OSEI TUTU II INSTITUTE FOR ADVANCE ICT STUDIES

KUMASI, GHANA

AFFILIATED TO

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

SCHOOL OF GRADUATE STUDIES

EXPLORING THE EXTENT OF USE AND ADOPTION OF FREE AND OPEN SOURCE SOFTWARE IN A TERTIARY INSTITUTION IN GHANA. (CASE STUDY OF KNUST)

BY

DANIEL AFFUM, B.SC. (HONS.) NAT. RES. MGT. (KUMASI)

OCTOBER, 2009

OSEI TUTU II INSTITUTE FOR ADVANCE ICT STUDIES KUMASI, GHANA

AFFILIATED TO

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

SCHOOL OF GRADUATE STUDIES

EXPLORING THE EXTENT OF USE AND ADOPTION OF FREE AND OPEN SOURCE SOFTWARE IN A TERTIARY INSTITUTION IN GHANA. (CASE STUDY OF KNUST)

A THESIS SUBMITTED TO OSEI TUTU II INSTITUTE FOR ADVANCE ICT STUDIES KUMASI, IN PARTIAL FULFILLMENT OF THE MASTER OF SCIENCE DEGREE IN ADVANCE ICT STUDIES

BY

DANIEL AFFUM, B.SC. (HONS.) NAT. RES. MGT. (KUMASI)

OCTOBER 2009

DECLARATION

I declare that, with the exception of references to other people's work which have been duly cited, this work, submitted as a thesis to the Osei Tutu II Institute for Advance ICT Studies Kumasi, Ghana for the Master Of Science Degree In Advance ICT Studies, is the result of my own investigation.

.....

DANIEL AFFUM

CANDIDATE

.....

HOSSANA TWINOMURINZI

DEPARTMENT OF INFORMATICS

UNIVERSITY OF PRETORIA

SUPERVISOR

.....

PROF. VASKO FOURNADJIEV

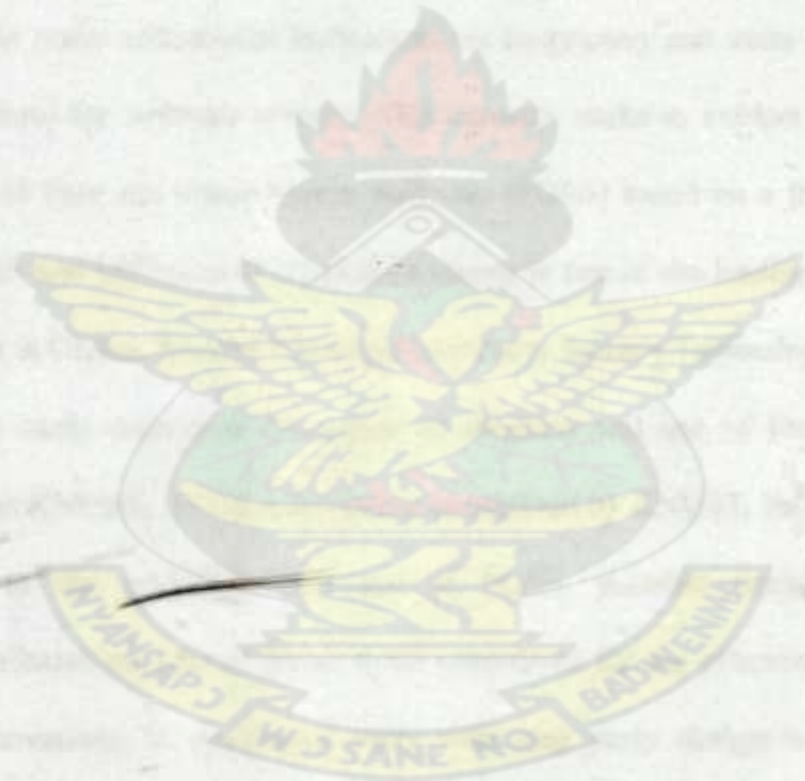
OSEI TUTU II INSTITUTE FOR ADVANCED

ICT STUDIES

ACADEMIC OFFICER

DEDICATION

To my wife, son and my unborn children



ABSTRACT

The emergence of the information and mass communication age has brought to light the irrevocable important role that information, knowledge as well as technology play in facilitating the socio-economic development of a country.

The use of ICT to develop, deploy and delivery services that enable efficiency at the work place is catching on in developing countries such as Ghana yet there is still so much that is needed to encourage the use of such technologies. Most of the software that are used in many educational institutions are proprietary and users need to pay for user licenses from the software owners. This research seeks to explore the potential of the adoption of Free and Open Source Software (FOSS) based on a framework developed from FOSS and Diffusion of Innovation theory in one of the leading tertiary educational institution in Ghana, Kwame Nkrumah University Science Technology (KNUST).

The study examined the extent of adoption and use of Free and open Source software at KNUST, FOSS innovations considered by KNUST, the challenges faced by KNUST in the adoptions and use of FOSS, possible solutions and finally a recommendation on critical issues to be considered for the effective implementation of FOSS innovations. A qualitative study with case study design was done. The study interviewed 12 permanent IT professional employees of the university, 22 national service personnel, 59 students randomly selected from specific colleges and 3 lectures. Also 500 out of the total 3000 plus computers that exist in the study area were randomly inspected to determine the operating environment as well as the type of FOSS user applications that were installed on them.

The findings indicated that, although the advantages of FOSS for KNUST far overshadow the disadvantages of migrating from the operating platform, FOSS adoption was very low than what the study expected. Additionally in terms of cost, features,

specifications and support for the current hardware FOSS provides the alternate solution. However, KNUST's FOSS adoption and use has been a failure due to a wide variety of reasons notably among them are poor student and lecturer educational awareness, the inability of the university to adequately support the ICT staff to implement FOSS innovations, and an ICT policy which is not well elaborate on the use alternate operating environment at the university. Challenges to implementing FOSS initiatives at KNUST ranged from inadequate ICT infrastructure at the study site, poor ICT skills of most lecturers as well as students. There were also inadequate funds for the ICT staff to implement alternate systems such as FOSS initiatives.

The results of this research are expected to make a THEORETICAL and/or PRACTICAL contribution to IS knowledge in proposing a Standard Operating Environment model based on FOSS and DoI.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DOI	-	Diffusion of Innovation Theory
GNU	-	GNU General Public License
HTML	-	Hypertext Markup Language
ICT	-	Information and Communications Technology
KNUST	-	Kwame Nkrumah University of Science and Technology
FOSS	-	Free and Open Source Software
SOE	-	Standard Operating Environment
IS	-	Information Systems
ICT4AD	-	ICT for Accelerated Development
TCO	-	Total Cost of Ownership
OSS	-	Open Source Software
NOC	-	Network Operating Center
MS Windows	-	Microsoft Windows, a proprietary operating system

ACKNOWLEDGEMENT

I am most grateful to the Lord God Almighty without whom I could not have been able to finish this dissertation. I am also grateful to my project supervisor Hossana Twinomurinzi at the department of Informatics, University of Pretoria for his guidance, criticisms, comments and contributions throughout this project. I am grateful also to all those who assisted me in my data collection efforts and research at KNUST, I am most grateful to you all for your assistance during my interviews and data collection.

Special thanks go to Mrs. Benedicta Affum my wife, Mr. Kwabena Affum and Dorothy Addy for their love and support throughout my many years of education.

Finally I would like to thank all those I am unable to mention here but who in diverse ways assisted me in the completion of this dissertation.

CHAPTER ONE

INTRODUCTION

1.1 *Background*

Information and communication technologies (ICTs) are widely recognized as tools that can contribute to the realization of the millennium development goals. However, in terms of being well equipped to make informed decisions on ICT architecture and choice of platform, a country like Ghana lags behind (Bruggink, 2003). Thus country is still unable to harness the full potential associated with the use of such tools to eradicate poverty. "These knowledge arrears contribute to incompatible information systems, expensive and ineffective maintenance of ICT infrastructures and resource-draining software licenses" (Bruggink, 2003). According to Bruggink (2003), addressing issue such as resource-draining software licenses with free and open source software , communities and educational institutions alike can be better equipped to develop local expertise and markets, based on ICT knowledge, and can develop a stronger domestic ICT-industry, as those seen developing in Asia over the past decade.

According to (Braimah and Frempong. 2004) the level of ICT dissemination is yet to get Ghana across the "digital divide" between the "technological haves" and the "technological have-nots". It is therefore government's responsibility to establish an enabling environment to ensure effective private sector participation for rapid deployment of ICTs if Ghana is to cross the digital divide.

The government of Ghana in 2003 released an 86 page document titled "The Ghana ICT for Accelerated Development (ICT4AD) Policy", which as the name suggests looks at ways to transform Ghana into an information-rich knowledge-based

society and economy through the development, deployment and exploitation of ICT within the economy and society.

According to this policy the implementation will be done in what they called the 5-parts rolling ICT4AD plans. The first roll out began from 2003-2006.

The Government of Ghana has placed a strong emphasis on the role of ICT in contributing to the country's economy. The country's medium-term development plan captured in the Ghana Poverty Reduction Strategy Paper (GPRS I&II) and the Education Strategic Plan 2003-2015 all suggests the use of ICT as a means of reaching out to the poor in Ghana(Mangesi 2007).

The realization of improved use of FOSS in Ghana for rapid ICT growth can also be possible if there are initiatives from government that will encourage investments in the area of creating a Standard Operation Environment (SOE) based on FOSS for use in the educational as well in government organizations. SOE is a specification for using a standard architecture and applications within an organization. An important point to note is that there is no industry-wide SOE standardization; however organizations usually deploy standard disks, operating systems, computer hardware with the same configuration and standard applications and software throughout their own organization. The benefits of having SOE specially within larger environments such as KNUST and public sector organizations, is that it leads to significant reductions in the Total Cost of Ownership (TCO) for the desktop computing environment as well as provide a framework for IT staff to effectively support and implement the university's IT infrastructure.

The Ghanaian tertiary institutions are relatively advanced in the deployment and use of ICT.. The country's major universities have their own separate ICT policy, which

includes an ICT levy for students. (Mangesi, 2007). One of such tertiary institution is the Kwame Nkrumah University of Science and Technology (KNUST) where ICT is been used for teaching, learning and research work.

The university infrastructure is based mainly on closed source software (proprietary software) infrastructure mainly Microsoft windows and its application. Students and the university alike use software that are proprietary with copyright licenses.

In the light of the above issues espoused, the researcher believes there was the need for a research work to be carried out to find how Free and Open Source Software was been used (i.e. development, deployment and implementation)and how such technologies are utilized to help in the area of teaching and learning.

The adoption of any innovation needs to be examined against a framework to help evaluate the pros and cons. The framework used in this study is the diffusion of innovation (DOI) theories, which gives rich explanations of how new innovations are adopted, and how adoption decisions are affected by perceptions of the technology itself as well as the character of the adopters (.i.e. individuals or organizations) and their environment (Tornatsky and Klein 1982; Davis 1989; Rogers 2003) .

1.2 *Problem Statement*

In a country like Ghana, finances are difficult to come by, or a country described as a developing country which is not able to finance majority of it's development projects. It is important for research work to be carried out to find alternate platform software that are more cost effective than the current software platform. This project seeks to explore how FOSS innovations are used to improve the development, deployment and exploitation of ICT in KNUST. The primary research question o is to determine:

- What Standard Operation Environment model can be created based on FOSS using the theory of Diffusion of Innovation as a guideline for developing SOE in an educational environment with specific reference to KNUST?

1.3 *Research Questions*

In trying to find answers to the primary research question, the following sub-research questions will be asked.. These questions will contribute to providing answers to the different portions of the research goal so that when merged together will contribute to answering the primary research goal:

- What information and awareness exist on the use of FOSS at KNUST?
- What Operating Environments exist in KNUST in terms of operating systems as well as application software?
- What decision adoption model can be proposed to the university for adoption, to maximize benefits from the adoption and use of FOSS?
- What SOE Model can be developed based on the Diffusion of Innovation Theory to encourage the adoption of FOSS?

1.4 *Justification*

Experiences reported from numerous projects and international institutions suggest that free and open source software has particular features that are important not only in cost reduction, but also in supporting sustainable development of software and capacity building (Bruggink, 2003). This project seeks to conduct and gather the necessary information about the use of FOSS innovations in the area of reducing cost in working environment. This information can be the basis for which other educational institution can use to evaluate the implementation of their ICT infrastructure. This case study would

gather information on the extent of knowledge, awareness and usage of FOSS in KNUST.

1.5 *Structure of the Thesis*

This study is divided into five chapters,Ch apter one is an introduction to the study. It presents a background to the study and justifies the choice of the study area as well as stating the research questions of the study.

Chapter Two provides a review of relevant literature, touching on the history of FOSS; impact of FOSS on the society. Also advantages and disadvantages are espoused for the reader interested in the use of FOSS; a review of Diffusion of Innovation theory which takes a look at how and why innovations are rejected or accepted in social systems is also presented.

Chapter Three gives a background to and describes the research methodology adopted in this study. While Chapter Four presents the results of the interview and discussions.

Chapter Five draws together the conclusions and recommendations of the study. The conclusions deal with the major findings of the study while the recommendations propose strategies which could be applied to help in the adoption and use of FOSS in KNUST.

1.6 *Research Limitations*

The major limitation in this study is the limited availability of research information in the area of the adoption and use of FOSS initiative in educational institutions in the country. Access to books and journals on the subject under considerations was also

difficult to come by from free journals, as most of those accessed for free were of little significance to the study. However the project supervisour was able lend me some of his personal documents for use

CHAPTER TWO

LITERATURE REVIEW

2.1 *Introduction*

A literature study was conducted to obtain and provide information on what FOSS is and issues that affects it. This section looks at the history of FOSS and its advantages and disadvantages as documented.. The chapter also provides a detailed description of the DOI theory.

Preliminary investigation at the study site conducted prior to writing this thesis shows that there was the need to provide a history of how 'Free and Open source software' (FOSS) began. Thus this introduction is being made available to those that may be new to FOSS phenomenon or movement. The following issues will be looked at:

- What is Free Open Source Software?
- A short history of Free Open Source Software
- What Free Open Source Software are available?
- The impact of Free Open Source Software on society

2.2 *What is Free Open Source Software?*

Analysis of any computer system shows that it comprises of hardware and software components. The hardware is the physical conglomerate of different components joined together to perform a processing function. For the processing function to come to fruition, the computer user needs software(s) that has been made for that particular processing function. This software is normally a text written in programming language for example C or C++ by programmers to run a particular activity. According to (Perens

1998), software can be classified as either proprietary software or free and open source software. The difference between these two categories has to do with the rights to which the user, who has obtained the software, is entitled to. Proprietary software typically denies rights that the user gets from free and open source software, the most prominent being the right to access to the source code. Examples of this category of software are Microsoft Windows 2000/XP/Vista/Windows 7, Microsoft Office suite, Macromedia Dreamweaver,Ad obe Photoshop, etc.

The Free Open Source Software (FOSS) development model has a different approach from that of the proprietary software development model. FOSS development model suggests that when the source code of software is made available there would be no need for another programmer to reinvent the wheel again. With the availability of the source code to the public, any programmer can modify the software and make this modified version available to the public.

