributed to the existing knowledge base recorded in chapter 2 through the findings in chapter 4 and the conclusions and recommendations made in this chapter.

Although this investigative study is limited to Obafemi Awolowo University and generalisation could not be made due to the small sample population, the researcher is of the opinion that the findings, implications, recommendations and the proposed guidelines will inform a wider stakeholder community, guiding these stakeholders in making the necessary decisions and implementations to the general benefit of research in Nigeria.

REFERENCES

Abubarkar, B. M. 2011. Academic libraries in Nigeria in the 21st century. *Library Philosophy and Practice (e-journal).*Paper 446. Available: http://digitalcommons.unl.edu/libphilprac/446 Accessed 4 April 2015.

ACET, Inc. 2013. *Selecting an evaluation: qualitative, quantitative, and mixed method approaches*. Minneapolis, MN.

Ajewole, O.I. and Odaibo, A. 2014. Data collection techniques, in Popoola, L, Olorunnisola, O. and Ademowo, O (eds), *Data collection techniques in data collection, management and analysis in academic research*: Proceedings of a Workshop, pp. 56-81

Anunobi, C.V. & Okoye, I.B. 2008.The role of academic libraries in universal access to print and electronic resources in the developing countries. *Library Philosophy and Practice (e-journal)*.Paper 189.

Appelbe, B, and Bannon, D. 2007. 'eResearch - paradigm shift or propaganda?' *Journal of Research and Practice in Information Technology*, vol 39 no 2, pp. 83-90.

Archie, D. 2015. Research methodology. Unpublished Student Conference Presentation, Makarere University, Uganda.

Arcila, C., Piñuel, J.L., and Calderín, M. 2013. The e-research on media & communications: attitudes, tools and practices in Latin America researchers. *Comunicar* vol 20 no 40, pp. 111–18. Available: http://dx.doi.org/10.3916/C40-2013-03-01 Accessed 21 September 2015

Argyle, M. 1991.*Cooperation – The basis of sociability*. London: Routledge.

Asubiojo, B.O. 2015.The role of HOL in enhancing local contents availability in OAU. A paper presented at a 2-day Workshop for University Officers, Obafemi Awolowo University.

Australian eResearch Infrastructure Council. 2010. Meeting Australia's research workforce needs. Available: http://www.innovation.gov.au/Research/ResearchWorkforceIssues/Documents/RWSsubmissions/Submission15.pdf Accessed 4 February 2013.

Australian Government. 2006. An Australian e-research strategy and implementation framework: Final Report of the e-Research Coordinating Committee. Available: http:/ncris.innovation.gov.au/Document s/eRCCReport.pdf Accessed 4 February 2013.

Bamgboye, E.A. & Okoruwa, V.O. 2014.*Designs of Experiments and* in Popoola, L, Olorunnisola, O. and Ademowo, O (eds), *Data collection techniques in data collection, management and analysis in academic research*: Proceedings of a Workshop, pp. 35-55

Baro, E.E. & Asaba, J.O. 2010. Internet connectivity in university libraries in Nigeria: the present state", *Library Hi Tech News,*27 (9):13 – 19. Available: doi:10.1108/07419051011110603 Accessed 10 April 2015.

Berman, F. & Henry B. 2005.*Cyberinfrastructure and the Social Sciences*. *Final Report: NSF SBE-CISE Workshop.* Available: vis.sdsc.edu/sbe/reports/SBE CISE-FINAL.pdf. Accessed 10 April 2015.

Berthon, P. & Leyland, P. & Dianne, C. & Campbell, C. 2008. E-readiness and trust: macro and micro dualities for e-commerce in a global environment. *International Marketing Review,* vol 25 no 6, pp. 700 – 714.doi:10.1108/026513308/0915592.

Bill and Melinda Gate Foundation 2014.*Bill & Melinda Gates foundation open access policy.* Available: http://www.gatesfoundation.org/How-We-Work/General-Information/Open-Access-Policy Accessed

Bradbury, S. & Borchert, M. 2010. Survey of eResearch practices and skills at QUT, Australia..*International Association of Scientific and Technological University Libraries, 31st Annual Conference.* Paper 3. Available: http://docs.lib.purdue.edu/iatul2010/conf/day1/3 Accessed 29 January 2013 Accessed 4 February 2013.

