ASSESSING THE COST-COMPONENTS OF THE TOTAL COST OF OWNERSHIP (TCO) OF A COMPUTER NETWORK IN TERTIARY EDUCATIONAL INSTITUTIONS. CASE STUDY OF THREE INSTITUTIONS IN KIGALI, RWANDA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE AWARD OF THE DEGREE OF THE MASTER IN BUSINESS ADMINISTRATION AND MANAGEMENT OF KAMPALA INTERNATIONAL UNIVERSITY

BY

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DECLARATION AND APPROVAL

I, Marcellin Mugabe, declare that this work is entirely the findings of my own and has never been presented for any academic award.

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Date. 1/11/2006

This dissertation entitled ***"Assessing the Cost-Components of the Total Cost of Ownership (TCO) of a Computer Network in Tertiary Educational Institutions" Case Study of Three Institutions in Kigali, Rwanda*** has been submitted to the Director of the School of Post Graduate Studies of Kampala International University with my approval as the supervisor.

Mr. Alex MBAZIIRA

Supervisor

Date. 1/11/06

DEDICATION

To my nieces Iris and Annélie who are brilliantly going through the early stage of their learning process,

To a few people who toil day and night not for self satisfaction nor maximization of own interests but seek to improve the quality of life of their fellow human beings,

... I dedicate this work.

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ACRONYMS

ARPEC	: *Association Rwandaise pour la Promotion de l'Education et la Culture* ("Rwandan Association for the Promotion of Education and Culture")
ATM	: Asynchronous Transfer Mode
AVU	: African Virtual University
CIO	: Chief Information Officer
CoSN	: Consortium for School Networking
FDDI	: Fiber Distributed Data Interface
FLOSS	: Free/Libre Open Source Software
FOSS	: Free Open Source Software
GTZ	: *[Deutsche] Gesellschaft für Technische Zusammenarbeit* ("German Agency for Technical Cooperation")
HR	: Human Resources
IAMSEA	: *Institut Africain et Mauricien de Statistique, et d'Economie Appliquée* ("African and Mauritian Institute of Statistics and Applied Economics")
ICT	: Information and Communication Technology
IDC	: International Data Corporation
IRR	: Internal Rate of Return
IS	: Information System
ISP	: Internet Service Provider
IT	: Information Technology
KIE	: Kigali Institute of Education
KIST	: Kigali Institute of Science and Technology
KIU	: Kampala International University
LAN	: Local Area Network
MBA	: Masters of Business Administration and Management
ROI	: Return on Investment
SAP	: *Systeme, Anwendungen und Produkte in der Datenverarbeitung* ("Systems, Applications and Products in Data Processing")
SOLAS	: School of Language Studies
TCA	: Total Cost of Acquisition

TCO : Total Cost of Ownership

ULK : *Université Libre de Kigali* ("Kigali Independent University")

UNDP : United Nations Development Program

VoIP : Voice over Internet Protocol

WAN : Wide Area Network

ABSTRACT

> "When a school district decides to buy new school buses, it is usually understood that some other line items in the budget must increase, too. The district will have to purchase more gasoline, allocate more money for parts and maintenance, and hire more drivers. Insurance premiums might go up, and over time, the bus eventually will have to be replaced with a newer model. But when it comes to purchasing computers and installing new technology, too many school leaders believe their job is done once their schools are wired and a brand-new multimedia PC sits on every fifth desktop. In fact, the job is only beginning" (Fitzgerald[1], 1999).

The citation above naturally leads one to pose the following question: Which are the most important cost-factors to be included in the total cost of ownership of an efficient computer network within a tertiary educational institution environment? This is our research question. A new financial tool called Total Cost of Ownership (TCO) has been developed for this purpose. The idea got under way in the mid-1980s, when computers became popular and widely used in many areas of business. TCO represents all of the costs involved with installing, operating, and maintaining a network of computers over a period of time.

Our basic assumption was that TCO can provide a financial statement reflecting the cost of acquisition and of all aspects involved in the further use and maintenance of a computer network in a tertiary educational institution. Therefore, this study assessed the TCO of computer networks in tertiary educational institutions, taking as a case study three tertiary educational institutions in Kigali (Rwanda), namely, the Kigali Institute of Education (KIE), the Kigali Institute of Science and Technology (KIST) and the Université Libre de Kigali (ULK). The ultimate aim of this study was to propose a structured methodology to perform a TCO analysis for the adoption of computer networking. TCO analysis varies among companies, and different consultants use different models and formulas to calculate it. in this study, the TCO was evaluated (i) in terms of directs costs related to networking itself (hardware and software acquisition, retrofitting costs, operations and technical support, administration and professional development; (ii) in terms of indirect costs, *i.e.*, costs related to the loss in productivity when users have to stop and fix their own computers or the network is down because of poor maintenance.

Our major recommendations contain a number of factors to be taken into account in order to control and, consequently, reduce each of the above mentioned cost categories.

[1] Sara Fitzgerald is the project director of the Consortium for School Networking (CoSN), a nonprofit coalition of school districts, state and regional educational groups and networks, corporations and education organizations in the USA that promotes the use of telecommunication in order to improve learning experience in K-12 classrooms (primary and secondary education).

CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

The first chapter of this study consists of a general introduction. In this chapter, after giving a view on the historical and pragmatic background of the study, the researcher proceeds by stating the research problem which immediately leads to the research question. The research question is followed by a glimpse into what would be the way forward in order to arrive at the answer of the postulated question. Next, the chapter spells out the objectives of the study, followed by the significance of the study and the definition of the key concepts contained in the title of the study.

1.1 Background of the Study

Computers have kept an upward trend in terms of usage. Back in 1960s, people wondered who would want a computer for his office or his home! Computers were too voluminous, too expensive and using them was very complicated. However, as computers evolved, they became smaller, cheaper and easier to use. Today, almost all forms of business rely on computer technology to assist them in almost every area of corporate life including processing data, storing information, working out complex mathematical problems, tracking inventory, among other functions performed by those "intelligent" machines.

Moreover, the advent of computers have inaugurated a new era in the telecommunication sector. Recently, our society has been introduced to different ways of communication through computers that are connected to each other (computer network). A computer network is a way of connecting different computers to allow passing information from one computer to another or sharing other resources such as printers and scanners. The commonly known and widespread form of computer networks is the Internet. Before the Internet was invented and popularized, people had to go to the post office and mail documents or information to other people in the world, a process that would take too much time compared to what it takes to send an electronic mail. Today, through the computer networks, we now have the ability to communicate with anybody throughout the world in matter of minutes.

Whereas this rapid and widespread evolution of information and communication technology (ICT) during the last 40 years has been beneficial in many areas of corporate life, at the same time it has brought in several challenges to top corporate management. As institutions adopted new technology also new problems cropped, thus leading to the need of innovative ICT management. The most challenging area in ICT management has always been to track the total cost of ownership (direct and indirect cost of acquisition and maintenance) of its specific ICT equipment, which means, it has been no small task for most companies to clearly identify and calculate the full range of costs involved in the ownership of their ICT equipment. This explains why many companies are expressing today the need for a well-defined strategic process to achieve an accurate picture of the true cost of ownership of an investment in an ICT project.

In this regard, educational institutions do not constitute an exception. Today, there is growing evidence that if technology is incorporated wisely in educational institutions, it can improve the learning experience relative to the traditional way of teaching. Thus, educational institutions are devoting more and more financial and human resources to the task of incorporating technology into the classroom. However, when an institution purchases computers or installs a network, the cost of the hardware is only one small part of the expenses it can expect in subsequent years if it is going to use those technological resources effectively.

In other words, if educational institutions don't properly plan for their technology budgets, there may not be enough money available to provide lecturers with adequate training, to maintain new computers or to replace them when they become obsolete. Institutions may fail to budget for increases in power consumption or necessary improvements in their physical plant. They may connect their computers to the Internet, but forget about the additional telecommunications costs associated with making that connection. As a result, an educational institution's investment in technology could fall short of its expected return. As one analyst rightly puts it, there is need for shifting from the question: "How do we get more computers in our institution?" to the more challenging question: "How can we afford to keep them?" (Slonaker, 1998).

1.2 Research Problem

The above considerations lead to the formulation of the following research problem.

The use of information technology in tertiary educational institutions is rapidly increasing in developing countries. But, sometimes, these institutions are ill prepared to cater for the entire range of financial requirements in relation to their technology investment. This is mainly due to the fact that many institutions fail to understand and calculate the total cost of ownership (TCO) vis-à-vis an IT investment. Instead, they base their buying decisions on the Total Cost of Acquisition Analysis (TCAA) which, however, varies dramatically against the TCO. In fact, whereas the latter includes costs that are incurred throughout the entire life cycle of the ICT project the former limits itself to only providing for the initial investment. Consequently, these institutions manage to gather the needed resources from a variety of sources including one-time grants and donations for the initial investment, but once the acquisition budget has been obtained, they come to realize that the actual implementation of the ICT project enshrines many more additional costs than those included in the initial budget. For instance many of the building hosting such institutions are found to be built some time back and, consequently, requiring important modifications in order to accommodate current and future technological needs. Moreover, in the majority of cases, operating costs, costs related to maintenance and technical support are often not properly budgeted for by educational institutions. Also, the various ICT resources in use differ in models, ages, and other characteristics and this increases the complexity and the cost of managing those resources efficiently. Therefore, the lack of proper budgetary practices in tertiary educational institutions leads to poor allocation of resources and, ultimately, to the system's inefficiency.

1.3 Research Question

The research problem stated above naturally leads one to pose the following general research question in relation to the cost of an investment in a computer network in a tertiary educational institution:

Which are the most important costs which are incurred throughout the entire life cycle of an efficient computer network within the environment of a tertiary educational institution in the developing world?

Faced with the need for a tool capable of measuring the cost of a technology investment, Gartner Group, a leading information technology research and advisory firm in the USA, developed, in 1987, what is today commonly known as the total cost of ownership (TCO). Gartner defines TCO as a comprehensive set of methodologies, models and tools to help organizations better measure and manage their IT investments (Gartner, 2006). The TCO analysis's goal is, therefore, to help consumers and enterprise managers assess all the costs (direct and indirect) related to the purchase and ownership of any capital investment, especially, an IT investment. Likewise, the basic assumption of this study was that TCO analysis allows measuring the cost of acquisition and of all aspects involved in the further use and maintenance of a computer network in a tertiary educational institution.