This led to the creation of a new model, where the source code of FOSS, included a license that said that the source code may be read and extended by any person. This also means that extended code will also be considered as "Open Source". This also implies that it is not possible for any person or company to extend a piece FOSS source code and then call it their own. It should also be noted that it is possible for a person or company to create proprietary software that implement other open source codes, and then sell the proprietary software, but open source and its extension must be published and anyone must be allowed to use them freely (Pothmann 2005).

2.3 *A short history of Free Open Source Software*

In the early days of computing, computers were as huge as houses and some were even as huge as a stadium. Computer manufacturers made money from the sale of

computer hardware. The computer software were freely distributed among programmers who freely modified it for their use and passed on the modified version to other programmers, but this did not last long as software companies sprang up and started to change the rules of how software was developed. These companies saw software as only a means of making money, rather than a means of making life easier for the users.

Up until the early 1980s, AT&T didn't have to think much about competition because if you wanted a phone in the United States, you had to go to AT&T. Thus the telephone company had the luxury of funding pure research projects and majority of such projects were at the bell laboratories. Engineers at the laboratories created the UNIX operating system and nurtured it in a communal environment. Its creation was not driven by market needs, but by a desire to overcome impediments to producing programs.

Before the AT&T divestiture in 1984, AT&T's had monopoly of the U.S. Telephone system. The U.S. Government was concerned that an unrestricted AT&T might dominate the fledgling computer industry. AT&T was thus forbidden to sell computer systems by their government which made AT&T sell licensed UNIX source code to universities for a nominal fee. At the time, many of the concepts (and even much of the early code) that made UNIX special had fallen into the public domain.

Another important landmark toward the conception of FOSS took place in 1975, when UNIX v6 became the first version of UNIX available for widespread use outside of bell laboratories. From this early UNIX source code, the first major variant of UNIX was created at university of California at Berkeley (UC Berkeley). It was named the Berkeley software distribution (BSD) which was released to the public in 1977. The UC Berkeley BSD made advances in the communal sharing of their source code similar to what pertained in the early bell UNIX Lab.

By the late 1980s, BSD developers at UC Berkeley had already rewritten most of the UNIX source code in the C programming language that made it more portable (i.e. C programming language can be installed on different computer brands)from the original UNIX code they got in the 1970s. In 1989, University of California (UC) Berkeley distributed its own UNIX clone code as Net/1 and later (in 1991) as Net/2. Just as UC Berkeley was preparing a complete, UNIX-like operating system that was free from all AT&T code, AT&T hit them with a lawsuit in 1992. The suit claimed that the software was written using trade secrets taken from AT&T's UNIX system. It's important to note here that BSD developers had completely rewritten the copyright-protected code from AT&T. Copyright was the primary means AT&T used to protect its rights to the UNIX code. The lawsuit was dropped when Novell bought UNIX system laboratories from AT&T in 1994. But, during that critical time period, there was enough fear and doubt about the legality of the BSD code that the momentum BSD had gained to that point in the fledgling open source community was lost (Negus 2008).

The next major effort towards the open source movement came from Richard M. Stallman who worked for the artificial intelligence lab at renowned Massachusetts Institute of Technology. Stallman had been around since the dark ages of computing, back when mainframe computers were "time-shared" among users who used small desktop terminals to access them. At MIT, the custom then was if you created a program to perform a particular task; you offered it to practically anyone who wanted it. Alternatively, if you found an existing program wasn't adequate or had a bug, you improved it yourself, and then made the resulting program available to others. This way of sharing software was disorganized and done on an ad hoc basis, but came about of its own accord. Nobody questioned it, and it seemed the best way of doing things(Hippel and Krogh 2003).

In the 1980s, everything changed, the world became more corporate, and with the rise of the Personal Computers (PC) which was developed by the computer giant IBM. Thus the software industries that were springing up then, received a major push as more and more people needed software to run on their new PCs. This led to the concept of proprietary software becoming widespread, and more companies started to sell software. They reasoned that this was impossible to do business if they shared their source code with everybody else, so they kept it a secret. Microsoft led this change and did very well with its proprietary software.

According Thomas and Sicam (2008), Stallman had nothing against software being sold for a profit, but he hated the fundamental ideas behind software source code being kept secret. He felt passionately that sharing software with it source code and being able to understand how it worked was akin to free speech which is necessary and vital for the furthering of technology, and therefore society itself. According to him, how could the new generation of programmers improve on the previous generation's work if they were unable to see how it worked? It was absurd to need to create software from scratch each time, rather than taking something that already existed and making it better. Because of his beliefs, Stallman resigned from his job in the MIT artificial intelligence lab and founded gnu. His aim initially was to produce a complete clone of UNIX that would be shared in the ways he knew from the early days of computing. This software would be available for everyone to use, to study, and to adapt. It would be free, in the same sense as free speech — shared and unrestricted. This gave rise to the vital concept of "free software" (Thomas and Sicam 2008). In 1984, Richard M. Stallman started the GNU project, which stands for gnu's not UNIX. GNU was intended to become a recoding of the entire UNIX operating system that could be freely distributed

In 1985 the Free Software Foundation (FSF) was formed to help promote the GNU project as well as other free software from other people and companies(Hippel and Krogh 2003). The foundation raised funds through the selling of copies of some of GNU programs such as Emacs (Even though the GNU software is "free" in the sense that anyone is allowed to copy the source code and work with it, the GNU project did need money to survive, and people were willing to pay a price for the free software) and through donations from users and some big IT companies like IBM, Cisco, and HP etc.

According to Pothmann (2005) the FSF in order to prevent companies from incorporating GNU source code into their own software and making the software proprietary, lawyers of the foundation created the GNU Public License (GPL). All of GNU source code and software were licensed by GPL.

It is important to note that by 1990 almost every component of the UNIX had been re-written except for central component of the operating system (i.e. the kernel) which controls the computer's resources (etc. memory, files and process).

In 1991 Linus Torvalds introduced a new paradigm in software development that is now maturing and has the potential to change the world. Torvalds developed an operating systems kernel called Linux. Initially he was interested in developing a small version of the UNIX operating systems based on Minix that had been developed by the Dutch computer science professor Andrew Tanenbaum for teaching.

In order to improve the software Torvalds decided to share his code with the software community outside the University of Helsinki in Finland using the Internet. The software community based approach in the development of Linux gave the real boost to the Open Source Software (OSS) philosophy. Since then OSS has proven that it is able to produce software that is able to contend with proprietary produced software.

It is important to know at this point that the Linux kernel was not a complete operating system thus the Linux community used the UNIX software developed by the GNU project to create a fully functional operating system. The kernel is also released under the GNU Public License. According to Pothmann (2005), since the release of the first GNU/Linux (a combination of the operating systems and supporting applications) by Torvalds in 1994, there has seen significant growth of its popularity among computer users.

2.4 *What FOSS Products are Available?*

The past twenty years or so of the FOSS development has produced hundreds of millions of lines of code, and tens of thousands of software programs and packages. At this point it is important to describe some of the most common and successful FOSS products and projects out there.

"These projects and resultant technologies have a huge potential for improving the security levels, stability and quality of computing environments, and for cutting costs in developed countries, but they also provide a viable and affordable alternative for developing countries in their pursuit of developmental goals"(Rajani, Rekola et al. 2003).

Table 2. 1 Show some FOSS that available

GNU/Linux	
GNU/Linux or Linux	Is most commonly known is the most prominent of the Free and Open Source Software. As an operating system, it is a very stable multi-user and multitasking operating system (OS). It can be used on servers, IT infrastructure (e.g. firewalls, routers), mobile phones, audio and video devices, watches, cameras, PDAs, Desktop computers, etc. Due to the open source nature of GNU/Linux, many companies compile their own Linux distribution that normally bears the aspiration of what the company seeks to achieve with that distribution. These distributions are normally named after the company which compiles or distributes them. Some well known Linux compilation or distributions (or simply called distros) include Debian GNU/Linux, Ubuntu Linux, SuSe Linux and Red Hat Linux. Apart from those distros listed here, one can also find about 180 distros of the GNU/Linux available for purposes which serve the needs of a huge variety of Linux users. It important to noted that all these distros use the same Linux kernel with some additional tools and applications
Infrastructure / Server Software	
Apache	Is the world's most popular web server. Netcraft's statistics show that Apache powers more than 60% of the world's web servers. This is about twice the size of Microsoft's IIS (Internet Information Server). Apache is available for more than 20 platforms, including Linux and Microsoft Windows.
Mozilla	Is a Web Browser project which descended from the Netscape browser; it is available on Linux, Windows and Mac Operating Systems. Today, the project has a modern browser (Firefox) and an email client (Thunderbird).
BIND	It is an acronym that stands for "Berkeley Internet Name Daemon", and is the Internet de-facto standard program for turning host names into IP addresses. More than 90% of the Domain Name Servers of the world use BIND.
Sendmail	It is developed by the Berkeley University, which is the most widely used mail server software in the world accounting for at least 40% of mail servers.
Postfix	Is a newer mail server which was developed as an alternative to the popular Sendmail. It is designed to be faster and more secure than Sendmail.
Squid	Used a proxy for the internet in a network environment.

Software for Linux / Windows interoperability	
Samba	Is an award winning Free Software/Open Source implementation of Microsoft's SMB/CIFS protocol for file and printer sharing. Samba lets a Linux computer act like Windows NT or 2000 servers, offering a better performance and stability. Samba is widely used software which makes a seamless co-existence of Windows, Linux and even Macintosh computers possible. According to an (itweek.co.uk) report, Samba outperforms Windows 2000 by a wide margin.
Rdesktop	Enables a Linux computer to access a Windows Terminal server (which means that Windows applications that run on a Windows server can be used from a Linux client).
WINE	Enables Linux computers to run Windows software
Software Development Tools	
PERL	Is a high-level programming language with an eclectic heritage written by Larry Wall and a cast of thousands terms around the world. It is the favourite tool of any system administrator, and runs on most of the UNIX platforms, Windows and Mac.
PHP	(Recursive acronym for "PHP: Hypertext Preprocessor") is a widely-used Open Source general-purpose scripting language that is especially suited for Web development and can be embedded into HTML.
Others	Include the GNU C Compiler, the programming language Python; the Concurrent Versions System (CVS); the text editor GNU Emacs; and many others.
Database	
MySQL	Is produced by the MySQL AB Company; it is the most popular open source database server in the world. MySQL is a relational Database Management System, which is stable and fast. The MySQL database has an estimated 4,000,000 active installations worldwide, these installation are used in powering dynamic websites, data warehouses, business applications, logging systems and more. One should note that MySQL database server is distributed under a dual licensing scheme, which means it, is available at zero prices under the GPL, but is also sold under a commercial license to those who do not wish to be bound by the terms of the GPL and require support.
Desktop Software	

Open Office20/ OpenOffice.org	Is the largest Open Source project in the world and over 30 million downloads of the Open Office desktop software have been made. It has been derived from the Star Office suite, which was bought by Sun Microsystems (and which is now also Open Source.) OpenOffice.org. components include word processing, spreadsheets, presentations, drawings, data charting, formula editing, and file conversion facilities (including those for Microsoft Office formats). OpenOffice.org uses EXtensible Markup Language (XML) as a standard for its data formats because it is an industry standard and the best choice for interoperability documents, which is a huge plus since any documents created by the Open Office applications can be opened with other XML aware applications.
Tex / Latex	Package was created by the computer science professor Donald Knuth of the Standford University, and is used mainly to write academic publications and books (like this one, for example).
Gimp	(GNU Image Processing) is digital image processing software, which has gained some maturity (and whose layout is similar to Adobe Photoshop).

2.5 *Impact of FOSS on Society*

At this point it is important to state both the positive and negative impact of FOSS that other countries which have implemented FOSS have documented.

For the past eight or so years, many governments around the world have conducted extensive research on the subject of FOSS. There is a list of many reports that have been prepared in western and developed countries, e.g. in the U.S.A, in Canada, Germany, France and many other European countries, and by the European Union (Office of Government Commerce (UK) 2004)[OGC]. One of such government in particular is the British Government that has carried out several studies. Out of these many documents, there are two main documents from the British Government that are of importance to this project,t hese are:

The case study "Open Source Software Trials in Government" by the Office of Government Commerce (OGC) in 2004, the other is from the private defense technology

company QinetiQ, 2002 in 2001 titled *"Analysis of the Impact of Open Source Software"*.

According Pothmann (2005), these two reports advised the British Government in two ways;

- How and if the Government should influence the adoption of Open Source in the country, for example by encouragement or by funding research.
- The other is how and whether, Open Source Software should be used in Government institutions and offices.

The reports consider Future Trends of Open Source, Advantages and Disadvantages of its Adoption and analyze trials of Open Source Software in several governments' institutions.

2.6 *Advantages and Disadvantages of Open Source*

The two quoted British report also listed a spectrum of advantages and disadvantages, which according Pothmann (2005) can be associated to different areas in the use of ICT:

(i) impact on society,

(ii) on business using the software,

(iii)t hen influence of the Open Source development model on the quality of software, and

(iv) the process of software development itself.

2.7.1 Advantages

2.6.1.1 Societal Impact of FOSS

- Interoperability: It should be noted that FOSS (or OSS) developers are aware that a lot of potential users of FOSS are already working or using proprietary software based on mainly Microsoft platforms. Thus they strive to make FOSS interoperability and compatible as much as possible with proprietary software. The Open Office suite from Sun Microsystems for example incorporates the capability to process and handle documents that have been created with Microsoft Office suite. QinetiQ, Report (p. vii) noted that: "many of the Government's risks arise from over dependence on proprietary protocols and data formats, for interoperability can be controlled by the selective use of open data standards. The Government can develop its own standards for use within communities-of-interest (e.g. MOD, Health etc)".
- Use in Research: the FOSS model of software development suits the unbound status and free attitude of researcher. Thus "Open Source is an obvious subject for projects in Universities" [QinetiQ, 2002, p. 7]. This is so because it is the nature of computer science minded students and programmers to want to take a closer look at a software source code so as to be able to develop new programs or modify it.
- Ease of User adoption: The ability of users to deploy and use OSS software without having to sign licenses, or make financial cases to their management, aids initial take up.

2.6.1.2 Impact on Business and Institutions

- Difficulties in identifying appropriate OSS applications for particular business problems: Because OSS is not advertised in quite the same way as is proprietary software, public sector institutions may not be aware that a particular OSS product is available to meet their needs [OGC, p. 8].
- Lack of experience and support for migration from proprietary software installations to FOSS: "Purchasers must be able to integrate OSS with their existing installed base and must understand how to migrate from a single supplier product to a more diverse product set." [OGC, p. 8] This situation is certainly true for many OSS projects; some however are marketed by large companies, like for example SuSe by Novell, or Red Hat that do provide support.
- Support for new hardware: FOSS currently exhibit some sort of delay in releasing support for new hardware as compared to Microsoft. "Largely this is a result of the hardware suppliers not releasing new drivers to the OSS community on time. But, as with the issue of maintenance and support, that problem is diminishing as the hardware suppliers themselves begin to use and market OSS on their platforms" [OGC, p. 8].
- Portability of FOSS packages: "Even where a particular platform is not currently supported, the open availability of the source code allows the community to port that software to a new platform relatively quickly. Platform independence gives the purchaser a wider choice of hardware in any procurement" [OGC, p.6].
- Avoidance of proprietary lock-in: According to Pothmann (2005), another risk posed by proprietary software to users, is that companies tend to design their products to be dependent on each other, which means buying one of them implies having to buy the others as well. On the other hand "OSS tends to be written to

be independent of any other related product. Purchasers can often assume that one software product will work best with another from the same family produced by the same manufacturer. Use of OSS offers users greater freedom to purchase other products, thus reducing the tendency to lock-in" (OGC, p.6).