Brandt, D. S. 2007. Librarians as partners in e-research Purdue University Libraries promote collaboration, *C&RL News*, 365-396. Available: http://crln.acrl.org/content/68/6/365.full.pdf Accessed 8 October 2015.

Breite, R., & Vanharanta, H. 2003. Evaluating collaboration and core competence in virtual enterprise. Psychology Journal, 1, 391–399.

Brikci, N. and Green, J. 2007. A Guide to Using Qualitative Research Methodology.Médecins sans Frontières. Available at: http://fieldresearch.msf.org/msf/bitstream/10144/84230/1/Qualitative%20research%20meth odology.pdf. Accessed 1 September 2015

British Academy. 2008. International *Development Select Committee Inquiry: DFID's Programme in Nigeria*. Available: http://www.britac.ac.uk/policy/nigeria.cfm Accessed 9 September 2015.

Brown, C. 2013. Implementing a virtual research environment (VRE): Understanding the tools and technologies needed by researchers. *JISC.* Available: https://www.jisc.ac.uk/full-guide/implementing-a-virtual-research-environment-vre Accessed 12 October 2015.

Brunvand, S and Duran, D. 2010. A Taxonomy of e-Research Collaboration Tools: Using Web 2.0 to Connect, Collaborate and Create with Research Partners. In M. Anandarajan and A. Anandarajan (eds.), *e-Research Collaboration*, Springer-Verlag Berlin Heidelberg. Available: DOI 10.1007/978-3-642-12257-6_7 Accessed 9 September 2015.

Burns, R.B., 1997. *Introduction to Research Methods.*2nd ed., Melbourne, Longman Cheshire.

Byrne, K., McKenzie, C. & Frances, M. 2012. E-Research and Libraries: a Perfect Partnership? In *6th eResearch Australasia Conference, Sydney, Australia, October 28 - November 1, 2012.* Sydney, Australia.

Candela L. 2011 Data use-virtual research environments. In Technological & Organisational Aspects of a Global Research Data Infrastructure - A View from Experts.

Candela, L.Castelli, D. and Pagano, P. 2013. Virtual research environments.*Data Science Journal*, 12. Available: http://doi.org/10.2481/dsj.GRDI-013 Accessed 12 October 2015.

Carusi, A and Reimer, A. 2010.Virtual research environment collaborative landscape study.A JISC funded project. Available: http://www.webarchive.org.uk/wayback/archive/20140615234259/http://www.jisc.ac.uk/media/documents/publications/vrelandscapereport.pdf Accessed 22 March 2015

Centre for eResearch and Digital Innovation (CeRDI) 2015. eResearch Available: http://www.cerdi.edu.au/cb_pages/eresearch.php Accessed 8 September 2015.

Chafe, A.I. 2010. Nigerian universities ICT solution project. NUC ICT Initiative presentation Available: http://www.forum.org.ng/system/files/NUC+ICT+INITIATIVE+PRESENTATION+TO+DICTs.pdf

Charters, S.M. 2010.*Visualisation for e-Research: Past, Present and Future*. Applied Computing Group, Lincoln University. Available: http://espace.library.uq.edu.au/eserv/ UQ:155352/era08_43.pdf Accessed 4 April 2013.

CHPC. 2010. *High performance computing.* Cape Town: Meraka Institute, CSIR. Available: http: //www.chpc.ac.za/hpc-service/ Accessed 4 April 2013.

Community Research and Development Information Service (CORDIS). 2015. EINFRA-9-2015 - e-Infrastructures for virtual research environments (VRE). European Commission. Available: http://cordis.europa.eu/programme/rcn/664625_en.html Accessed 12 October 2015.

Confederation of Open Access Repositories (COAR) 2013. Library and repository communities join together to identify new competencies for academic librarians. Available: https://www.coar-repositories.org/activities/support-and-training/task-force-competencies/ Accessed 8 September 2015.

Connaway, L. S., and Powell. R. R. 2010. *Basic research methods for librarians*. Santa Barbara, Calif: Libraries Unlimited.