1.4 Objectives

1.4.1 General Objective

The general objective of this study was to determine the cost-components of the Total Cost of Ownership (TCO) of a computer network in a tertiary educational institution, taking as a case study three institutions in Kigali (Rwanda), namely, the Kigali Institute of Education (KIE), the Kigali Institute of Science and Technology (KIST) and the Université Libre de Kigali (ULK).

1.4.2 Specific Objectives

The specific objectives of the study were to:

1 Evaluate the importance of the following cost-categories as regard to a computer network in a tertiary education institution:

  1.1 Hardware acquisition
  1.2 Software Acquisition
  1.3 Retrofitting of the physical site
  1.4 Operations and technical support

1.5 Administration and professional development

2 Evaluate the importance of the following cost-categories as regard to a computer network in a tertiary educational institution

2.1 End-users' operations

2.2 Downtime

3 Determine whether or not there exist a significant relationship between the first group of cost-categories (direct costs) and the second ground of cost-categories (indirect costs).

4 Provide a number of recommendations based on the findings of the study.

By conducting this study with these objectives in mind, our aim was to come up with a framework within which tertiary educational institutions would be enabled to calculate their own TCO. In order to achieve this, we chose to highlight important cost factors of TCO (taking into account particular circumstances of an educational institution in a developing world) that will help those institutions improve the way they manage their technology assets, adopt best practices, and simplify the management of information technology resources.

1.5 Significance of the Study

First of all, as it can be drawn from the background of the study, the findings of this study will be useful for all the organizations which have invested or intend to invest in a computer network. In other words, the findings of this research will be of value for buyers of IT equipment looking for ways to lower existing costs by comparing their results with those of other similar buyers. Vendors or suppliers of this new technology too would benefit by using comprehensive TCO data in order to refine their products and services with the goal of lowering TCO and increasing overall customer value.

Secondly, findings of this study will be useful for decision makers in public and private administration. It will provide them with an instrument to compare costs between the organization set-up before, during and after computer networking by surfacing costs hidden in a usual income statement. However, this study will be based on the peculiar context of selected universities in Kigali, Rwanda. Therefore, any generalization of the results and conclusion of this study will need to take this into consideration.

Thirdly, a TCO assessment can help government institutions, on the one hand, to determine the level of efficiency of the ICT investment in terms of marginal benefits to beneficiaries. On the other hand, knowing costs involved in computer networking and connectivity implementation can help minimize the expenses involved in the local administration of the country. In fact, in Rwanda like in Uganda, through the e-government initiative, participants in various sectors are striving to use ICT to prompt changes in the standards and delivery of local government services and, more importantly, in the way citizens interact and participate in governance. Voluminous paperwork, delays in service delivery and stifling bureaucracy can soon be a thing of the past, if new ICT plans, including networking and connectivity, are efficiently implemented across the country. A TCO assessment can facilitate an efficient implementation of this government's project.

Finally, the research results will be useful for the researcher. In fact, in addition to contributing to his academic achievement, the research itself represents an exciting opportunity of exploration into a not much known, and yet extremely relevant, field of financial management oriented towards managing information and communication technology.

1.6 Definition of Key Concepts

Before proceeding further, it is convenient to make explicit the meaning and the scope of two major technical terms encountered in the title of this study, namely, the "computer network" and the "total cost of ownership".

1.6.1 Computer Network

A computer network can be defined as two or more computers linked together to share information and resources. A Local Area Network (LAN) covers a limited area (a single site, usually within one building), and facilitates the sharing of information and of resources such as printers and scanners. A Wide Area Network (WAN) is a network that spans a relatively large geographical area, incorporating more than one site. In this case, connections are made using methods such as telephone lines and modems, ISDN lines and ISDN terminal adapters, radio waves or satellite links. A network where dedicated computers handle the sharing of information and resources is known as a server-based network, and a network where each workstation can share information and resources is known as a peer-to-peer network (GTSlearning, 2002).

1.6.2 Total Cost of Ownership

Total Cost of Ownership (TCO) is a financial estimate designed to help consumers and enterprise managers assess direct and indirect costs related to the purchase of any capital investment. TCO analysis originated with the Gartner Group in 1987 and has since been developed in a number of different methodologies and software tools. A TCO assessment ideally offers a financial statement reflecting not only the cost of purchase but all aspects in the further use and maintenance of the equipment, device, or system considered. This can include a variety of costs factors such as the costs of training support personnel and the users of the system, costs associated with failure or outage (planned and unplanned), diminished performance incidents (*i.e.*, if users are kept waiting), costs of security breaches (in loss of reputation and recovery costs), costs of disaster preparedness and recovery, floor space, electricity, development expenses, testing infrastructure and expenses, quality assurance, incremental growth, decommissioning, and more (Wikipedia, 2006). Therefore TCO is sometimes referred to as total cost of operation. When incorporated in any financial benefit analysis (e.g., NPV, ROI, IRR, etc.) TCO provides a cost basis for determining the economic value of that investment.

CHAPTER TWO

THEORY

2.0 Introduction

This chapter consists of three major sections. The first section gives a theoretical framework in which the researcher, first, attempts to give a concise definition of what is referred to as a financial cost, second, gives a general classification of costs and, third, talks about the importance of the cost analysis. In the fourth instance, the researcher introduces the notion of total cost of ownership (TCO) as a relatively new financial tool for measuring the full range of costs for any investment. The second section is constituted by the conceptual framework whereby the researcher strives to examine various TCO models from which he induces a new TCO model judged to be the most appropriate for a computer network in a tertiary educational institution. In the third and last section of this chapter the researcher gives a historical background of various TCO models, draws a contrast between the TCO and the Life Cycle Costing (LCC) as two financial methods aiming at calculating the full range of costs for a product or an investment and, finally, he spells out some of the major weakness of the TCO.