- Independence: This point is one of the beauties in the use of FOSS as we are not tied to one company or software maker. "If OSS is used then the source is already available to the purchaser (as well as the wider community) and Government could simply take that code to a new supplier, should the original supplier disappear or withdraw support for whatever reason."(OGC, p.6)
- Lower Licensing Cost: According to the QinetiQ, report (p.6) asserts that, "Although, in reality, software licensing costs are not a major part of the Total Cost of Ownership (TCO) of IT, the attraction of the software being free should not be underestimated." According to Pothmann (2005), this is especially the case in developing countries where expensive corporate software licenses for many computers may be unaffordable in such economies.

2.6.1.3 Quality of FOSS Software

These are advantages to society and business as well.

- Fast Updates: The large number of people participating in the use and testing of FOSS leads to quick responses to user requirements, and quick update cycles: "The upgrade cycle for Open Source is usually much faster than the typical 12 - 18 months cycle of proprietary products" [QinetiQ, 2002, p. 8].
- Large developer community: Currently the size of the Open Source developer community is very large. The QinetiQ, Report - "estimate that there are many tens of thousands of active Open Source developers; hundreds of thousands of active beta testers (A "beta version" is a software release that has not been tested

sufficiently. A "beta tester" is thus a person who tries to find bugs in the software (by using it) and reports bugs to the developers.); and a non-proprietary user base of about 5 million Open Source supporters (and many more millions of users) (QinetiQ 2002).

- Reliability: Because security leaks are found, reported and patched quickly by many users and or testers, "most OSS becomes highly robust at a surprisingly early stage of its development, and mature Open Source products are setting new industry standards ….." [QinetiQ, 2002, p. 8].
- Attraction of experienced developers: "The Open Source community attracts very bright, very motivated developers, who although unpaid, are often very disciplined. In addition, these developers are not part of corporate cultures where the best route to large salaries is to move into management, hence some Open Source developers are amongst the most experienced in the industry" [QinetiQ, 2002 , p. 6].

2.6.1.4 The Process of Software Development

- Unique advantage in "Crossing the Chasm": "The reason that products drop into the chasm (i.e. they fail to establish a sustainable market share) is that companies choose to cut their losses rather than keeping on funding the product in the hope that it achieves acceptance in a niche or mainstream market. Proprietary developers solve this problem by having the resources and management commitment to continue pushing products that they believe in (e.g. Microsoft with Windows and Windows NT) for as long as it takes for them to take off. Open Source solves this by having a zero cost base – so running out of money is not a problem - as long as the group of developers maintain their interest they can keep on going" [QinetiQ, 2002 , p. 6].

- Well written code: "Open Source is often better structured and with better program documentation than proprietary software - after all, everyone can see an Open Source developer's code so personal pride (and the need to maintain the respect of one's peers) usually ensures it looks pretty. Indeed large, geographically dispersed teams can only work well if the software design is highly modular" [QinetiQ, 2002, p. 9].

2.7.2 Disadvantages

2.6.2.1 Business and Institutions Using Open Source

- Uncertainty about the future: The large growths of Free and Open Source software are over the last twenty years or so, cannot just be a hype. According Pothmann (2005), it is hard to predict in which areas it will grow even further. "This is not a disadvantage of Open Source itself but it comes with any kind of new possibilities. In order to make strategic decisions, it is however necessary to know what "everyone else" is going to use in the future" (Pothmann 2005).
- Negative Perceptions of FOSS: It must be noted that there are a lot of negative perceptions that FOSS still has to overcome. Even though "most of these perceptions have little actual substance, it will require lots of additional publicity about deployment of Open Source in large, respected companies to overcome them." [QinetiQ, 2002, p. 9]. Some negative perceptions as quoted from QinetiQ, 2002 include :
  - Senior managers are likely to equate "free" with "unreliable".
  - There is no proprietary organization you can sue if something goes wrong.
  - Because I don't pay the software developer I don't have control over them.

- Because the developers are motivated by recognition rather than by money, they are unpredictable; for example, they might rush off and work on a new, more exciting Open Source project.

- Difficulties in identifying appropriate FOSS applications for a particular business problem: Business institutions as well as public sector institution may not be aware that a particular FOSS product is available to meet their needs. This situation is due to the fact that FOSS is not advertised quite the same way as proprietary software, [OGC, p. 8]
- Lack of experience and support for migration from proprietary software installations to OSS: "Purchasers must be able to integrate OSS with their existing installed base and must understand how to migrate from a single supplier product to a more diverse product set." [OGC, p. 8] This situation is certainly true for many OSS projects; some however are marketed by large companies, like for example SuSe by Novell, or Red Hat that do provide support.

2.6.2.2 Quality of Software

- Documentation of FOSS: "Documentation can be idiosyncratic i.e. non-understandable by non-technical people or sometimes non-existent. Many OSS developers are primarily motivated by software development rather than producing documentation which is expected by proprietary buyers" [OGC, p. 8].
- Late Implementation of Ease-of-Use Features: FOSS developments are carried out with no funded product development budget. In practice, this means that FOSS tends to have ease-of-use features and user-oriented documentation significantly implemented later in their life cycle than proprietary products. This was the case in early Linux distributions, which caused Linux Operating System

attract a lot of justifiable criticism for the complexity and lack of standardization of their installation and management processes.

2.6.2.3 The Process of Software Development

There is no marketing budget to push the product: An OSS project can only rely on its developers and on users and software magazines finding the product interesting. A good project thus may not find a large group of users and not be developed any further.

Break up of FOSS project: "Open Source developers tend to be very passionate about technical issues. Consequently, without a project leader with good people skills an Open Source project can break up in acrimony" [QinetiQ, 2002, p. 7].

2.7 *Adoption Theory Used In the Study*

2.8.1 Introduction

In this section a literature review is made on the issues of how innovations are diffused in a community. A look at literature reveals the work of (Tornatzky and Klein, 1982; Rogers, 2003) as providing appropriate framework with which any diffusion of innovation can be conceptualized. This section also throws light on factors that should be considered when one tries to initiate innovation, if that innovation is to become accepted and used.

2.8.2 Diffusion of Innovations Theory

The adoption process of new innovations such as FOSS in a social system has been studied for almost three decades now. . According to Kautz (1999), diffusion of innovation literature describes patterns of technology adoption and explains the process

of a particular technology's use within a social system, which assists in predicting how and whether a new innovation will be successful in a social system. Ryan and Gross (1943) work in rural sociology has been cited as the beginning of diffusion of innovation research. In their work they used interviews as their main method of data collection; this has been the trend in diffusion research ever since (Yates 2001)

Rogers' diffusion of innovations theory is the most appropriate framework for investigating the adoption of FOSS technology in tertiary education and educational environments as a whole (Parisot 1995; Medlin 2001). Thus diffusion of innovation theory can inform the government of Ghana on how to effectively plan and implement policies and initiatives in tertiary institution to aid in the adoption of FOSS for rapid ICT growth.

Rogers (2003) described Diffusion as the process by which an innovation is communicated through certain channels over a time period among the members of a social system.

"An innovation may have been invented a long time ago, but if individuals perceive it as new, then it may still be an innovation for them. The newness characteristic of an adoption is more related to the three steps (knowledge, persuasion, and decision) of the innovation-decision process." (Sahin, 2006).

Rogers (2003) espouses four major theories that deal with the diffusion of innovations. These are the innovation-decision process theory, the individual innovativeness theory, the rate of adoption theory, and the theory of perceived attributes.

2.8.3 Four Main Elements in the Diffusion of Innovations

Charlton et al. (1998) described four generally accepted elements which are involved in the diffusion of new ideas such as FOSS in a social setting:

- the innovation itself;

- the communication channel(s) through which an innovation is disseminated;
- the time-frame in which this occurs;
- and the social system where the innovation is introduced

It should be noted that Rogers' (2003) diffusion of innovation paradigm has been particularly influential in elaborating these elements. Which describes the characteristics of an innovation as in the case FOSS, which influences the rate of adoption? The theory also requires that a diffusion process considers the norms and beliefs of a social system and examines adopter behaviour and rates of adoption by individuals within their local contexts (Simpson, 2005).

2.8.3.1 Theory of Perceived Attribute (Innovation)

Simply put: "An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). The characteristics of an innovation, as perceived by the members of a social system, determine its rate of adoption (Rogers, 2003 p.219). Thus the theory of perceived attribute is based on the notion that individuals will adopt the use of an innovation if it has attributes that is consistent with their needs (Yates, 2001). This theory more or less helps explain why certain innovation spread more quickly than others.

- Relative Advantage of FOSS: Rogers (2003) defined relative advantage as "the degree to which an innovation is perceived as being better than the idea it supersedes" (p. 229). The degree of relative advantage may be measured in economic terms, but social prestige, convenience, and satisfaction are also important factors. It does not matter so much if an innovation has a great deal of objective advantage, what does matter is whether an individual, an educational or public institution will perceives the innovation as advantageous. Therefore the

greater the perceived relative advantage of FOSS innovation, the more rapid its rate of adoption will be.

- Compatibility of FOSS: Rogers (2003) stated that "compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p. 15). According to Rogers & Scott (1997) an idea that is not compatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. The adoption of an incompatible innovation often requires the prior adoption of a new value system, which is a relatively slow process". Thus the project will seek to find whether this problem is evident in the university's social system.
- Complexity of FOSS: According to Rogers (2003) complexity is "the degree to which an innovation is perceived as relatively difficult to understand and use" (p. 15).Rogers noted that, opposite to the other attributes, complexity is negatively correlated with the rate of adoption. This implies that, excessive complexity of an innovation is an important obstacle in its adoption. Thus new innovations that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding. Thus if FOSS is more user-friendly and less complex than the already existing systems, then they might be adopted successfully in our educational institution (Martin 2003).
- Triability of FOSS: Rogers (2003) defined, "Triability as the degree to which an innovation may be experimented with on a limited basis. New ideas that can be tried on the installment plan will generally be adopted more quickly than innovations that are not divisible. An innovation that is triable represents less uncertainty to the individual who is considering it for adoption, who can learn by

doing (Rogers and Scott 1997). This is a strong point of FOSS where individual can obtain copies of FOSS from the Internet and install them and try for free.

- Observability of FOSS: The last characteristic of innovations is Observability. Rogers (2003) defined it as "the degree to which the results of an innovation are visible to others" (p. 16). The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Such visibility stimulates peer discussion of a new idea such as FOSS.(Rogers & Scott, 1997)

2.8.4 Communication

The next element in the diffusion of innovation theory is the communication channel. According Rogers (2003), communication is "the process by which respondents create and share information with one another in order to reach a mutual understanding" (p. 5). The ensuing communication occurs through channels between sources. Rogers states that "a source is an individual or an institution that originates a message. A channel is the means by which message gets from the source to the receiver" (p. 204). Mass media and interpersonal communication are two communication channels that are available for use (Sahin, 2006). It should be noted that mass media channels are more effective in creating knowledge of innovations, whereas interpersonal channels are more effective in forming and changing attitudes toward a new idea (Rogers & Scott, 1997).

Mass media channels may include TV, radio, or newspaper, while interpersonal channels consist of a two-way communication between two or more individuals. On the other hand, "diffusion is a very social process that involves interpersonal communication relationships" (Rogers, 2003, p. 19). Thus to influence the decision to adopt or reject a new idea such as FOSS, most individuals will evaluate the FOSS innovation, not on the basis of scientific research by experts, but through the subjective evaluations of near-peers who have adopted the innovation (Rogers & Scott, 1997).

2.8.5 Time

2.8.5.1 Innovation-decision process theory

The third main element in the diffusion of new ideas is time. The time dimension is involved in diffusion in three ways. According to Rogers & Scott (1997), first, time is involved in the innovation-decision process theory. The innovation-decision process is the mental process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. Rogers in 2003 described the innovation-decision process theory as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p. 172).

According to Rogers (2003), the innovation-decision process theory involves five step processes: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages typically follow each other in a time-ordered manner. This process is shown in Figure 2.1

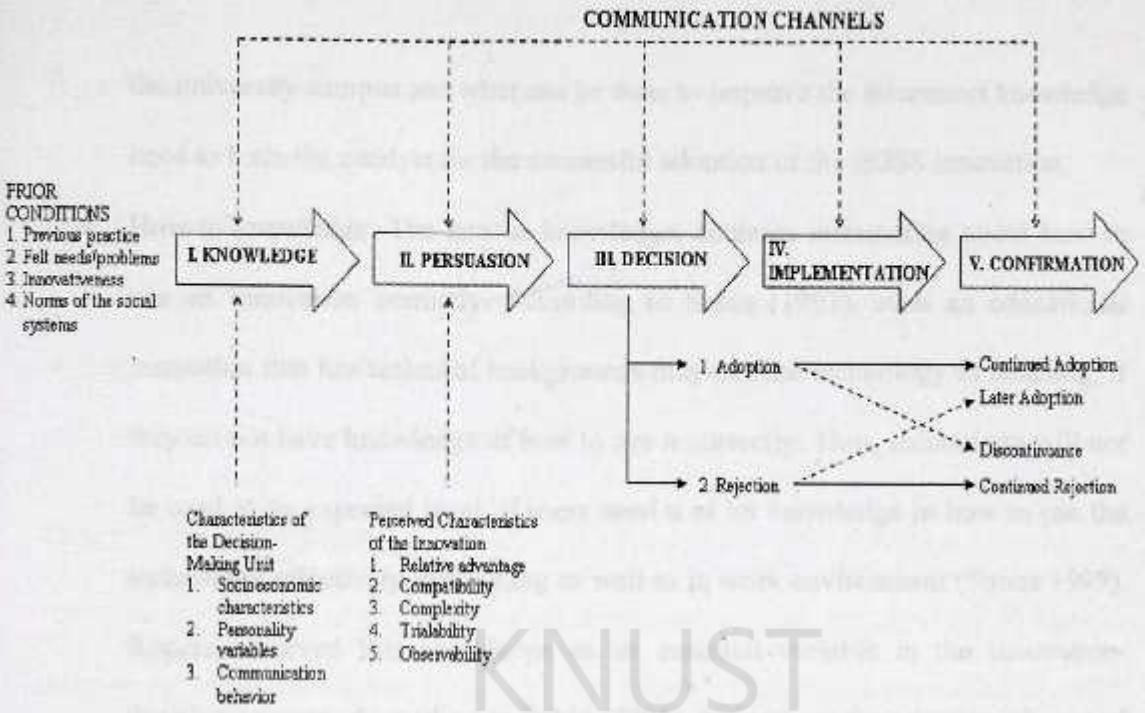


Figure 2 1: *A Model of Five Stages in the Innovation-Decision Process*

Source (Diffusion of Innovations, Fifth Edition by Everett M. Rogers.)