Creswell, J. W., and Clark, V. L. 2007.*Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Distributed Systems Technology Centre (DSTC). 2004. *E-Research Middleware: The Missing Link in Australia's e-Research Agenda*, Discussion whitepaper submitted to The Department of Education, Science and Training. University of Queensland, Australia. Available: http://archive.itee.uq.edu.au/~ eresearch/ papers/eResearchMiddleware.pdf Accessed April 2013

Ebuehi, A. 2012.Underfunding, poor infrastructure, bane of research – Don. *Punch Newspaper,* 8 April. Available: www.punch.com Accessed 12 October 2015

Etekwa, M. 2007. Refocusing ICT development as tools in the library for sustainable national development. *Knowledge Review*, vol 15 no 3. Available: http://www.globalacademicgroup.com/journals/knowledge%20review/Etekwa.pdf 9 September 2015.

Fernihough, S. 2011. *e-Research: An Implementation Framework for South African Organisations* [Online]. University of South Africa, pp.1-139. Available: http://uir.unisa.ac.za/bitstream/handle/10500/4474/2011%20MBA3%20Research%20Report%20S%20Fernihough.pdf?sequence=1 Accessed 1 November 2012.

Fitzek, F., & Katz, M. (Eds.). (2006). Cooperation in wireless networks: Principles and applications – Real egoistic behaviour is to cooperate. Dordrecht, The Netherlands: Springer.

Foraker Design. 2007. Usability first: Groupware applications. Available: http://www.usabilityfirst.com/ Accessed 30 August 2015.

Garner, I. 2006. Library support for research in a university context. Proceedings of the IATUL Conferences. Paper 24.

Gilbet, N. (ed.) 2008. *Researching Social Life.*3rd ed. London, Sage.

Gold, A. 2007.Cyber infrastructure, data, and libraries, part 2: libraries and the data challenge: roles and actions for libraries. *D-Lib Magazine,* vol 13 no 9/10 doi:10.1045/july20september-gold-pt2

Gutwin, C., & Greenberg, S. 2000. The mechanics of collaboration: developing low cost usability evaluation methods for shared workspaces. Paper presented at the 9th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises, Maryland, USA.

Halland, Y. 2013. Doing it together for cost effective access to scholarly information: a south african perspective. Proceedings of the IATUL Conferences. Paper 33. Available: http://docs.lib.purdue.edu/iatul/2013/papers/33 Accessed 9 October 2015

Hanafizadeh, P. Hanafizadeh, M.R, &Khodabakhshi, M. 2009. Taxonomy of e-readiness assessment measures. *International Journal of Information Management* vol 29 pp. 189 195.

Harley, J & Blismas, N. 2010.An anatomy of collaboration within the online environment. In M. Anandarajan and A. Anandarajan (eds.), *e-Research Collaboration*, Springer-Verlag Berlin Heidelberg. Available: DOI 10.1007/978-3-642-12257-6_7 Accessed 9 September 2015.

Heijne, M. 2009. Recording (e)research: a role for academic / research libraries!? IATUL *Seminar*, Hong Kong.

Hellmers, L. 2009. eResearch practices, barrier s and needs for support : Preliminary study findings from four NSW universities. Available: http://eresearchau.files.wordpress.com/2012/10/66-e-research-practices-barriers-and-needs-for-support-an-accounting-and-finance-perspective.pdf Accessed 4 February 2013.

Henty, M. 2008. Developing the capability and skills to support eResearch. *Ariadne, 55*. Available: http://www.ariadne.ac.uk/issue55/henty/Accessed 1 November 2012.

HOL 2013.About Hezekiah Oluwasanmi library. Available: http://library.oauife.edu.ng/index.php/about-us Accessed 9 October 2015.

Houghton, J.W., Steele, C. & Henty, M. 2003.*Changing Research Practises in the Digital Information and Communication Environment* [online].Australia - Department of Education, Science and Training, Canberra. Available: <http://eprints.vu.edu.au/456/1/c_res pract. pdf> Accessed 31 January 2013.

INTECU 2014.Information technology and communication unit. Available: http://intecu.oauife.edu.ng/

ISSR. 2010. *Synopsis. The 2nd IEEE International Workshop on Security in e-Science and e-Research'.*Taipei, Taiwan. 6-9 September .

Jankowski, N. 2009.The Contours and Challenges of e-Research.In Jankowski, N. (ed.), *e-Research: Transformation in Scholarly Practice*.[Online]. London: Routledge. Available: http://scholarly-transformations.virtualknowledgestudio.nl/ Accessed 31 January 2013.