2.1 Theoretical Framework

This section is a presentation of the financial theory of cost, as well as a general classification of costs, which will lead us to understand better the notion of total cost of ownership (TCO).

2.1.1 Financial Cost: Definition

In his book entitled *Managerial Accounting*, Pandey (1999) dedicates the entire fifth chapter to the theory of cost. Pandey defines "cost" as "a foregoing measured in money terms, incurred or potentially to be incurred for a specific purpose" (Pandey, 1999). Thus, costs are incurred for an object. A cost object may be a product, a group of products, a department, a division, a machine, an order or a job. According to the same author, the basic purpose of cost determination is the inventory valuation and profit determination. In addition to this, cost data are very useful in financial decision-making. They are required for making decisions such as pricing, volume, make-or-buy, replacement, product mix, and assets acquisitions. Costs data also aid in planning and control and performance evaluation (Pandey, 1999).

It has to be noted that the terms "cost" and "expense", though sometimes interchangeable, do not exactly mean the same thing. Expenses are **expired costs** (those which have already been used to generate revenue) while **unexpired costs** are known as assets. Expired costs are also known as revenue expenditures, and unexpired costs as capital expenditures (Pandey, 1999).

2.1.2 General Classification of Costs

According to the same author (Pandey, 1999), costs may be divided into two general categories: direct and indirect. **Direct costs** are those which can be identified directly with a cost object. The cost of cables used to connect two computers is an example of a direct cost. **Indirect costs** are those which cannot be identified with a cost object. For example, the Chief Information Officer's salary may be an indirect cost for the IT Department if the organization's structure wants him to be included among the top management personnel and paid from the common costs section. In this research, the term "indirect costs" will be technically used to refer to the costs related to the loss of productivity due to the time wasted when end-users are troubleshooting their own problems and due to the system downtime.

Another classification of costs is **product costs** and **period costs**. Those costs which attach to units of finished goods are called product costs. Period costs are incurred for a time period whether or not products are manufactured. For instance, the cost incurred to acquire tangible hardware assets can be classified among "product costs" whereas the monthly salary of technical support personnel would be qualified as a "period cost" since it is incurred independent of whether or not he/she has rendered any particular service during that specific month.

For planning and control purposes, four important classifications of costs are made, and these include: (i) budgeted and standard costs, (ii) fixed and variable costs, (iii) controllable and non-controllable costs, and (iv) differential and managerial costs. A **standard cost** is a predetermined cost under given operating conditions. For instance, we can say that for an educational institution, the cost of acquiring and connecting a multimedia PC to the information superhighway is UGX 5 million per year in an institution hosting more than 2 thousand end-users. On the contrary, **budgeted costs** are those costs which are expected to be incurred for the planned activities of an enterprise for a specified period. Using the same example, the institution administration may decide to budget for UGX 5.5 million or less according to the availability of funds. As we can see, standard costs are used as a basis for formulating budgets. They also constitute an important managerial tool of controlling costs and evaluating performance (Pandey, 1999).

Variable costs are those costs which change in total indirect proportion to changes in volume or level of activity. For instance, fees dedicated to professional development such as the salary of the training staff is classified as a variable cost. **Fixed costs** are those which remain constant in total with changes in volume of activity. For example, the internet connection fee to an internet service provider (ISP) over a given period may remain the same irrespective of the number of users who access the internet within an institution (assuming that the changing number of end-users doesn't make it necessary to change the connection bandwidth).

Controllable costs are those costs which can be influenced to a real and significant extend by the authority or action of an individual at a specific responsibility level within a specific time span. Consequently, **non-controllable costs** are those costs which are not subject to the direct authority and actions of an individual (responsibility center) at his level of responsibility. This means that the individual or the responsibility center has no influence over their incurrence. For a responsibility center, controllable costs would generally include material costs, labor cost and those overhead which it can control (Pandey 1999).

Sometimes, financial situations involve choosing between various alternatives. In such a situation, **differential cost** is the difference between total costs of two alternatives. Differential cost is sometimes known as **incremental cost**. But since the difference between two projects may be an increase or a decrease, the appellation "differential" is more appropriate than "incremental". For example, an institution may contemplate between utilizing technologically savvy lecturers and students for technical support or outsourcing for the same purpose. Since each option has a cost, the decision should be made on the basis on the differential cost of the two options. Sometimes, economists use the term **marginal cost** for differential cost. Technically speaking (in accounting), marginal cost refers to the change in variable cost with the assumption that fixed costs remain constant. For instance the increase in the student population within an institution may cause a change in IT operational costs (hiring a new lecturer). This action may change the total cost of IT investment without having changed the capital investment. The change which occurred (expressed by one unit, *i.e.*, per every new student) is referred to as "the marginal cost in IT investment following the enrolment of one new student".