2.8.5.1.1 The Knowledge Stage

The innovation-decision process begins with the knowledge stage, at this stage; an individual learns about the existence of innovation and seeks information about the innovation (Sahin, 2006). "What?", "how?", and "why?" are the critical questions in the knowledge phase. During this phase, the individual attempts to determine "what the innovation is and how and why it works" (Rogers, 2003, p. 21). Rogers's states that, the questions forms three types of knowledge: (1) awareness-knowledge, (2) how-to-knowledge, and (3) principles-knowledge.

- Awareness-knowledge: Awareness-knowledge represents the knowledge of the innovation's existence. This type of knowledge can motivate the individual to learn more about the innovation and, eventually, to adopt it. Also, it may encourage an individual to learn about other two types of knowledge (Sahin, 2006).Thus this type of knowledge is very important, to inquire if it thus exist on

the university campus and what can be done to improve the awareness knowledge need to form the catalyst for the successful adoption of the FOSS innovation.

- How-to-knowledge: The how-to-knowledge, contains information about how to use an innovation correctly. According to Sahin (1993), even an educational institution that has technical backgrounds may not use technology in teaching, if they do not have knowledge of how to use it correctly. Thus, technology will not be used at an expected level, if users need a of lot knowledge in how to use the technology effectively in teaching as well as in work environment (Spotts 1999). Rogers observed this knowledge as an essential variable in the innovation-decision process. According to Sahin (2006), to increase the adoption chance of an innovation, an individual should have a sufficient level of how-to-knowledge prior to the trial of this innovation. Thus, this knowledge becomes more critical for relatively complex innovations.
- Principles-knowledge: The last knowledge type is principles-knowledge. This knowledge includes the functioning principles describing how and why an innovation works. An innovation can be adopted without this knowledge, but the misuse of the innovation may cause its discontinuance (Sahin, 2006). It should be noted that, an individual may have all the necessary knowledge required, but this will not necessarily translate to mean that the individual will adopt the innovation. This is because the individual's attitudes also shape the adoption or rejection of the innovation.

2.8.5.1.2 **The Persuasion Stage**

The persuasion step occurs when the individual has a negative or positive attitude toward the innovation, but "the formation of a favorable or unfavorable attitude toward an innovation does not always lead directly or indirectly to an adoption or rejection"

(Rogers, 2003, p. 176). The individual shapes his or her attitude after he or she knows about the innovation, so the persuasion stage follows the knowledge stage in the innovation-decision process. Furthermore, Rogers states that while the knowledge stage is more cognitive- (or knowing-) centered, the persuasion stage is more affective- (or feeling-) centered. Thus, the individual is involved more sensitively with the innovation at the persuasion stage (Sahin, 2006).

2.8.5.1.3 **Decision Stage**

At the decision stage in the innovation-decision process, the individual chooses to adopt or reject the innovation. While adoption refers to "full use of an innovation as the best course of action available," rejection means "not to adopt an innovation" (Rogers, 2003, p. 177). If an innovation has a partial trial basis, it is usually adopted more quickly, since most individuals first want to try the innovation in their own situation and then come to an adoption decision. The vicarious trial can speed up the innovation-decision process. However, rejection is possible in every stage of the innovation-decision process (Sahin, 2006).

2.8.5.1.4 **The Implementation Stage**

At the implementation stage, an innovation is put into practice. However, an innovation brings the newness in which "some degree of uncertainty is involved in diffusion" (p. 6). Thus, the implementer may need technical assistance from change agents and others to reduce the degree of uncertainty about the consequences. Moreover, the innovation-decision process will end, since "the innovation loses its distinctive quality as the separate identity of the new idea disappears" (Rogers, 2003, p. 180). Reinvention usually happens at the implementation stage, so it is an important part of

this stage. Reinvention is "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers, 2003, p. 180).

2.8.5.1.5 The Confirmation Stage

At the confirmation stage the individual looks for support for his or her decision. According to Rogers (2003), this decision can be reversed if the individual is "exposed to conflicting messages about the innovation" (p. 189). However, the individual tends to stay away from these messages and seeks supportive messages that confirm his or her decision. Thus, attitudes become more crucial at the confirmation stage. Depending on the support for adoption of the innovation and the attitude of the individual, later adoption or discontinuance happens during this stage (Sahin, 2006).

2.8.5.2 Individual innovativeness Theory

The second way in which time is involved in diffusion is in the individual innovativeness theory or other unit of adoption. Rogers (2003) described, innovativeness as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system" (p. 22). Also Braak (2001) described innovativeness as "a relatively-stable, socially-constructed, innovation-dependent characteristic that indicates an individual's willingness to change his or her familiar practices" (p. 144). From the definition asserted by Rogers arise the issue of adopter categories.

Rogers (2003) thus define the adopter categories as "the classifications of members of a social system on the basis of innovativeness" (p. 22). This classification includes innovators, early adopters, early majority, late majority, and laggards as shown

in figure 2.2. In each adopter category, individuals are similar in terms of their innovativeness.

2.8.5.2.1 **Adopter Categories**

- Innovators are the "first 2.5 percent of the individuals in a system to adopt an innovation. Their interest in new ideas leads them out of a local circle of peer networks and into more cosmopolitan social relationships. Communication patterns and friendships among a clique of innovators are common, even though the geographical distance between the innovators may be considerable. Being an innovator has several prerequisites. Control of substantial financial resources is helpful to absorb the possible loss from an unprofitable innovation. The ability to understand and apply complex technical knowledge is also needed. The innovator must be able to cope with a high degree of uncertainty about an innovation at the time of adoption. While an innovator may not be respected by the other members of a social system, the innovator plays an important role in the diffusion process: That of launching the new idea in the system by importing the innovation from outside of the system's boundaries. Thus, the innovator plays a gatekeeping role in the flow of new ideas into a system from outside" (Rogers & Scott, 1997, p. 5).
- Early adopters are the "next 13.5 percent of the individuals in a system to adopt an innovation. Early adopters are a more integrated part of the local system than are innovators. Whereas innovators are cosmopolites, early adopters are localites. This adopter category, more than any other, has the greatest degree of opinion leadership in most systems. Potential adopters look to early adopters for advice and information about the innovation. This adopter category is generally sought by change agents as a local missionary for speeding the diffusion process. Because early adopters are not too far ahead of the average individual in

innovativeness, they serve as a role-model for many other members of a social system. The early adopter is respected by his or her peers, and is the embodiment of successful, discrete use of new ideas. The early adopter knows that to continue to earn this esteem of colleagues and to maintain a central position in the communication networks of the system; he or she must make judicious innovation-decisions. The early adopter decreases uncertainty about a new idea by adopting it and then conveying a subjective evaluation of the innovation to near-peers through interpersonal networks" (Rogers & Scott, 1997, p. 5).

- Early majority is the "next 34 percent of the individuals in a system to adopt an innovation. The early majority adopt new ideas just before the average member of a system. The early majority interacts frequently with their peers, but seldom holds positions of opinion leadership in a system. The early majority's unique position between the very early and the relatively late to adopt makes them an important link in the diffusion process. They provide interconnectedness in the system's interpersonal networks. The early majority are one of the two most numerous adopter categories, making up one-third of the members of a system. The early majority may deliberate for some time before completely adopting a new idea. "Be not the first by which the new is tried, nor the last to lay the old aside," fits the thinking of the early majority. They follow with deliberate willingness in adopting innovations, but seldom lead" (Rogers & Scott, 1997, p. 5).
- Late majority is the "next 34 percent of the individuals in a system to adopt an innovation. The late majority adopt new ideas just after the average member of a system. Like the early majority, the late majority make up one-third of the members of a system. Adoption may be the result of increasing network pressures

from peers. Innovations are approached with a skeptical and cautious air, and the late majority do not adopt until most others in their system have done so. The weight of system norms must definitely favor an innovation before the late majority is convinced. The pressure of peers is necessary to motivate adoption. Their relatively scarce resources mean that most of the uncertainty about a new idea must be removed before the late majority feel that it is safe to adopt" (Rogers & Scott, 1997, p. 5).

- Laggards are the "last 16 percent of the individuals in a system to adopt an innovation. They possess almost no opinion leadership. Laggards are the most localite in their outlook of all adopter categories; many are near isolates in the social networks of their system. The point of reference for the laggard is the past. Decisions are often made in terms of what has been done previously. Laggards tend to be suspicious of innovations and change agents. Resistance to innovations on the part of laggards may be entirely rational from the laggard's viewpoint, as their resources are limited and they must be certain that a new idea will not fail before they can adopt" (Rogers & Scott, 1997, p. 6).

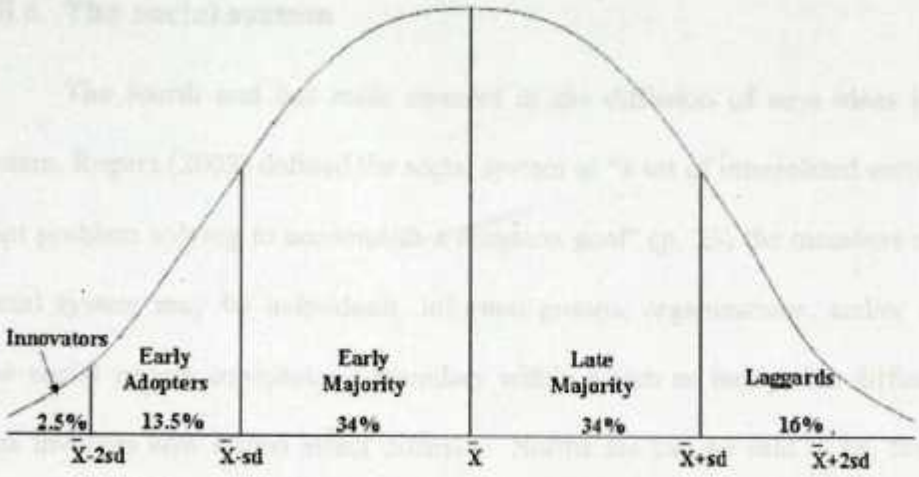


Figure 2 2: *Adopter Categorization on the Basis of Innovativeness. (Source: Diffusion of Innovations, fifth edition by Everett M. Rogers)*

2.8.5.3 Theory of rate of adoption

The third way in which time is involved in diffusion is in theory of rate of adoption. Rogers (2003) defined the rate of adoption as "the relative speed with which an innovation is adopted by members of a social system" (p. 221). The rate of adoption is usually measured as the number of members of the system that adopt the innovation in a given time period. The five characteristics of innovations as described in earlier sections have effect on the rate of adoption. In addition to these attributes, the innovation-decision type (optional, collective, or authority), communication channels (mass media or interpersonal channels), social system (norms or network interconnectedness), and change agents may increase the predictability of the rate of adoption of innovations. For example, personal and optional innovations usually are adopted faster than the innovations involving an organizational or collective innovation-decision (Sahin, 2006).

2.8.6 The social system

The fourth and last main element in the diffusion of new ideas is the social system. Rogers (2003) defined the social system as "a set of interrelated units engaged in joint problem solving to accomplish a common goal" (p. 23) the members or units of a social system may be individuals, informal groups, organizations, and/or subsystems. The social system constitutes a boundary within which an innovation diffuses. Another area involves how norms affect diffusion. Norms are can be said to be, the acceptable established behavior patterns for members of a social system (Rogers & Scott, 1997). Next important area has to do with opinion leadership, which can be said to be "the degree to which an individual is able to influence informally other individuals' attitudes or overt behavior in a desired way with relative frequency" (Rogers & Scott, 1997, p. 6). The last area of concern is a change agent, who is an "individual who attempts to influence clients' innovation-decisions in a direction that is deemed desirable by a change agency" (Rogers & Scott, 1997, p. 6).

CHAPTER THREE

RESEARCH DESIGN

3.1 *Introduction*

In this chapter we discuss the research design employed in this research work, the selection of the research design is of importance in conducting a research. Research design can be said to be a plan or proposal and the procedures that are used to assist researchers conduct research (Creswell 2009). Involved in this plan are the various decisions that include assumptions to the detailed methods of data collection and analysis. The major decision however is what design should be used to study the project topic under consideration. According to Creswell (2009) the choice of a particular design should be based on the worldview [which according to the same author *"is a basic set of beliefs that guide action"* (p. 6)] assumption or paradigm that the research uses in the study; the strategies of inquiry and the methods of data collection, analysis and interpretation. The other issues considered were the nature of the problems, the researcher's personal experiences as well as the audiences for the research work.

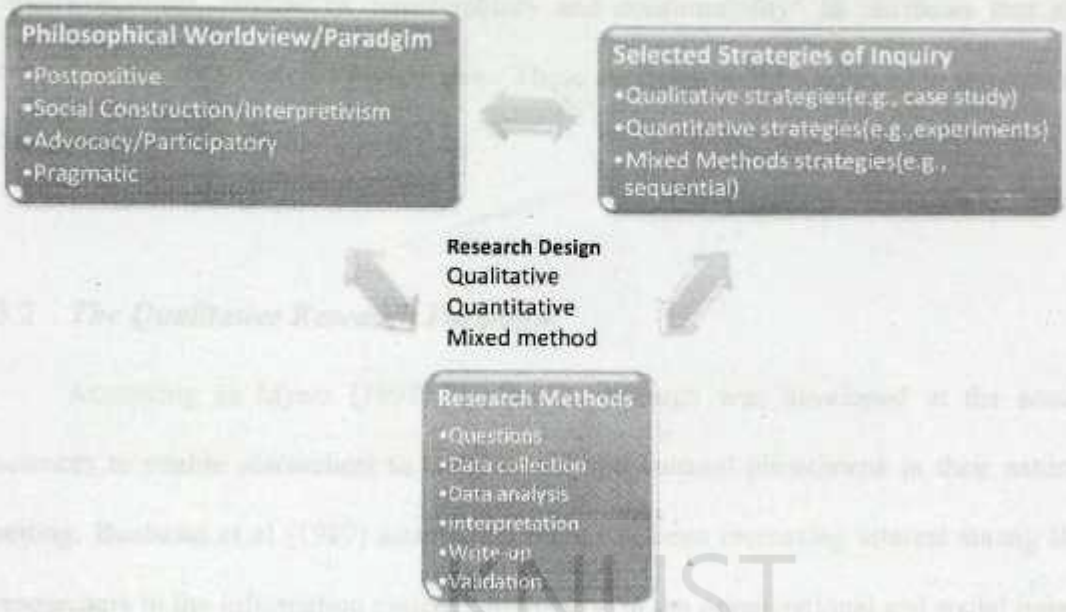


Figure 3. 1: *Framework for Design –the interconnection of Worldviews, Strategies of inquiry, and Research methods (Creswell, 2009)*

This research assumes a social constructivist worldview which is often combined with interpretivism. This worldview has been regarded as a typical approach to qualitative research (Creswell, 2009). Researchers that hold the social constructivist worldview, according to Creswell (2009) have the assumptions that individuals seek understanding of the world which they live and work in. In this study, it is believed that the adoption of innovative technology will be influenced by different actors, coming from different perspectives. Thus the goal of this research is to rely as much as possible on the respondents and interviewees views on the use of FOSS in the case area. This is because individuals develop subjective meanings of their experiences, which are varied and multiple.

Thus the research will be able to scrutinize the complexity of views on what affects the adoption of FOSS. It is also important to note that Denzin and Lincoln (1994) characterized constructivism, as a substantive formal interpretive paradigm in which interpretive case studies and ethnography feature heavily. In their work they cited

"trustworthiness, credibility, transferability and confirmability" as attributes that are central to the constructivist perspective. These attributes will be adhered to throughout the course of this work.