JISC, 2011.Virtual environment program. Available: http://webarchive.nationalarchives.gov.uk/20140702233839/http://www.jisc.ac.uk/whatwedo/programmes/vre.aspx Accessed 31 January 2013.

JISC. 2013. Virtual research environment programme. Available: http://www.jisc.ac.uk/whatwedo/programmes/vre.aspx Accessed 4 February 2013.

Johnson, R.B., Onwuegbuzie, A.J. & Turner, L.A. 2007.Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, vol 1 No 2 pp. 12–133. Available at: http://mmr.sagepub.com/content/1/2/112.abstract.

Khatibi, V. & Montazer, G.A. 2012. *E-Research Methodology.* In Collaborative and Distributed E-Research: Innovations in Technologies, Strategies and Applications, Angel Juan, et al., Editors, Hershey, PA: IGI Global.

Kothari, C.R. 2004. *Research Methodology: Methods and Techniques*, New Age International (P) Limited.

Kumar, R. 2014. *Research methodology: a step-by-step guide for beginners*. 4th ed. Los Angeles: SAGE.

Leggott, M., Moses, D. and Hooper, D. 2014.*Highlighting Evolving Roles for Libraries*. In eResearch @ UPEI.

Leiss, C. & Lockhart, J. 2015.Librarian ' s skills for eResearch support : joint project at TUM and CPUT. Paper presented at 36th Annual IATUL Conference, Hanover, Germany.

Lehto, A., Toivonen, L., Tevaniemi, L., Iivonen, J & Partanen, M. 2010.University libraries' role in eResearch.I FLA Poster Presentation. Available: www15.uta.fi/kirjasto/pdf/IFLA2010_posteri.pdf Accessed 8 October 2015.

Li, Y., Yang, S., Jiang, J. & Shi, M. 2006.'Build grid-enabled large scale collaboration environment in e-Learning grid', *Expert Systems with Applications*, vol 31, pp. 742-754.

Librarians' Registration Council of Nigeria (LRCN). 2014. Minimum Standards and Guidelines for Academic Libraries in Nigeria. Available: http://www.lrcn.gov.ng/Minimum%20Standards%20and%20Guidelines%20for%20Academic%20Libraries%20in%20Nigeria.pdf Accessed 9 October 2015

Library Handbook.2012. *Hezekiah Oluwasaanmi Library handbook.*

Lombardi, J.V. 2000.Academic libraries in a digital age. *D-Lib Magazine,* vol 6 no 10.Available: www.dlib.org/ Accessed 8 September 2015.

Luce, R. E. 2008. A New Value Equation Challenge: The Emergence of eResearch and Roles for Research Libraries. *Council on Library and Information Resources.* Available: http://www.clir.org/pubs/reports/pub142/luce.html Accessed 8 October 2015

MacColl, J. & Michael, J. 2011.Supporting Research : Environments, Administration and Libraries. *OCLC Research*. Available: www.oclc.org/research/publications/library/2011/2011-10.pdf

Markauskaite, L. 2011. Digital Knowledge and Digital Research: What does eResearch Offer Education and Social Policy? in L. Markauskaite et al. (eds.), Methodological *Choice and Design, Methodos* Series 9, Springer. Available: DOI 10.1007/978-90-481-8933-5_21. Accessed 9 September 2015

Markauskaite, L., Kennan, M. A., Richardson, J., Aditomo, A., & Hellmers, L. 2012. Investigating eResearch: collaboration practices and future challenges. In A. Juan, T. Daradoumis, M. Roca, S. Grasman, & J. Faulin (eds.), *Collaborative and distributed e-Research: Innovations in technologies, strategies and applications,* pp. 1–33. Hershey, PA: IGI. doi:10.4018/978-1-4666-0125-3.ch001

Martin, V. 2014.*Demystifying eResearch: A Primer for Librarians*. ABC CLIO: Libraries Unlimited.

Maryann, U. E. & Udeajah, R. 2014. Influence of ICT in the media report of Abuja bomb blast new media and mass communication. *IIST*, vol 29, p. 65.

Mattessich, P., Murray-Close, M., & Monsey, B. R. 2001.*Collaboration: what makes it work.*2nd ed.. Minnesota, USA: Wilder Publishing Centre.