2.1.3 Importance of Cost Analysis

One important objective of the cost accumulation is to determine unit cost of a product and determine the price of the product. In a firm with various divisions, therefore, all costs will have to be identified with the unit of a product. Thus, indirect or common costs will have to be allocated. The steps involved in the cost allocation are: (i) to divide cost centers into production and services; (ii) to assign direct costs to respective cost centers; (iii) to distribute common (indirect) costs to cost centers on some logical and equitable bases; (iv) to distribute total cost of service cost centers to production cost centers; (v) to change costs of production cost centers to the units of product on some logical basis (Pandey, 1999). The basis for cost allocation to product could be the number of units produced or labor hours and/or machine hours used. It should be realized that allocation methods may suffer from biases and arbitrariness. However, cost allocation remains important in the financial management of any firm, and the same logic is followed in allocating different costs before the computation of the TCO of an IT investment.

2.1.4 TCO, a New Financial Concept

A relatively new cost concept is referred to as the Total Cost of Ownership (TCO). In many areas of business companies are increasingly aware that costs incurred are often greater than the price of a specific commodity. For example, the total cost of a library software incurred by a University is more than the purchase price of that application in as much as other factors are taken into account including the time spent selecting the appropriate application to purchase, purchasing activity, installation, training time for employee(s), maintenance and repair over the life of the product, upgrading costs, and possibly disposal costs (upgrading to a new program). All those factors, and sometimes more, are components of the real cost of the software.

2.2 Conceptual Framework

The conceptual framework will outline the relationship between the variables, in this case, the relationship between various cost-factors included in the TCO analysis. Many consumers, businesses, governments and, inevitably, educational institutions fail to understand and calculate TCO of their IT equipment. In some circumstances they rely on the Total Cost of Acquisition analysis (TCA) to make buying decisions. However, it has to be born in mind that TCO varies dramatically against TCA and usually TCO is far more relevant in determining the viability of any capital investment because it directly relates to a business's total costs across all projects and processes.

Nevertheless, the TCO analysis doesn't go without challenges. One of the most challenging issues in TCO computation is the identification of the major cost factors, the quantification of those factors and their translation into a particular currency value. In fact, what cost factor is included into the calculation of the TCO depends on the specific case and is generally driven by common sense. For instance, the type of costs involved in networking different branches of a multinational Commercial Bank will differ from those included in connecting computers on a university campus. Likewise, the type of costs linked with the ownership of computer software will not be the same as those linked with the ownership of hardware equipments. For this reason, there have been a variety of TCO models as shown in the table below.

Table 1: Cost-Components of Four Traditional TCO Models

IDC TCO model	SAP TCO model	CoSN TCO model	Gartner TCO model
web workload	hardware/software investment	Retrofitting	hardware and software acquisition
file workload	implementation	Professional Development	operations
print workload	hardware/software ongoing operations	Software	administration
networking workload	continuous improvement projects	Support	end user operations
Security workload	upgrade projects	replacement cost	Downtime
email workload	end user usage	Connectivity	

As we can observe from the above given table, there are as many TCO models as there are IT analyst firms. In order to know more about these different models, it will be of great interest to consult (IDC, 2005) for the International Data Corporation model, (SAP, 2005) for the SAP model, (CoSN, 2001) for the Consortium for School Network módel and (Gartner, 2003a) for the Gartner Group model. The limited scope of this study doesn't allow a thorough comparative study of these various models. In the present study, the researcher strived to examine the different traditional models in order to identify cost factors which can be typically identify with a computer network of a tertiary educational institution within the context of the developing world. In this regard, seven cost-factors have been retained, *i.e.*, hardware acquisition, software acquisition, retrofitting the old buildings, technical support and operations, administration and professional development, end-users' operations and downtime. While the first five cost categories are referred to as the direct costs, the last two cost categories are referred to as indirect costs. Direct costs, on the one hand, are a direct measure of the costs included in the institution's financial statements as regard to the computer network. Indirect costs, on the other hand, can be viewed as a second order effect of the direct spending.

The following diagram portrays the common cost categories that have been retained as the framework within which the TCO of computer network shall be examined considering the particular environment of a tertiary educational institution in the developing world. It must be noted that in developing this model, the researcher heavily relied on the CoSN TCO model (CoSN, 2001) and the Gartner TCO model (Gartner 2003a).