3.2 *The Qualitative Research Paradigm*

According to Myers (1997), qualitative research was developed in the social sciences to enable researchers to study social and cultural phenomena in their natural setting. Benbasat et al (1987) asserts that there has been increasing interest among the researchers in the information system community, in the organizational and social issues associated with the development and implementation of computer-based information system. This trend has led to awareness of the need to use qualitative research methods which focuses on understanding social phenomena in their natural setting as well as the cultural context (Myers 1997). Creswell (2009), states that qualitative research is a means for researchers to explore and understand the meanings, that individual or groups ascribe to a social or human problem.

Qualitative research can be positivist, interpretive, or critical (Myers, 1997). It follows from this that the choice of a specific qualitative research method (such as the action research, case study research and ethnography) is independent of the underlying philosophical position adopted. For example, case study research can be positivist (Yin 2003), interpretive (Walsham 1993), or critical. These three philosophical perspectives and how they affect qualitative research are shown in the figure below.

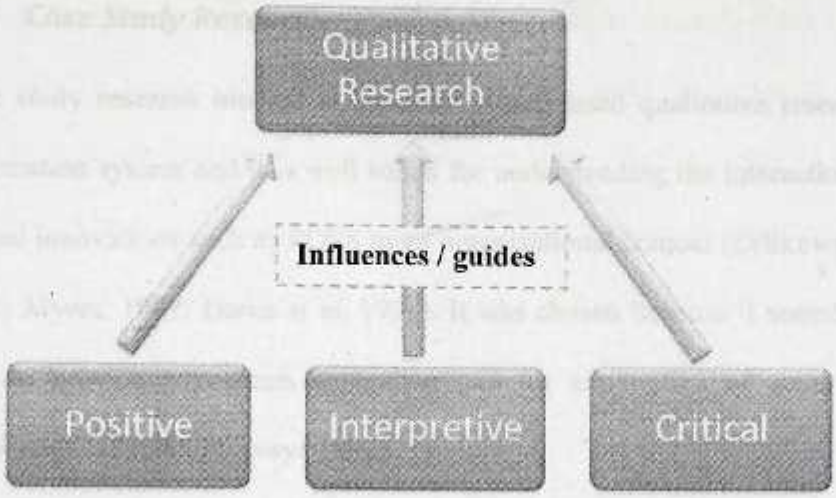


Figure 3. 2 Underlying philosophical assumptions (Myers, 1997)

Thus the motivation for doing this qualitative research, as opposed to quantitative research, is formed from the observation that, one of the things that differentiate humans from the natural world amongst other things is our talking ability (Myers, 1997).

3.3 *Qualitative Strategy of Inquiry (Research Methods)*

Qualitative strategy of inquiry or qualitative research method can be said to be a type of qualitative design or model that provide specific direction for the procedures in a research design (Creswell, 2009). The qualitative strategies of inquiry chosen for this research is the case study, due to the fact that majority of these questions in the problem formulation chapter are 'how' and 'why' questions. Robert Yin states that case study research is the preferred strategy when 'how' and 'why' questions are being posed, when the investigator has little control over events, and when focus is on a contemporary phenomenon within some real-life context (Yin, 2003).

3.4 *Case Study Research*

Case study research method is the most widely used qualitative research methods in information system and it is well suited for understanding the interactions between ICT related innovations such as FOSS in an organizational context (Orlikowski and Baroudi, 1991; Myers, 1997; Darke et al, 1998). It was chosen because it seemed most relevant way to provide hypothesis generation and for exploration of areas where existing knowledge is limited (Cavaye 1996).

Yin defines "case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. It is a way of investigating an empirical topic by following a set of pre-specified procedures" (Yin, 2003, p.23).

It must be said that this research has very little control over the events and that our focus is a contemporary phenomenon within some real-life context. Thus our case studies might be defined as exploratory process. The research therefore intends to follow interpretive research tradition which is based on an ontology that assumes the perspective that reality is subjective, a social product constructed and interpreted by humans as social actors according to their beliefs and value system (Darke et al, 1998).

3.5 *The Researcher Role*

In qualitative research, the role of the researcher as the primary data collector necessitates the identification of personal values, assumptions and biases at the outset of the study(Miller as cited in Creswell, 2009, p.196). This phenomenon is termed as reflexivity in qualitative research; which can be seen as the condition of taking account of the personality and presence of the researcher within the investigation. According to May (1998), the concepts of reflexivity may be a way of bringing qualitative methods to

account for themselves in a way that goes some way to satisfy the demands of scientific method. This is generally a matter of questioning how the processes of research and analysis have an effect on research outcomes. This whole process of self-examination has become known as 'reflexivity' (p.22). Nightingale and Cromby (1999) states that,

> *Reflexivity requires an awareness of the researcher's contribution to the construction of meanings throughout the research process, and an acknowledgment of the impossibility of remaining 'outside of' one's subject matter while conducting research. Reflexivity then, urges us "to explore the ways in which a researcher's involvement with a particular study influences, acts upon and informs such research (p. 228).*

Reflexivity can be grouped into two distinct types; personal and epistemological. Personal reflexivity asks researchers to reflect on how our own person impacts the outcome of the research; whilst epistemological reflexivity urges us to consider if the way that we have asked the question, somehow influences the answer.

As a researcher engaging in the use of qualitative research, it is important to be self aware of the opinions, experience, prejudices and interpretations of meaning that the researcher bring to the study.

In terms of personal reflexivity, my perceptions of the use of FOSS to drive ICT infrastructure as opposed to proprietary software have been shaped by my personal experience in the use of FOSS. My first experience in the use of FOSS occurred in 2003 with the use of Red hat Linux distribution to secure my files from virus during my undergraduate studies as a student of the Faculty of Renewable Natural Resource (FRNR) at the Kwame Nkrumah University of Science and Technology. I must confess that the experience was not pleasant and friendly due to fact that there were almost no other person that I could go to for help and the use of the internet was very limited on

campus and expensive at that time. This made me to switch straight back to my pirated MS Windows. I have since 2006 been using the FOSS for various reasons such as creating websites; using open office for spreadsheets, documentation and graphic design; trying various Linux flavours for use as replacement for Microsoft windows and server operating system when I was employed on contract as systems administrator at FRNR. Over the years of experimenting with FOSS for as little as a penny, has motivated my perception that the use of FOSS in educational institution and a other organization with tight budget will go a long way to reduce the monetary burden ICT can bring.

In terms of epistemological reflexivity, the researcher hopes not to constrain the study too tightly at the initial stages. Some exploratory or preliminary unstructured interviews would be carryied out to help the researcher understand the meanings and stories of those involved in the 'ICT front' at the study area. From these exploratory studies, the researcher then hopes to form a clearer idea of the adoption and use of FOSS in the study area. This will hopefully lead to a gradual and a more focused study targeted at eliciting greater levels of depth than what the preliminary unstructured research methods might provide.

3.6 *Data Collection Procedures*

3.6.1 *Scope & Environment*

The environment, in which the case study was conducted, is a real-life environment because of the existence of test group (respondents). This study was conducted on the KNUST campus at Kumasi in the Ashanti Region of Ghana. The main area of concentration will be at the Networking Operating Center (NOC) and some selected faculties. The test group will validate the findings of the case study with their real-life

experience in the field. During the project several meetings with the respondents were organized in order to discuss the findings.

3.6.2 *Case Study Site*

The Kwame Nkrumah University of Science and Technology (KNUST) was established by a Government Ordinance on 6th October 1965; to provide higher education with special reference to science and technology and to act as a catalyst for the technological development of the country. It was originally established in 1951 as the Kumasi College of Technology.

It began formal operation on 22nd January 1952, with 200 Teacher Training students who were relocated from Achimota College to form the pioneering students of the college. Before its accession to a university status in 1961, the college expanded drastically in the area of academic disciplines and infrastructure. It began with the establishment of the School of Engineering and the Department of Commerce in October 1952, the Department of Pharmacy and Agriculture in 1953, followed by the Department of General Studies, School of Agriculture, Town Planning and Building, and the Faculty of Science.

As the College developed, a decision was taken to make it a science and technology oriented institution. To this effect, the Teacher Training College, exclusion of the Art School, was transferred in January 1958 to Winneba Training College and the Commerce Department was also relocated to Achimota College to form the present University of Ghana Businesses School, Legon.

The Government of Ghana in December, 1960, appointed a University Commission to advise it on "the future of university Educational in Ghana, in connection with the proposal to transform the University College of Education and the Kumasi College of Technology (KCT) into an independent University in Ghana." the

Government decided, based on the recommendation from the commission in 1961, to establish two independent Universities, one in Kumasi and the other at Legon, near Accra.

Consequently, the KCT was converted into a full-fledge University by an act of Parliament on Tuesday the 22nd August, 1961. On the Wednesday, 29th November 1961, the Kwame Nkrumah University of Science and Technology was formally inaugurated.

In October 1965, the Department of Applied Physics, Applied Biochemistry and Chemical Technology were established; the name of the faculty thus changes to the Faculty of Applied Science. In additional, a Department of Science was formed in the faculty to teach sixth form science subjects. The university decided in November 1966 to reconstitute the faculty to teach specialist courses in Biochemistry, Biology, Chemistry, Chemical, Technology, Mathematics and Physics. It should be noted that at the same time, the university took steps to discontinue the Preliminary Science Courses, which were finally ceased at the end of 1968/69 academic year. Now the Department of Chemical Technology was also transferred to Faculty of Engineering under a new name, Chemical Engineering. The school of Graduate Studies took over the Board of Postgraduate Studies in 2000, with the mandate of coordinating postgraduate programmes in the University.

In October 2001, the School of Mines of the KNUST in Tarkwa was elevated to a semi-autonomous institution called the Western University College. It has since October 2004 become a full-fledge university known as the University of Mines and Technology (UmaT).

KNUST has two campuses, one in Kumasi and the other at Sunyani the capital of the Brong Ahafo Region. The main university campus is situated about eight kilometers

away from the center of Kumasi, the Ashanti Regional capital. The Kumasi campus is situated on a campus of about seven square miles (18 square kilometers) of undulating land and pleasant surrounding campus presents a panorama of beautiful and modern buildings interspersed with verdant lawns and tropical flora, which provide a cool and refreshing atmosphere congenial to academic studies.

The Sunyani Campus which houses the Faculty of Forest Resources Technology adds to this rich ecological heritage with its Tinte Bepo Forest Reserves, and the campus teak plantation as well its wildlife sanctuary.

There are six halls of residence and five hostels in the university. Three of the halls are for males and females, two for males only while one for females only. The halls are as follows:

- Queen Elizabeth II -Male and Female
- Independence Hall -Male and Female
- Republic Hall -Male and Female
- University Hall -Male
- Unity Hall -Male
- Africa Hall -Female

The five available hostels to the university, two are for postgraduate students, one for both undergraduate and graduate students which is managed by the Ghana Universities Staff Superannuation Scheme (GUSS). The medical student of Komfo Anokye Teaching Hospital also occupy one, while the last one is under the management of the Social Security and National Insurance Trust (SSNIT).

The University also has a number of municipal facilities. These include a hospital, basic schools (i.e. nursery, primary and junior high schools), maintenance and estate organization, transport department, photocopy unit, printing press, bookshop, senior staff

club, sports stadium an Olympic size swimming pool, proprietary and banking facilities, post office, places of worship and guest houses. A senior high school is also located on the campus of the University.

The University has within the short period of its existence become an important centre for the training of scientists and technologists not only for Ghana but also for other African countries and countries of the European Union and North America. It can also boast of ultra modern science and engineering laboratories. Construction of new lecture theatres and a museum is ongoing.

3.6.3 *Actors*

The respondents in this study were the systems administrators, systems programmers at the NOC and the faculties, students and Lecturers. Their participation will be as the result of arranged interviews.

3.6.4 *Events and Process*

Using interpretative case study research methodology, the focus of this study will be the interpretation of the everyday experiences and activities of respondents in connection with FOSS as they administer the KNUST ICT infrastructure, as well as the perceptions and meaning they attached to those activities and experiences. This includes the assimilation of surprising events or information, and making sense of critical events and issues that arises.

3.7 *Ethical Considerations*

In carrying out this study, approval was sought from the ICT Research committee for the research to be undertaken. The University's ethical procedures were followed at

all times during the study period. As per the university ethical procedures, the researcher has an obligation to respect the rights, needs, values, and desires of the respondents. Data collection was overt and respondents were asked to approve the use of their data input in the study. It is only proper to assume that some information that will be collected in the course of the research might be sensitive. If this occurs, the study intends to account for this possibility by assuming that all respondents' responses are anonymous, and that data would be stored in a way that their names could not be traced back to their statements. Where interview transcripts were used in this research to illustrate a specific point, they were not attributed to any individual or organization.

3.8 *Data Collection Strategies*

In selecting the appropriate research methods for exploring FOSS initiatives in educational organization, It was decided to use a qualitative methods approach, in order to give the researcher practical exposure in the use of this research methods in understanding FOSS initiatives in an educational institution. Multiple data collection methods were typically employed in case research studies. Ideally, evidence from two or more sources will converge to support the research findings. Robert Yin (2003) identifies several sources of evidence that work well in case research, these are:

- Documentation-: Written material ranging from memoranda to newspaper clippings to formal reports.
- Archival records-: Organization charts; service, personnel or financial records.
- Interviews.
- Direct observation-: Absorbing and noting details, actions, or subtleties of the field environment.
- Participant observation

- Physical artifacts-: Devices, outputs, tools.

Out of these six sources of evidence three were considered appropriate for this study, that is; documentation, archival records, and interviews. Other sources such as direct observations, participant-observation and physical artifact collection are less relevant in this case study. Primary data collection using interviewing was collected from March to May 2009. While secondary data collection from archival records and documentation started from January to May 2009.

3.9 *Qualitative Methods*

3.9.1 *Interviews*

According to Walsham (1995) qualitative interview is probably the primary data source in interpretive case study research, which makes it possible for a researcher to best access respondents' interpretation of actions and events that they go through in their natural setting. Semi-structured interview will be employed in this study and the researcher will prepare interview guidelines that will consist of a set of questions. The second part is a close and open questions in a short questionnaire. The guidelines will allow the researcher to keep track of the interview while investigating areas of interest in detail.

Interviewing sessions was carried out twice a week in a 15-30 minutes, paper recorded interviews with respondents.. In addition the respondents agreed to provide record documentation and archival records of their impressions in the use of FOSS where possible. To assist in the data collection phase the researcher intends to utilize a field log, providing a detailed account of ways the researcher spends time when on-site, and in transcription and analysis phase. In some cases the interviews followed a semi-structured

format with a pre-defined set of questions, however, the structure was sufficiently flexible to accommodate an interviewees own views and orientation.

3.9.2 *The interviewing setup*

In this phase, the following steps were performed:

- Planning the interviewing setup
- Perform an evaluation interview to test the interview questions
- Specify the required information and documents needed
- Make appointments with respondents
- Carry out the interview

An evaluation interview was tested with two of the real respondents, based on this preliminary test some enhancements were made to the interviewing process. The primary data consisted of semi structured interviews based on a common protocol. Also some basic respondents' background data were collected, such as their:

- Name
- Sex
- Occupation
- Number of computers that they manage or use
- operating system used
- Whether they use FOSS
- Benefits they derive from their use of FOSS.
- Qualification

As needed, follow-up questions were asked by phone or e-mail.