McAlpine, K. & McIntosh, L. 2015, Honing the edge: an integrated model for supporting eResearch. *ALIA Information Online* 2015: at the Edge, ALIA, Sydney, pp. 1-13. Available: http://ro.uow.edu.au/asdpapers/485Accessed 9 September 2015.

McDonald, D. W. 2003. Recommending collaboration with social networks: a comparative evaluation. Paper presented at the CHI 2003 Conference on Human Factors in Computing Systems, Fort Lauderdale, Florida USA.

Monette, D. R., Thomas, J.S. & Cornell, R.D. 1986.*Applied social research tools for the human service,* Forth Worth, TX, Holt, Rinehart and Winston.

Mutula, M.S. & Brakel, P.V. 2006. E-Readiness of SMEs in the ICT sector in Botswana, with respect to information access. *Elect. Library*, vol 24, pp. 402-417.

National Universities Commission, 2015.List of Nigerian Universities and Years Founded. Available: http://www.nuc.edu.ng/pages/universities.asp Accessed 5 September 2015.

NECTAR. 2007. Network for effective collaboration through advanced research. Available http://www.nectar-research.net/about-nectar.php Accessed 30 August 2015

Nigerian Research and Educational Network, 2015.NgREN- at a glance. Available: http://ngren.edu.ng/about/at-a-glance 13 October 2015.

NSF 1997.Overview of Qualitative Methods and Analytic Techniques. Available at: http://www.nsf.gov/pubs/1997/nsf97153/chap_3.htm Accessed 31 August 2015.

OAU Annual Report 2014.Obafemi Awolowo University Publication.

Odia, L. O., & Omofonmwan, S.I. 2013. Research and Development Initiatives in Nigeria: Challenges and Prospects. *Mediterranean Journal of Social Sciences,* vol 4 no 2, pp.257–266. Available: doi:10.5901/mjss.2013.v4n2p257. Accessed 21 September 2015.

Okojie, J. 2012. Nigeria Can Address Research Problems through Collaboration. *This Day*. 28 November. Available: http://www.thisdaylive.com/articles/-nigeria-can-address-research-problems-through-collaboration-/131892/Accessed 10 October 2015

Okunlola, F. 2015. Nigerian Universities get online research platform. *Pulse,* 2 October Available: http://pulse.ng/tech/in-nigeria-nigerian-universities-get-online-research-platform-id4224087.html Accessed 13 October 2015

Olson, G. M., Zimmerman, A., & Bos, N. (2008). *Scientific collaboration on the internet*. Cambridge, MA: The MIT Press.

Ongori, H 2009. Role of Information Communication Technologies Adoption in SMES: Evidence from Botswana. *Research Journal of Information Technology,* vol 1 pp, 79-85.

Page-Shipp, R.J., Hammes, M.M.P., Pienaar, H., Thomas, F.G., van Deventer, M.J. & Veldsman, S. 2005.e-Research support services: responding to a challenge facing the South African research and information communities. *The South African Journal of Information Management*, vol 7 no 4, pp. 3-8.

Pearsall, J. (ed) 1999*. The concise oxford dictionary*, 10th Edition. USA: Oxford University

Perrott, R. & Harmer, T. 2008.e-Science Infrastructure for digital media broadcasting. *Computer*, vol 41 no 11, pp. 67-72.

Pienaar, H. and van Deventer, M. 2009. To VRE or not to VRE?: do South African malaria researchers need a virtual research environment? *Ariadne* Issue 59 Available: //www.ariadne.ac.uk/issue59/pienaar-vandeventer/ Accessed 4 February 2013

Ranking Web of University. 2015. Available: http://www.webometrics.info/en/Africa/Nigeria Accessed 5 September 2015

Risenga, P.R. & Lebese, T.R. 2014. Lived experiences of first time mothers towards breastfeeding at Muyexe Village in Mopane District, Limpopo Province. *Journal of Medicine and Medical Research* Vol. 2 no 4, pp. 51-58.

Rogers, D., & Whetten, D. (eds.). (1982). Inter-organisational coordination – Theory, research and implementation. Iowa, USA: Iowa State University Press.