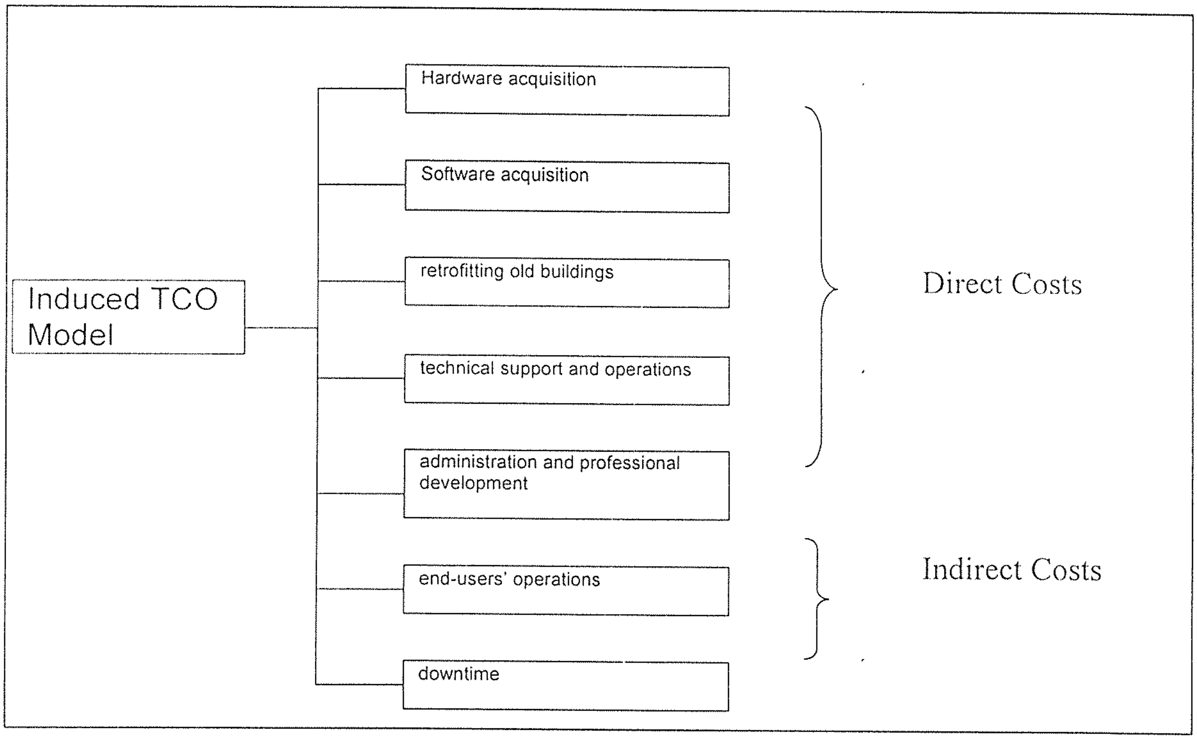
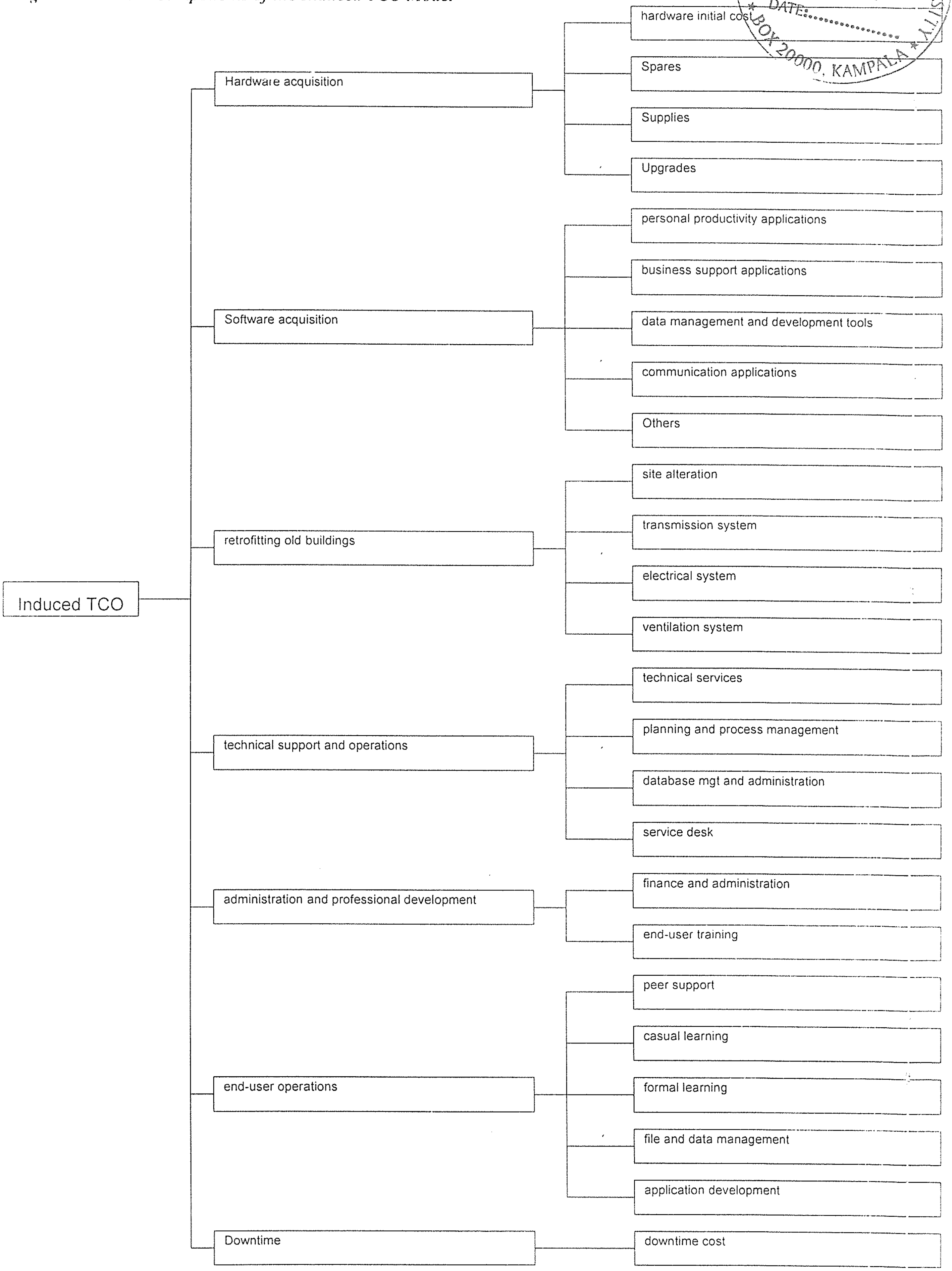


Figure 1: Components of the Induced TCO model (appropriate for a computer network in a tertiary educational institution)

Each cost-category is divided into sub-categories as shown in the table below. Where applicable, the sub-categories have been identified following Gartner TCO model (Gartner, 2003a). The detailed content of each of the sub-cost category shall be given in the fourth chapter together with the corresponding financial figures collected from the field.