The study interviewed 12 permanent IT professional employees of the university, 22 national service personnel, 59 students randomly selected from specific colleges and 3

lecturers. Also 500 out of the total 3000 plus computers that were present in the study area were randomly inspected to determine the operating environment and the type of FOSS user applications that were installed on them.

3.10 *Data Analysis and Interpretation*

Creswell (2009) contend that data analysis should be conducted concurrently with data collection making interpretation and writing reports. According to Yin, data analysis consists of examining, categorizing, tabulating, testing or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of a study (Yin, 2003, p.76). Several qualitative researchers claim that qualitative data analysis primarily entails classifying things, persons, and event and the properties which characterize them. This was achieved by collecting open-ended data based on questions and developing analysis from what were provided by the field respondent. During the data analysis process the researcher analyzed the data for themes or issues (Stake, 1995). This was aimed at assisting the researcher to identify and describe patterns and themes that will arise from perspective of the respondent(s). Field notes and diary entries was regularly reviewed.

3.11 *Verification & reliability*

During the selection of appropriate research methods for this case study, two troublesome concepts encountered were the issue of validity and reliability. Validity is particularly troublesome in a study such as this, where it is hard to gauge whether research findings are specific to the subject under examination, or whether more generic outcomes can be learned. Brinberg and McGrath (1985) comes to the study's rescue by

their asserted that '*validity is not a commodity that can be purchased with techniques... Rather validity is like integrity, character, and quality, to be assessed relative to purposes and circumstances'.*

In ensuring internal validity, the following strategies will be employed:

- Triangulation of data: Data will be collected through multiple source to include interviews ,archival records and document analysis;
- Member checking: The respondents will serve as a check throughout the analysis process. An ongoing dialogue regarding my interpretations of the respondents' reality and meanings will ensure the truth value of the data.
- Spending prolong time in the field: enough time and follow-up interviewing at the research site will occur to help ensure accurate raw data over the data collection period; this will help the researcher develop an in-depth understanding of the phenomenon understudy which will help convey details about the site and the people that lends credibility to the narrative account (Creswell, 2009).
- Clarifying the researcher bias –At the outset of this study researcher bias had been articulated in writing the research proposal study itself under the heading, "The Researcher Role".

Three techniques to ensure reliability will be employed in this study. First, the researcher provides detailed account of the focus of the study, the researcher's role, the respondents' position and basis for selection and the context from which data will be gathered. The second was the provision of the use of triangulation or multiple methods of data collections and analysis used, which strengthens reliability as well as internal validity. Finally, data collections and analysis strategies will be reported in detail in order to provide a clear accurate picture of the methods used in this study.

3.12 *Research Results reporting*

The research data was first organized and prepared for data analysis by the data using Hyper Research tool for qualitative analysis. The data was then read through thoroughly; discrete parts were identified, and labeled to enable the creating of themes and descriptions. These were then analyzed and ranked in accordance with the total number of times the same themes appear in the coded data. However, rather than using the identified labels during the coding process, the labels were further group into themes derived from literature known to affect the adoption of innovations. These predefined set of labels from literature have been suggested to affect the use and acceptance of FOSS; social setting, top management support, and satisfaction with use (Bruggink 2003; Rajani et al 2003; Reijswoud and Topi 2004; Pothmann 2005).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 *Introduction*

In this chapter, the interview result as gathered from the respondent in the study area is presented and discussed. The results and discussions are divided into sections to represent the various research questions in the study.

4.2 *Social Settings*

The data collected from the study showed some issues that affected the use of FOSS in the study area and prominent among them are the gender of the respondent, course studying, availability of information on FOSS as well as access to computers.

4.2.1 *Gender distribution of respondents*

The gender distributions of the respondent interviewed favoured the male gender as the results showed that 78% of the sample populations were male and 22% were female Out of the twenty-one female respondents interviewed, one was national service personnel from the center, the other was a lecturer and the rest were students. This bias towards male individuals in our sample was due to the selection criteria used;w hich was based on the fact that the individual must at least be having asses to a computer on regular basis. The works of several researchers have shown that fewer women are engaged in the use of ICT (Kwapong 2007) and also the number of male to female ratio at the computer science department confirmed the findings. These finding support the notion that more males are engaged in ICT than females which clearly showed that FOSS adoption may be affected by the gender of the individuals. This was the fact that

most of the respondents that were not aware of FOSS were females. Most of these respondent when asked what FOSS was, said "Please oh I have never heard of it oh!"

4.2.2 Lack of Information on FOSS

An initial causal look at numbers showed that 44% of the respondents had some awareness of FOSS and 56% had no awareness of FOSS, but a careful look at numbers shows that there is great lack of knowledge and awareness of FOSS in the study site, except among the few IT professional (34%) who were actively involved in the use of FOSS. Only 10.3% of non-IT professionals have knowledge on FOSS, therefore the values in the figure below should be used carefully.

On the issue of availability of information on FOSS the study showed that much of the information that exist on the study site can be found among the few IT professional(34%) and only 10.3% of the non IT respondent had some information on FOSS.

It was also interesting to note that lack of awareness and information on FOSS was highest among the undergraduate student (48.5%). When asked whether the level of awareness in their opinion was campus wide or not, 94% of the respondent answered that it not campus wide (No) but rather it exists among a few group of individuals and departments.

A bottom up approach was commonly employed in FOSS use and adoptions at the study site mostly by student who have finished their first degree (BSc Hon.) and these are either IT professionals employed by KNUST or national service personal.

When asked what made them to have interest in FOSS they listed a number of issues as and some which are presented below:

- Most of the windows application they were using had licenses problems
- Wanted access to the source code of a particular software for tweaking
- Windows platform they use are constantly been attacked by viruses
- Adventure to try new software platform
- Some said they came to meet it and therefore had to learn about them.

Adoption and use of FOSS at the university was normally initiated by an interested person's (in this case the IT professionals interviewed) rather than policy driven by the university. This was a significant development as the presence of these 'early adopters' could be used to build up the critical mass needed to help diffuse FOSS in the university (Rogers & Scott, 1997).

The study also noticed that at least 7 out of 10 of the PCs sampled had least one FOSS installed on it, but many of the respondents were unaware that they had at least one FOSS applications on their PC which in this case was the Firefox browser. Thus most of the respondents and computers at the university are actually using FOSS applications unknowingly mainly because it was readily available. This lack of awareness of FOSS and its benefits clearly hinders the users from understanding the benefits they derive from the use of FOSS.

Respondents' perception, observed during the interview s was that the benefits that could be derived from the use of FOSS by simply implementing programs and activities to increase the level of awareness on FOSS may not be the answer. Though some may argue that raising awareness may help initiate changes in the different departments and

faculties; most of the respondent in the study alleged that consultation with the 'powers that be', including a cost-benefit analysis should be conducted when FOSS initiatives is to be implemented in the initial stage to help provide the bases for comparison between the current operating environment and the proposed migration to FOSS.

According to all the respondents interviewed, the existing laws are presently not sufficient to protect proprietary software and unauthorized copying of software is known to be widespread (Bruggink, 2003; Schutz et al. 2005).

When the study inquired why there was a low awareness level of FOSS, 75 % of the respondent asserted that one of the reasons for the very low awareness of FOSS in the study area they believed was the lack of interest and financial incentive by the authorities to explore alternative software solutions including FOSS; although FOSS may be far cheaper than proprietary software.

This lack of interest could be due to the observed widespread unauthorized copying and distributions of proprietary software that has become rampant on the study site and the country as a whole. These pirated copies of proprietary software exchange hands among both the IT professional and student alike, which is against university's ICT4KD Policy. The use of these unauthorized copies, according to those interviewed seemed to be the order of the day because users of such software assume that such software are free because they are readily available. It is however important to state that the study believed that in the near future this can lead to unforeseen costs.

During one of the interview sessions the study was informed of a workshop that was organized to educate the university IT staff on the use of unlicensed (pirated) Microsoft products which has become rampant in the country and study site and the measures being put in place by the company's representatives in Ghana. According to these companies in the near future legal sanction could be meted out to violators of the company's copyright laws within the university and the country, in accordance to Ghana's Copyright Act,2005 (Schutz, Khan et al. 2005).

Data gathered from the study area revealed that 4 out of every 5 interviewees were of the opinion that the high ascendancy in the use of pirated software could be a thing of the past if the university had a policy to actively promote FOSS; but were not willing to openly admit the use of pirated software. But further questioning of how they acquired the software they were using revealed that, apart from those faculties that had projects with foreign donors, who require the purchase and use of genuine software all the rest of computers found in the faculties and departments, used either pirated operating systems or application software.

Some respondents were of the perception that FOSS was not a good alternative to commercial software in the study area.. According to them, software produced for free, could not be of the same quality and a viable alternative to Microsoft products. Other concerns expressed by these respondents included:

- High initial switching cost from proprietary software to FOSS could make it difficult for the university with limited resources to change its software infrastructure;

- Lack of awareness concerning available FOSS alternatives that could replace proprietary software and maintenance support team;

In summary the there was a general lack of information on the existence and use of FOSS in the study area. The prevalence of pirated software seems to be the major stumbling block to the successful adoption and use of FOSS.

4.3 *Operating Environment*

Almost 68% of 30 servers observed at study site had Linux server operating system installed on them; while the remaining 32% of the servers were running on proprietary operating system, predominantly MS Windows Servers. Data the study gathered showed that 90.7% of the respondents were using MS Windows operating systems on their desktops and laptops, 3.1% used Linux while 6.2% had windows installed on desktops and Linux on their PCs for those that had access to more than one computer.

When the respondents were asked what was the predominate operating system in their work place, 97% of the respondent believed that it was the MS Windows OS, while 2% of the respondent predominantly IT professionals said it was Linux. Thus it is safe say that,Micr osoft Windows operating systems was the popular and prominent operating environment among non-IT respondents while Linux with other FOSS application was more prominent with IT professionals. Thus for the use and adoption of FOSS to become wide spread in the study area there is the need to train more IT professional who have a deep understanding in FOSS to serve as the critical mass that will sustain the initiatives (Reijswoud and Topi 2004).

The use of FOSS on the servers and by IT professionals can be attributed to a functional failure of the original windows versions; a good example being the windows proxy server that was chronically dropped connections and requests from client. The failure of Windows Server 2000 proxy server led to the adoption of squid proxy server been installed in some selected faculty and colleges to improve access to the world wide web(internet).

Computer Operating Systems (COS) are critical for any operation to be carried out on a computer system and are necessary for the functionality of an organization IT operating environment(Martin Bruggink 2003; Office of Government Commerce (UK) 2004). The key requirements in selecting COS are; scalability, vendor support, cost etc (Schutz, et al 2005). In the instance of KNUST the study foiun that support for the Windows Server software was high, yet the support for FOSS appears to be in bad supply. This was due to the fact that IT courses that exist on the study site are taught, mostly using proprietary software. This then leads to a situation where most IT professional being produced from such educational institution lack the knowledge and expertise to use and implement FOSS in their various place of work. Cost was also an issue in adoption and use of FOSS (Schutz, Khan et al. 2005). According to interviewees at the NOC, whenever the University finds an opportunity that it can spend less through the use of FOSS to implement a new service, it does so. The budget for IT expenditure at the University does not include license renewals etc, yet there were no

indications that the university has any policy that aid its consideration in implementing and adoption of FOSS innovations.

The respondent's perspective on the relative low use of FOSS operating system on KNUST was the issue of lack of readily available IT professional, to support the use and adoption of Linux operating server system. The findings of this research show that the use of FOSS operating systems on the server side was significant but lack widespread use on client side.Th e study's also revealed that, three issues concomitantly are playing an important role in the growing use of FOSS on the server side at the study area especially at the NOC. The initial issue is that almost all IT staff at the university whether permanent or temporary, had a good, and in many cases deep understanding of computers and software, making the more complicated FOSS pose less difficulties for IT professionals. Next, according to the IT professional is that the FOSS community has put a huge effort into simplifying and making configuration and administering more easily and friendly over the past few years. Lastly, the number of IT project at the study site based on FOSS is increasing, as more of the IT professional are seeing the need to personalize the software for such projects, which is normally only possible when using FOSS.

In summary: thought the level of information as well as awareness on FOSS in the study area was low, FOSS was relatively well known among IT professional at the university. It could be said to have it place at the server side where it is used to drive the

university IT infrastructure from its use as proxy server to web mail. It is also important to emphasis that the use of software in the university tends to depend on two critical issues; budgetary constraints and software support.

4.4 *FOSS Usage and Adoption at KNUST*

The result from interviews in relation to FOSS use in the study area showed that 28.9 % of the respondents have used one or more flavours of the FOSS operating systems, while 71.1% mostly student claimed they have never used it before. Almost all respondent said that they had used free application software before especially the Mozilla Firefox web browser on their computers.

When asked if they had knowledge on the principles behind FOSS, they replied that they had no idea. This reveals the need for awareness campaign to educate students and lectures while most of the IT professional hinted that there is the need for the university to provide funds for the training of the few IT professionals at the university in the proficient use and support for FOSS, to help in the adoption and use of FOSS. They believed that such a move will help the university to advance its policy of protecting intellectual property and preventing copyright abuses that exit on campus as per the university ICT4KD policy document (*ICT4KD, p.42*). As this will enable the university use theses IT professional as a catalyst for the rapid adoption and deployment of FOSS innovation as well as carry out the necessary training of the student and lecturers in the use of FOSS.

Data collect randomly from 500 computers situated at various faculties and department at the university with densely populated computers, revealed that 72.8% of the desktop computers, 12.2% of laptops and 2.2% of server had windows installed on them with Firefox web browser as the only FOSS found on them, while 8.4% of the desktops had Linux and other FOSS installed on them.

In the early days of FOSS, it was only seen within the academic and corporate research circles in the developed world. Thus the university should get involve in providing the needed leadership as well as the manpower, which could go a long way to make it easy for learning and use of FOSS. Although FOSS initiative is gaining momentum all over the world, both in the developed as well as developing countries (Lane 2002), here in Ghana there is the need for government to partner institution such as KNUST to develop measures that will accelerate use and adoption of FOSS. A look at literature reveals that the use and adoption of FOSS is much effective with the government taking the lead as it controls the money and power to bring about change. Governments lead initiatives provide a huge potential for FOSS, not only as means for implementation FOSS, but more importantly as propagators of the philosophy behind the FOSS movement (Office of Government Commerce (UK) 2004).

An example from literature showed that the Government of Brazil has been one government that has actively pursued the open source model. Brazil policies regarding adoption Free and Open Source software have been successful, notably in the states of Rio Grande do Sul and Pernambuco (Reijswoud and Topi 2004).