Romano, N. C., Chen, F., & Nunamaker, J. F. 2002.Collaborative project management software. Paper presented at the 35th Annual Hawaii International Conference on System Sciences, 7-10 January, Hawaii, USA.

Rossman, G. B., & Rallis, S. F. 1998.*A guide for instructors for learning in the field.* Thousand Oaks, CA: Sage.

Sargent, M. 2006. *An Australian e-Research strategy and implementation framework* [online].National Collaborative Research Infrastructure Strategy. Melbourne: NRIC.

Schermerhorn, J. (1975). Determinants of inter-organisational cooperation. Academy of Management Journal, 18, 846–856.

Schrage, M. (1990).Shared minds: The new technologies of collaboration. New York, USA:

Shearer, K., Argáez, A. and Swanson, M. 2010.*Addressing the Research Data Gap: A Review of Novel Services for Libraries*. Canadian Association of Research Libraries.

Simons, N. & Searle, S. 2014. Redefining the librarian in the context of emerging eResearch services.In *VALA2014 Conference*.

Speer, J., Mathews, B. & Walters, T. 2013. Hubs and centers as transitional change strategy for library collaboration. *IATUL Conference*. Available: https://vtechworks.lib.vt.edu/bitstream/handle/10919/19333/IATUL-presentation-final.pdf?sequence=2 Accessed 6 October 2015.

Susan, M. K. and Baby, M.D. 2012. Developing Technology Skills for Academic Librarians: A Study Based on the Universities in Kerala, India*. Library Philosophy and Practice* Available: http://unllib.unl.edu/LPP/ Accessed 6 October 2015.

Tebbetts, D.R. 1991. Expandability, flexibility, compatibility: Key management considerations in academic library automation. Available: web.simmons.edu/~chen/nit/NIT'91/223-teb.htm

TechTarget. 2007. What.is. Available: http://whatis.techtarget.com/ Accessed 4 April 2015.

Thomas, J. 2011. Future-Proofing: The Academic Library's Role in E-Research Support. Library Management 32 (1/2): 37–47. Available: doi:10.1108/01435121111102566. Accessed 9 September 2015.

Thyer, B.A. 1993. 'Single-systems research design', in R.M. Ginnell [eds], *Social Work Research and Evaluation* (4th ed.), Itasca, IL, F.E. Peacock.

University of Melbourne. 2012. eResearch trainings and skills. Available: http://www.eresearch.unimelb.edu.au/activities/studying_eresearch Accessed 4 February 2012.

van Deventer, M. 2015. Virtual research environments (VREs): managing, facilitating, learning, sharing and looking at the generic e-Research process. Unpublished Carnegie CPD Programme Presentation, University of Pretoria, South Africa.

Wang, M. 2014. Academic library, e-science/e-research, and data services in a broader context. *ACRL,* Indianapolis http://www.ala.org/acrl/sites/ala.org.acrl/files/content/conferences/confsandpreconfs/2013/papers/Wang_AcademicLibrary.pdf

Whitmire, A. L. 2013. Thoughts on “eResearch”: a scientist’s perspective. *Journal of eScience Librarianship* vol 2 no 2, Article 3. Available: http://dx.doi.org/10.7191/jeslib.2013.1045 Accessed 12 October 2015.

Virtual research environment. 2014. *Wikepedia,* wiki article, Available: https://en.wikipedia.org/wiki/Virtual_research_environmentAccessed 12 October 2015.

Wolski, M. and Richardson, J. 2015.improving data management practices of researchers by using a behavioural framework. In *THETA: The Higher Education Technology Agenda*, 11–13. Australia, Gold Coast.

Yang, X and Allan, R. 2006. Web-based virtual research environments (VRE): support collaboration in e-science. *The 3rd International Workshop on Web-based Support Systems (WSS'06) held in conjunction with WI 2006, Hong* Kong p.1. Available: http://193.62.125.70/Sakai/papers/conf.pdf Accessed 1 November 2012.

APPENDIX A

UNIVERSITEIT VAN PRETORIA
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School of Information Technology

2015-07-27

ETHICAL CLEARANCE FOR OMOBOLADE ADEAGBO

Dissertation Title: Guidelines for the Library to effectively support eResearch activities at the Obafemi Awolowo University, Nigeria

.