Figure 2: Detailed Components of the Induced TCO Model



Notice that **indirect costs** are affected as a result of spending too much or too little in **direct costs**. The relationship between direct and indirect costs can be summarized in the two diagrams below. The first diagram represents an institution which is TCO-reduction oriented whereas the second diagram represents an institution which is not TCO-reduction oriented.

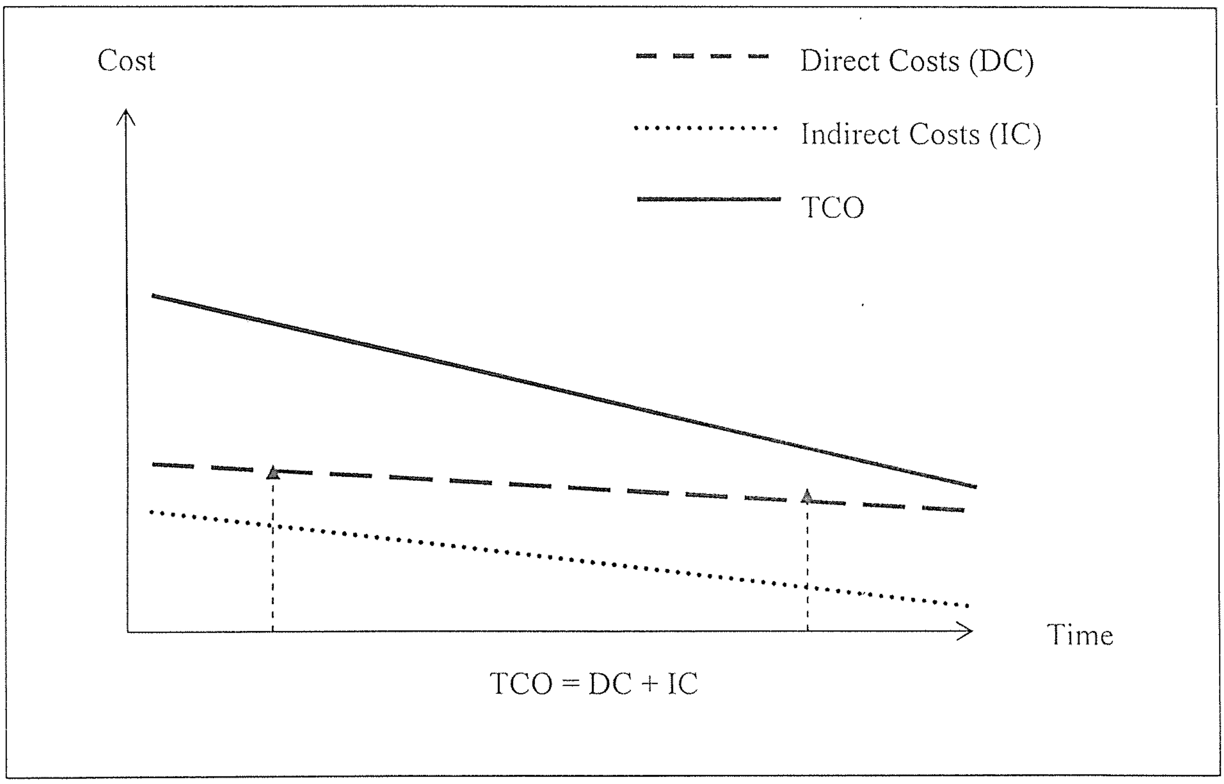


Figure 3: Effects of Direct and Indirect Costs on the TCO for a TCO-reduction-oriented Institution

A TCO savvy institution devotes enough resources for direct costs by maintaining them high compared to the initial investment. This implies that the institution in question devotes enough resources for staff development, it provides enough and competent computer support, makes provisions for regular upgrading of software packages, budgets to replace computers on a regular schedule, recognizes that many buildings will require modifications of electrical and cooling systems to accommodate new technology and budgets accordingly, it plans its network in a way that provides connection that provides enough bandwidth to manage current and future connectivity needs thus preventing the system slowness and downtime. This maintains the level of direct costs relatively high, but by doing so, the indirect costs are drastically reduced and, consequently, the total cost (TCO) is also continuously declining.