Research shows that government led initiatives should be carried out with the following success *factors* in mind, in order to tap huge possibility that comes along with the use of FOSS:

1. *FOSS initiative must generate value when implemented*: government lead initiatives must be able to produce economic value through the reduction of costs incurred when proprietary software was the sole software that is in use in a social system, which will lead to saving of some foreign currency used in the transaction. It should also create the environment that enable personal development through training and education (Reijswoud and Topi 2004).
2. *Availability of Sufficient competent IT professionals to implement, use and maintain FOSS initiatives*: There is the need to have sufficient trained people who will use and support the FOSS initiatives. Training users and support team needs to be of high priority during government lead initiatives (Moyle 2003).
3. *Policy support for an FOSS strategy*: Support for FOSS needs to expand to all key players at governmental level, departmental level, IT professionals and computer users in general(Moyle 2003).

In summary the potential for the university to adopt and use FOSS will come faster if the government provides a clear policy and resources to support the adoption, development, deployment and use FOSS. The training of a lot more IT professionals with deep understand of FOSS and seem to be an important factor that will also help improve the use of FOSS in the study area.

4.5 *Respondents Criteria for FOSS Usage and Adoption*

During the study several characteristics of FOSS were constantly mentioned by IT professionals as factors that influenced their adoption decision. These criteria's were

consistent with Rogers (2003) theory as well as that of Tornatzky and Klein (1982). These characteristics were grouped under relative advantage, compatibility, complexity and triability of FOSS respectively; and below is sample list of respondents' criteria for using FOSS:

- More flexibility
- Use of open standards
- Distributed development and collaboration
- Price/performance
- Lack of license fees
- Lack of vendor lock-in
- Better security
- Better stability
- Less virus attacks
- Ability to tweak source code
- Requires less computer resources

4.5.1 *Relative advantage of FOSS*

According to the IT professionals the relative advantage of Linux compared with proprietary operating systems in terms of cost and reliability is incomparable. The cost advantage of FOSS consists of two aspects, hardware cost and software cost.

For FOSS platform, hardware cost is low as most of the FOSS innovations are made to run on low end computers such as Pentium 1 computers. This results from the fact that most of FOSS innovations require less resource to perform their functions(Reijswoud and Topi 2004) as compared to their windows counterpart performing the same function. This gives it a cost advantage over proprietary software.

The second advantage was software cost or licensing fees ; according to the respondents most FOSS innovations can be downloaded from the internet for free, making it cheaper than their alternative proprietary software. These software packages can also be upgraded free of charge when newer versions become available. This means that for those using FOSS there is no ongoing cost to stay with the latest version of FOSS, unlike proprietary software (Dedrick and West 2004).

The reliability of FOSS was another advantage that was also often cited by the respondents. Most of them were of the conviction that FOSS was functionally more stable, with less bugs and where a bug is found it is quickly fixed due to the community development model that is used in FOSS development; as well as being less vulnerable to virus attack and more secure (OSI 1990).

4.5.2 *Compatibility of FOSS*

The decision to adopt FOSS innovations at the NOC appears to be greatly influenced by the compatibility of FOSS innovations with their current computers hardware and more specifically with the skills and knowledge of the IT staff. Compatibility of the to-be implemented FOSS innovation with current applications as well as existing data is a major concern in their adoption decision made by IT professionals (Dedrick and West 2004).

4.5.3 *Triability of FOSS*

The ability to try out most FOSS(s) at almost no cost was frequently cited, coupled with the issue of the software being able to run on existing hardware or on a virtual PC which

could be downloaded for free from numerous websites. Before any implementations of FOSS initiative is carried out, IT professionals at the study site first learned how to use the FOSS by casually trying it at home. This in turn improves the programmer's knowledge of the use and the functions of the software which reduces the perceived risk of open source adoption. This assertion by the respondents is consistent with Rogers (2003) and Eveland and Tornatzky (1990), who argue that technologies innovations are more likely to be adopted if they can be tried and assimilated in small chunks over a period of time(Dedrick and West 2004).

4.5.4 *Complexity of FOSS*

The study discovered that for those that knew about FOSS and did not use it, most of these respondents ascribe their unwillingness to try FOSS because for most of them, FOSS configurations are mostly done at the command line interface. This makes it unattractive compared to the graphic user interface (GUI) that MS windows provided for most of its configuration. The study informed these group of respondents about the open source "X-server" that is now been implemented in most Unix and Linux operating systems which gives the FOSS operating systems a comparative advantage in terms of stability as compared to windows. These were all welcomed news but all said they still preferred window due to its ease of use and the low learning curve for normal end user.

4.5.5 *Observability of FOSS*

Most of the IT professional were of the view that their ability to test FOSS for a very long time to prove it s ability to provide the needed services with no cost of any kind is always welcome news. This aspect of FOSS enables one to observe the functioning of

the FOSS innovation before they are fully deployed in the study area, making it possible for the results of the proposed innovation to be visible to others. Such visibility stimulates peer discussion of the new pros and cons that such FOSS innovations provides (Rogers & Scott, 1997).

4.6 *Obstacles that affect Extensive Use of FOSS at KNUST*

Several researches and reports have shown convincing evidence that developing countries definitely stand to gain in very many ways from the adoption and extensive use of FOSS(Martin Bruggink 2003; Rajani, Rekola et al. 2003; Reijswoud and Topi 2004; Pothmann 2005; Schutz et al. 2005).Th us when study asked the respondent the question: "Why, does the university not widely adopt FOSS innovations?" The answers from respondents were divided into three thematic areas:

1. Financial considerations ,
2. Technical considerations,
3. Prior considerations

4.6.1 *Financial Considerations*

According to those interviewed, the availability of financial resources is an important factor that affects development effort of the university as it has a tight monetary budget. Even the government of the country have constrain as to what it can do at a time, and often have to choose between acute issues like poverty, illiteracy, ethnic conflicts, droughts, disease, and lack of simple infrastructure.

It is also a recognized fact that people in developing countries don't pay or can't really afford to pay for software that they use,beca use of low level of financial resources

available to people in those poor countries. This is where FOSS can be used to improve development effort if a reasonable investment in ICT infrastructure is made(Rajani et al. 2003).

The study revealed that there is relative abundance of computer hardware at the study site and FOSS can be used to provide the needed software for those computers and help reduce the financial burden on the university.

Policy makers at the university should also not see ICT as a cost center, but with the right investment, it also carries a significant possibility of earning money and job creation. (Rajani, Rekola et al. 2003).

4.6.2 *Technical Considerations*

According to the respondents due to the steep learning curve involved in the use of FOSS the current staff will not be able to support migration to FOSS. There will be the need to employ and train more computer science student in the FOSS platform which in turn can be employed by the university.

Trained IT professionals are a very important factor that must be present for initial spread of FOSS in the study area. According to Rajani et al.(2003), the issue can be addressed by paying attention to educational and vocational training institution through the provisions of facilities , which ensure that students get a chance to be exposed to multiple technologies platforms (in this case FOSS and proprietary), this will help prevent the predominance of a single vendor such Microsoft and Oracle or technology in the educational curriculum (Rajani et al. 2003).

Several researchers are in agreement with the view that investment in education and ICT is something that developing countries cannot afford not to pay attention to; as countries that don't, will find it hard to deal with the needs of the present and the future as well as global challenges.

4.6.3 *Prior Considerations*

The introduction of any FOSS innovation must take into consideration existing systems and norms of the social system where such initiatives are to be implemented. This issue is what seems to be lacking in the study area as it seems that those 9k,implementing FOSS projects do not undertake any of such analysis that consider the norms and existing ICT culture of the study area (Rogers, 2003)

4.7 *Development of SOE Model based on FOSS*

One of the issues that came up during the study was the issue of internet bandwidth available to the university. The university spends a huge chunk of its ICT budget to pay for internet bandwidth, even the available 8Mb/s is woefully inadequate for the over 3000 plus computers that exist at the study site. This makes the adoption of FOSS relatively difficult for end users at the study site. The lack of reliable and sufficient bandwidth is often a deterrent to downloading FOSS because most FOSS are available on the internet freely for download, making it difficult for users to get these software. This challenge provides the avenue for the development of standard operating environment based on FOSS.

The establishment of local server farms that will mirror FOSS repositories will enable the university over a period of time download local copies of these packages. These packages will be available to all members of the university who will be able download them at relatively faster speed and thus free up the internet bandwidth which will otherwise have been used for downloading. Those who want will have it on other storage media will have provided the medium for the transfer to take place.

The university could also initiate a policy that will seek to gradually encourage the use of FOSS by its staff through the replacement of non critical software such MS Office suite with FOSS version such as Open Office.

The implementation SOE based on FOSS needs to be facilitated by a prepared technical environment, but more importantly the target social system needs to be ready to engage with FOSS initiatives. An educational institutional receptiveness to FOSS based SOE initiative will be influenced by the extent to which the initiative matches the educational institution's aspirations, values and needs, or its perceived contribution to the delivery of its core duty (Rogers 2003). Social systems ICT aspirations, values and needs, and a shared sense of the future well-being of the university's development through the use of ICT are aspects of *social system* (Simpson, 2005). The social system is therefore a critical factor in the receptiveness to FOSS initiatives as well as the acceptance of FOSS based technology, and consequently the likelihood of the FOSS initiative to succeed and be sustained (Rogers, 1995).

Using the principles of Diffusion of Innovations theory and FOSS philosophy, a discovery of the following components was found to be imperative to the adoption of

FOSS. These components also make up the inputs to the proposed SOE model. The inputs '*soft technology*' and '*technology culture*' assist in understanding how FOSS initiatives will be diffused in a social system. These components interact with one another, to encourage widespread uptake of the initiative by building the skills and confidence of individuals (Simpson, 2005).

Once accepted, SOE based on FOSS initiative has the potential to increase the levels of efficiency of service delivery in an educational institution. The recognition of these components, the researcher believes provides the basis for the development of a conceptual SOE model that emphasizes the interplay between ICT infrastructure, soft technologies, technology culture, and social satisfaction elements in the framework, for the effective implementation and sustainability of FOSS initiatives. Thus the proposed SOE model has to include the following key inputs:

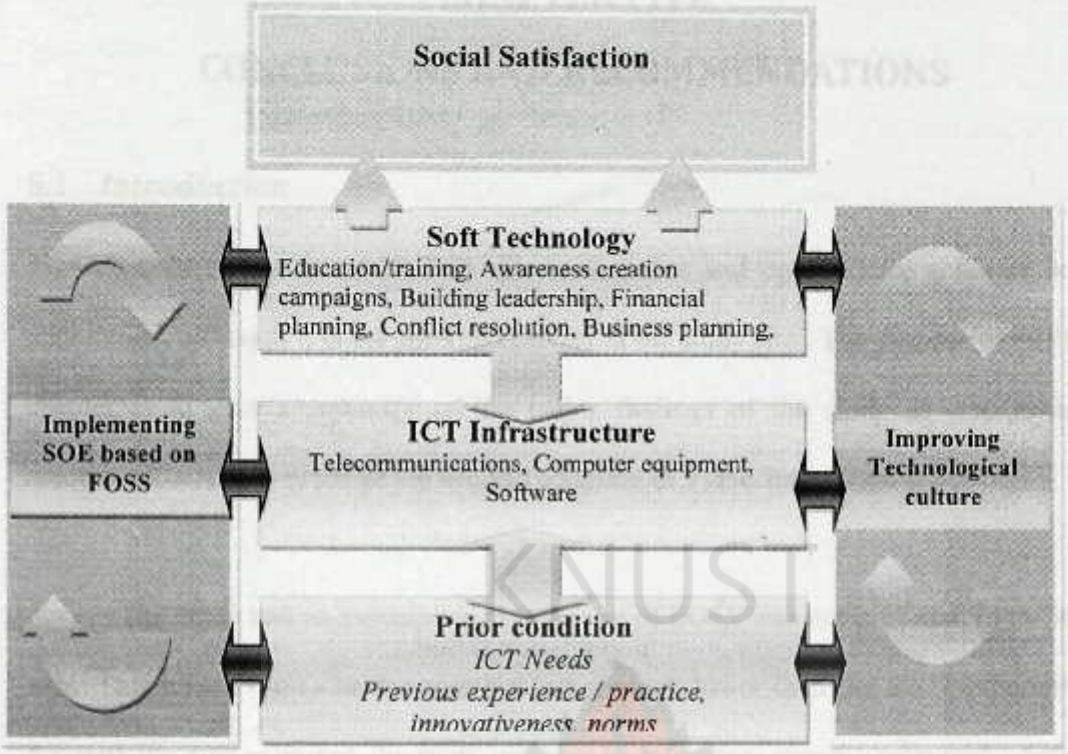
Prior condition (ICT Needs) — this is the first stage in determining what society's ICT needs are. If carefully evaluated will provide the true state of what social system needs are, which will go a long way to provide the ICT solutions needs to improve goods and services delivery. This includes the previous experience or practice, innovativeness, as well as the norms of the social system.

ICT infrastructure — in the buildup of developing SOE based on FOSS or any FOSS initiatives considerations must be given to the technology that is available to the community (e.g. telecommunications infrastructure) and the physical equipment (such as computers, software and other peripherals). The physical equipments may also include computer networks install by the community which they directly control(Simpson 2005).

Soft technology — This consist of formal and informal activities which includes awareness raising, education and training, building leadership and activities that provide opportunities for leadership to embrace the adoption of FOSS. This may also include other capacity building activities that seek to develop the skills and knowledge required by members of social system to maximize the use of FOSS initiative (Simpson, 2005).

Technology culture — the structural arrangements including community organizations and institutions, networks, volunteerism, and community services and resources that enable individuals and groups to interact with one another.

Social satisfaction — the intangible social reward that are outcomes from interaction and participation in local and external networks. The output of this conceptual model is the *social satisfaction.* This occurs when the implementation of an ICT system based on FOSS initiatives delivers the expected result that fulfills the ICT needs of that social system.



SOE Model - Authors construct

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 *Introduction*

The research conducted at KNUST shows that free and open source software is not uncommon, although it is not used extensively at the study site. The purpose of this final chapter is to give a summary of the major findings of the study as well as some recommendations to promote the use and adoption of FOSS innovation at KNUST.

The study had an assumption that the use of FOSS was not prevalent in the study area. This turned out to be the case but rather much lower than the study expected. So far, with the data collected, the study was able to define two specific categories of people that are using FOSS. The first group was the IT professionals at the study site who uses FOSS in a more significant manner, but most of this implementation of FOSS are either on the server side or on their personal computers for learning purposes. The other group happens to be other workers and students of the university that were interviewed, where although there was some implementation of FOSS, but on less significant level. This group of respondents required lot more information on FOSS; it seems that improving availability of information on FOSS in the study area, is what awareness campaign should aim at.

5.1.1 *Extent of FOSS use at KNUST*

The study showed that the use of FOSS was almost non existent among non IT professionals especially among the students and lecturers interviewed. At the NOC the

use of FOSS has proven to be a true alternative to proprietary software, both in terms of technological reliability in service delivery such email system, as well as financial value. There was extensive use of FOSS at the Mathematical Student computer pool, where FOSS was the platform being used on the computes at the center. The IT professionals on KNUST are conversant with FOSS, but almost all FOSS implementation normally ends at network level. One can conclude that Free and Open Source software can be a viable alternative to proprietary software, if innovations based on FOSS are carefully implemented. Total Cost of Ownership (TCO) can be lower; Free and Open Source software avoids vendor dependency and is compliant to open standards, thus offering the possibility to alter the software.