To whom it may concern:

This is to confirm that the Research Committee of the Department of Information Science approved the application by Omobolade Adeagbo for ethical clearance. Ms Adeagbo complied with the standard requirements for ethical clearance as set out by the University of Pretoria's Faculty of Engineering, Built Environment and Information Technology (EBIT), as follows:

- She signed and submitted all the application forms required for ethical clearance;
- She submitted her data collection instruments for vetting by both the Research and Ethics Committees; and
- She implemented all corrections recommended by the above-mentioned committees.

The Research Committee of the Department of Information Science therefore requests permission for Ms Adeagbo to collect the data she needs in order to complete and submit her mini-dissertation for examination. The Committee further appreciates any effort by appropriate authorities to expedite this process, and expresses its gratitude in anticipation.

Yours sincerely

Dr Marlene Holmner

Dr Marlene Holmner
Academic Coordinator: Carnegie MIT
Department of Information Science
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APPENDIX B

INTERVIEW SCHEDULE FOR THE RESEARCHERS

Introductory remarks

Dear Sir/Madam

I am Mrs. Omobolade Opeyemi Adeagbo, a Reference Librarian at Hezekiah Oluwasanmi Library, OAU and currently undergoing MIT Carnegie programme with the University of Pretoria, South Africa. I am carrying out this research to assess the various eResearch activities of researchers in OAU with the aim of proposing guidelines for the library to effectively support these activities. eResearch is a new way of doing research, collaborating globally and nationally while making use of ICT infrastructure to do research in an online environment. The result of this research will be used for Masters level study. This interview will take about 30 minutes. Participation in this research is voluntary. Your prompt and honest response is hereby solicited. The information provided and your identity will be kept confidential and used solely for research and scholarship purpose.

Thank you for your cooperation

Informed consent form

(Form for research subject's permission)

(Must be signed by each research subject, and must be kept on record by the researcher)

1 Title of research project: **Guidelines for the Library to effectively support Research Activities at the Obafemi Awolowo University, Nigeria**

2 I …… hereby voluntarily grant my permission for participation in the project as explained to me by
Omobolade Opeyemi Adeagbo

3 The nature, objective, possible safety and health implications have been explained to me and I understand them.

4 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially.

5 I am aware that the results of the investigation may be used for the purposes of publication.

6 Upon signature of this form, you will be provided with a copy.

Signed: _____ Date: _____

Witness: _____ Date: _____

Researcher: _____ Date: _____

INTERVIEW SCHEDULE FOR THE RESEARCHERS

Planned interview duration: 60 minutes

A. eResearch Activities

1. Have you heard about the terms 'eResearch'or 'e-Science' or 'Virtual Research' or 'Open Science'?
   *[Prompt: if no, explain that it is about conducting research as a team member where the research team includes researchers who are not employed by the university]*If yes, could you please explain what you understand the term(s) to mean.
2. Are you involved in a research project or projects where at least one of the team members is not employed by this university?
   [Prompt: Do you engage in online collaboration with researchers based outside of Nigeria when carrying out your research?]
3. If yes, could you please explain the project(s) to me?
   [Prompts: where are the team members based, what is the project about, what are you hoping to discover?]
   If no: are you aware of anyone else at the university being involved in projects with team members who are based in other countries or other institutions?

Note: If from the response it is clear that the researcher is not participating in eResearch activities ask what support he would like to receive from the library and end the interview.

B. eResearch Skills and Practices

1. Who is funding the research and what are some of the important conditions of the grant?
2. Please explain to me what technologies your team uses to communicate with each other? *[Prompts: For example, ResearchGate, Skype , Mendeley, Google Drive, Google Docs, Wikis, Blogs , Video Conferencing, Virtual Research Environments (VREs) e.g. Sakai, IfeREN, OAU Institutional Repository, Online Forums]*
3. How do team members maintain reference lists and items to read?
4. How does the team ensure that all know the deadlines for deliverables?
   [Prompt: Do you have shared calendar? Do you have regular online meetings or video conferencing?]