5.1.2 *Strategic management support*

Most of the users were of the perception that the reason that adoption and use of FOSS is low at the study site was due to lack of management involvement in the implementation and use of FOSS. Without the acceptance and support from the top management (strategic level) changes to KNUST's ICT infrastructure are less likely to succeed. This calls for the need to get the necessary management support during initial stage of a possible switch from proprietary software to FOSS or initiating a FOSS innovation. It is also important that change management and adequate thought be given to the implications for each computer-user in the study site during the planning stages.

5.1.3 *Most FOSS prevalent at the back-office*

The study of respondents' perceptions showed that the Linux operating systems and open source web, email servers, and other FOSS server applications, were the most commonly

used open source applications. Web development tools and content management systems that used in the study area are also often based on open source software, among web application developers. Desktop use of Free and Open Source software is still limited but is incrementally gaining popularity as user groups gain momentum and value, as professional support improves, and as licensing regulation becomes more severe.

5.1.4 *Limited availability of Professional IT support for FOSS*

This is reflected in the limited number of certified personnel with demonstrable knowledge and skills of open source software, and augmented by the fact that most training institutes focus on proprietary software like Microsoft Windows and Office. Without adequate professional, certified technical support, Free and Open Source software cannot be adopted by professional organizations whose income depends on the reliability of their technical infrastructure

5.1.5 *Software piracy and familiarity is common practice*

When it comes to ICT, a person rather tends to conform to what is popular in the mainstream, and are reluctant to try new technologies, despite potential financial gains or improvement in delivering services and good. This attitude is what tends to breed software pirating and copy right abuse in the study area as people are so used to the MS windows. Therefore for the adoptions of FOSS to be fruitful any awareness campaign should focus on how to encourage end users to change attitudes and try other platform that gives them independence from soft vendors.

5.1.6 *Government lead initiative*

The study could not find any government initiative to encourage FOSS utilization in the study area. Some government departments and sections already use FOSS, but is not done explicitly as part of government's strategy or vision. This was due to lack of awareness of FOSS among many government policy makers and planners. It was also due to their lack of recognition of FOSS as a necessity for good and stable access to the Internet. To increase the knowledge and awareness of FOSS ultimately, the first priority should be to advocate increased use of basic ICTs among the government officials.

5.2 *Recommendations*

Government can lead the way by implementing Free and Open Source software within the public sector. Countries like South Africa have already made commitments to stimulating the use of Free and Open Source software for certain sectors and by this are in a strong position to negotiate with proprietary vendors who fear losing deals to their open source competitors.

- Aspects like the availability of support, total cost of ownership and organizational needs determine what option is best. In appendix A, adoption models is presented that can support ICT-managers in their decisions.
- To clear the path for open source software, some of the hurdles presented above have to be overcome. Government can play an important role, by developing a clear vision on the use of Free and Open Source software and formulating this vision in a FOSS policy. Government should make money available to the university, to organize awareness campaign and seminars that will provide the

needed information and awareness on FOSS on the study site. Seminars that will be organized would increase awareness on what the possibilities and benefits that FOSS could provide. These seminars should focus on at least the following:

- Providing information on the principles and the philosophy of FOSS.
- Providing information on which and what types of FOSS innovations.
- Establishing pilot projects that will demonstrate Linux and other FOSS application to dispel misconceptions concerning user friendliness and ease of installation and configuration.
- Provision of information about FOSS implementation and migration processes have worked in other countries.
- Providing examples and case studies of organizations using open source software
- Providing information about compatibility of FOSS and proprietary products (e.g. OpenOffice.org – Microsoft Office, etc.)

❖ That the development of documentation comparing features of proprietary and FOSS applications such as MS Word and OpenOffice to assist in migration to FOSS be promoted

❖ That the curriculum at KNUST be revised to ensure that there is enough comparable emphasis on FOSS and proprietary software and that it sufficiently addresses the phenomenon and philosophy of FOSS

REFERENCES

Benbasat, I., D. K. Goldstein, et al. (1987). "The Case Research Strategy in Studies of Information Systems." MIS Quarterly Retrieved Denzin, N. K. and Y. S., (11:3), from http://www.jstor.org/stable/248684

Braak, J. V. (2001). "Individual characteristics influencing teachers' class use of computers." Journal of Educational Computing Research **25(2)**: 141-157.

Braimah, I. and Frempong, G.(2004). "Strengthening of Information and Communication Technology Policy in Africa: Governance and Equity Issues - The Case of Ghana, ATPS, Nairobi." Retrieved January 12, 2009, from http://ijedict.dec.uwi.edu//viewarticle.php?id=185&layout=html.

Brinberg, D. and McGrath, J. E. (1985). Validity and the Research Process. Thousand Oaks, CA, Sage Publications.

Cavaye, A. L. M. (1996). "Case study research: a multi-faceted research approach for IS." Information Systems Journal **6**: 227-242.

Creswell, J. W. (2009). Research Design--Qualitative, Quantitative and Mixed Methods Approaches. California, SAGE Publication, Inc.

Davis, F. D. (1989). "Perceived usefulness, perceived ease of use and user acceptance of information technology." MIS Quarterly **13(3)**: 319-340.

Dedrick, J. and West,J. (2004). "Why Firms Adopt Open Source Platforms: A Grounded Theory Of Innovation And Standards Adoption." Standard Making: A Critical Research Frontier for Information Systems **MISQ Special Issue Workshop**: 236-257.

Denzin, N. K. and Lincoln, Y. S. (1994). Handbook of Qualitative Research. . Thousand Oaks, CA, , Sage Publications.

Eveland, J. D. and Tornatzky ,L. G. (1990). "The Deployment of Technology." in Tornatzky, Louis G. and Mitchell Fleischer, The processes of technological innovation. Lexington, Mass: Lexington Books: 117-147.

G.o.G (2003). The Ghana ICT for Accelerated Development (ICT4AD) Policy. Accra: 1-86.

Hippel, E. v. and G. v. Krogh (2003). "Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science." Organization Science **Vol. 14**(No. 2).

Kautz, K. (1999). "Editorial: Special Issue on Diffusion, transfer and adoption of information technology innovations." Information Technology & People **12(1)** (ix).

Kwapong, O. A. T. F. (2007). "Problems of policy formulation and implementation: The case of ICT use in rural women's empowerment in Ghana." International Journal of Education and Development using Information and Communication Technology (IJEDICT) **Vol. 3**(Issue 2): 68-88.

Lane, D. (2002). "A Quick History of Open Source." Retrieved May 27 2007, from www.open2.org/oshistory.php.

Mangesi, K. (2007). "ICT in Education in Ghana: Survey of ICT and Education in Africa." Ghana Country Report Retrieved January 18, 2009, from http://www.infodev.org/en/Publication.406.html.

Martin Bruggink (2003). Open Source Software: Take It or Leave It? The Status of Open Source Software in Africa: A study towards informed decision-making on ICT-platforms: 1-57.

Martin, M. H. (2003). "Factors influencing faculty adoption of Web-based courses in teacher education programs within the State University of New York." ProQuest

Digital Dissertations (Doctoral dissertation, Virginia Polytechnic Institute and State University, 2001).

May, T. (1998). "Reflexivity in the age of reconstructive social science." International Journal of Social Research Methodology, Theory and Practice **Vol No 1,January – March**.

Medlin, B. D. (2001). "The factors that may influence a faculty member's decision to adopt electronic technologies in instruction." ProQuest Digital Dissertations (Doctoral dissertation, Virginia Polytechnic Institute and State University, 2001).

Moyle, D. K. (2003). Open source software and Australian school education: An introduction

Myers, M. D. (1997). "Qualitative Research in Information Systems." (MISQ Discovery, archival version, June 1997, http://www.misq.org/discovery/MISQD_isworld/. MISQ Discovery, updated version, last modified: November 5, 2008 www.qual.auckland.ac.nz/a): 241-242.

Negus, C. (2008). Linux Bible 2008 edition: Boot up to Ubuntu®, Fedora, Knoppix, Debian, OpenSuse, and 11 other distributions,Wiley Publishing, Inc.

Nightingale, D. and J. E. Cromby. (1999). "Social constructionist psychology." Open University Press. From http://www.psy.dmu.ac.uk/michael/qual_reflexivity.htm Retrieved on April 18, 2009.

Office of Government Commerce (OGC) (UK) (2004). Open Source Software Trials in Government - Final Report

Orlikowski, W. J. and J. J. Baroudi (1991). "Studying Information Technology in Organizations: Research Approaches and Assumptions." Information Systems Research **2**: 1-28.

OSI (1990). "Open Source Philosophy." Retrieved Nov 12, 2008, from http://www.opensource.org/.

Parisot, A. H. (1995). "Technology and teaching: The adoption and diffusion of technological innovations by a community college faculty." ProQuest Digital Dissertations(Doctoral dissertation, Montana State University, 1995).

Perens, B. (1998). "The open source definition." From http://perens.com/Articles/OSD.html. Retrieved on Nov 28, 2008

Pothmann, C. (2005). "ICT Development and Education with Open Source in Zambia." Computer Science Technical University of Berlin

QinetiQ (2002). Analysis of the Impact of Open Source Software Report on behalf of the UK Office of Government Commerce by QinetiQ a private defense technology corporation); prepared in Nov. 2002.

Rajani, N., J. Rekola, et al. (2003). Free as in Education: Significance of the Free/Libre and Open Source Software for Developing Countries. **1:** 1-96.

Reijswoud, V. v. and Topi, C. (2004). "Alternative Routes in the Digital World: Open Source Software in Africa." Retrieved Nov 12, 2008, from www.viagroep.nl.

Rogers, E. M. (2003). Diffusion of innovations. New York, Free Press.

Rogers, E. M. and K. L. Scott (1997). "The Diffusion of Innovation Model and Outreach from the National Network of Libraries of Medicine to Native American Communities." National Network of Libraries of Medicine 1-13. .

Ryan, B., & Gross, N. (1943). "The diffusion of hybrid seed corn in two Iowa communities." Rural Sociology **8**: 15-24.

Sahin, I. (2006). "Detailed Review of Rogers' Diffusion of Innovations Theory and educational Technology-Related Studies Based on Rogers' Theory." The Turkish Online Journal of Educational Technology - TOJET **volume 5** (Issue 2 Article 3).

Schutz, M., N. Khan, et al. (2005). A Baseline Survey on Free and Open Source Software (FOSS) in the South Pacific: Knowledge, Awareness, and Usage.

Simpson, L. (2005). "Community Informatics and Sustainability: Why Social Capital Matters." The Journal of Community Informatics: 102-119.

Spotts, T. H. (1999). "Discriminating factors in faculty use of instructional technology in higher education." Educational Technology & Society **2**(4): 92-99.

Stake, R. (1995). The Art of Case Study Research. Thousand Oaks ,CA, Sage.

Thomas, K. and J. Sicam (2008). Beginning Ubuntu Linux, Apress. **3rd edition**.

Tornatsky, L. G. and K. J. Klein (1982). "Innovation Characteristics and Innovation Adoption Implementation" IEEE Transactions on Engineering Management **29**(1): 28-45.

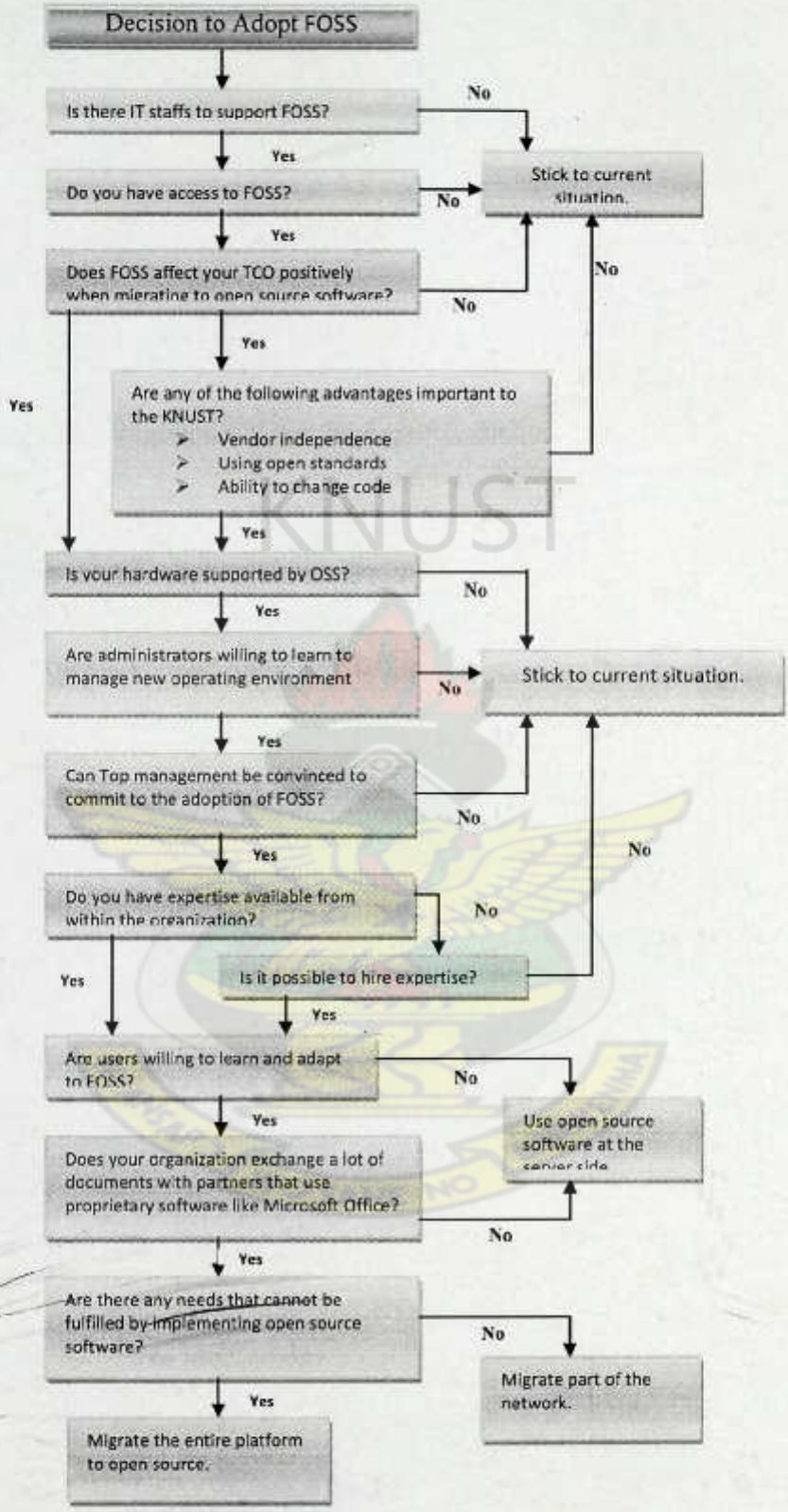
Walsham, G. (1995). "Interpreting Information Systems in Organizations: nature and method." European Journal of Information Systems, **4** 74-81.

Walsham, G. (1993). "Interpreting Information Systems in Organizations." Chichester, Wiley.

Yates, B. L. (2001). "Applying Diffusion Theory: Adoption of Media Literacy Programs in Schools". Paper presented at the Annual Meeting of International Communication Association, 51st, Washington DC, ERIC.

Yin, R. (2003). Case Study Research Sage Publications.

APPENDIX A



FOSS Adoption Model adapted from Rajani et al. (2003)