5. How do team members share relevant new information with each other?
   [Prompt: Do you use collaborative technologies e.g. email, peer to peer file sharing, a wiki, an online forum or blog?]
6. How do you share your research data?
   [Prompts: Hoe is your data collected? Do you have documented data management practices e.g. backing up your digital data or using pre-existing data for your work. Do you store your data on one server or is each researcher responsible for his own data? In what format is the data: spreadsheet, database management system]
7. Who is responsible for data analysis and how is this done?
   [Prompts: what tools & techniques do you use e.g. statistical analysis software, survey software?]
8. Do you make use of remote research instruments?
   [Prompt if yes: Please explain how this is done]
9. Do you make use of data visualization tools?
   [Prompts: e.g. google maps, geographical information systems (GIS), photo editing suite, big data visualisation?]
10. Do you make use of computational tools? If yes please explain
    [Prompt: e.g. high performance computing, developing a parallel program for complex data?]
11. Are you aware of/or does your team use any Open/Free Source software for your research? [Prompt: If yes, please mention the software and indicate the use. If no, what software do you use for your research?]
12. Could you please explain how you acquired the necessary skills/practices to be able to participate in (or manage) the project?
    [Prompt: Was it part of your undergraduate training/ did you receive training at another institution?]
13. What are the challenges you face in carrying out research while being dependent on an online digital environment?

C. Library/ Institutional Support

1. How do you think the library can support your online digital research activities? *[Prompt: would it help if you could use your journal articles directly from your workspace? Do you need assistance with information overload? Do you need guidance with aspects such as predatory publishing or the use of online communication tools?]*
2. What will happen to your research data and reports after project closure? *[Prompt: will all outputs be transferred to the funder/ one of the research partners? Who will ensure that the outputs remain accessible in future? Have you asked the library for assistance?]*

Thank you for your time and participation in this research. It is highly appreciated.

APPENDIX C

INTERVIEW SCHEDULE FOR LIBRARIANS

Introductory remarks

Dear Sir/Madam

I am Mrs. Omobolade Opeyemi Adeagbo, a Reference Librarian at Hezekiah Oluwasanmi Library, OAU and currently undergoing MIT Carnegie programme with the University of Pretoria, South Africa. I am carrying out this research to assess the various eResearch activities of researchers in OAU with the aim of proposing guidelines for the library to effectively support these activities. eResearch is a new way of doing research, collaborating globally and nationally while making use of ICT infrastructure to do research in an online environment. The result of this research will be used for Masters level study. This interview will take about 30 minutes. Participation in this research is voluntary. Your prompt and honest response is hereby solicited. The information provided and your identity will be kept confidential and used solely for research and scholarship purpose.

Thank you for your cooperation

INTERVIEW SCHEDULE FOR THE LIBRARIAN

Planned interview duration: 30 minutes

1. Have you heard about the terms 'eResearch' or 'e-Science' or 'Virtual Research' or 'Open Science'?
   [Prompt: if no, explain that it is about conducting research as a team member where the research team includes researchers who are not employed by the university] If yes, could you please explain what you understand the term(s) to mean.
2. Are you aware of any such research in the University?
   [Prompt: do you know of any ongoing collaborative project among OAU researchers?]
3. Do you think the library is providing support in any of the following phases of eResearch?
   a. Planning phase
      [Prompts: Workshops for researchers on how to use the library eResources and how to seek for funds or grants]
   b. Data capturing/creation phase
      [Prompts: providing training on how to use survey tools like Google form/Survey Monkey for data collection]
   c. Data storage phase
      [Prompts: providing links to Dropbox or Google drive on the library website]
   d. Data management phase
      [Prompts: trainings on how to organize and document data using avenues like Mendeley, Scopus e.t.c.]
   e. Data collection and analysis tools & techniques
      [Prompts: providing access to High Process computing resources and statistical packages through the library website]
   f. Visualization of data
      [Prompts: providing access to open source visual data analytics software like 'R' or data explorer through the library website]
   g. Sharing data
      [Prompts: ensuring automated sharing of data through the Institutional Repository, IfeREN and Google Scholar]
4. If not, is there any plan to support these researchers in all the eResearch phases?*[Prompts: either presently or in the future]*

5. How do you think the library can effectively support online digital research activities? *[Prompt: with reference to the eResearch phases mentioned above]*
6. If there is a guideline for the library to effectively support eResearch activities in the University, will the library management be ready to implement it?

[Prompts: a step by step guide on how to provide supports for eResearch activities in all the phases}

Thank you for your time and participation in this research. It is highly appreciated.