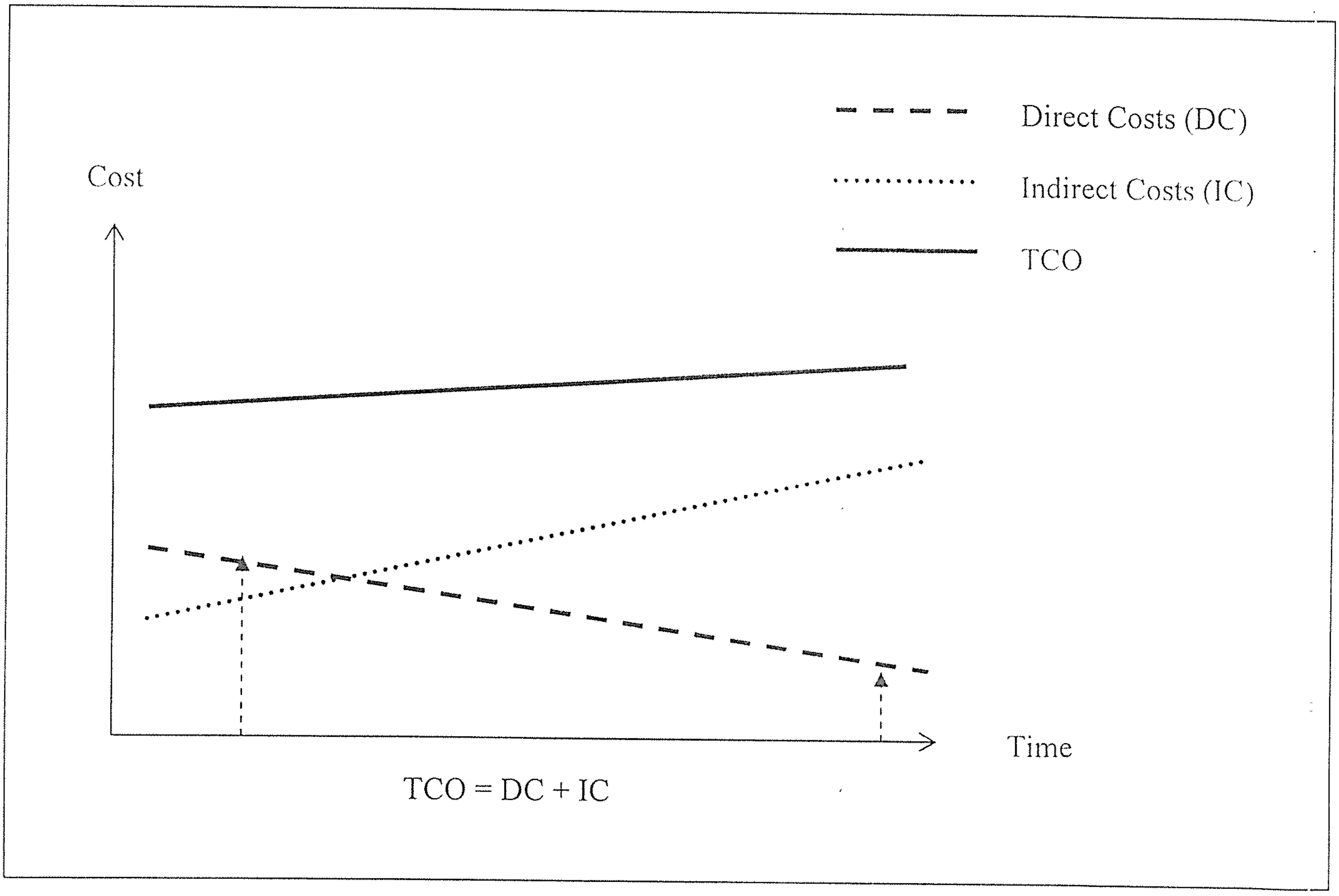


Figure 4: Effects of direct and indirect costs on the TCO for a non-TCO-reduction-oriented institution

An institution which is not TCO oriented is tempted to drastically reduce the direct costs after the initial investment. It assumes that lecturers and staff will learn on the job, that everybody relies on peer-to-peer informal support; it expects support personnel to manage whatever software happens to be installed on a computer within the institution; it assumes that equipment purchased in the initial phase will last for ever; it doesn't care about upgrading the electrical system thus running the risk of causing electrical accidents, and it doesn't bother about its connectivity speed. By doing this they intent to reduce the direct costs, but the indirect costs increase and consequently the TCO is kept ever increasing.

2.3 Review of the Related Literature

2.3.1 Historical Background of Existing TCO Models

Determining IT costs using the TCO is nothing new. TCO has been a steady beacon in the information technology landscape since 1987 when Bill Kirwin, vice president and research director at Gartner Group first applied the model to desktop systems (Emigh, 1999). At the time, the approach was focused on the end user and broke down the costs per individual user. Also, the interest was initially in the user's IT equipment. Over the years, Gartner extended its analysis and methods. Today, Gartner provides a comprehensive IT costs analysis that takes into account not just the user's IT equipment, but also all the systems being used. Gartner Group has extended the model into local area networks (LANs), client/server software, distributed computing, telecommunications, mainframe data centers, etc. Like Gartner, many other companies tackled the determination of customer IT costs, which is why today there is a plethora of options, methods, and tools for carrying out IT cost analysis.

SAP was one of those other companies which turned their attention to TCO. When the concept of TCO was still in its infancy, SAP began collecting data about customers' experiences by means of direct customer contacts, and then took them into account and developed a software capable of identifying and optimizing key cost areas. However, the potential uses of SAP software were simply too many and varied, and the customer requirements too different, making it impossible to identify all the relevant cost potentials for each individual customer.

Another American company, the International Data Corporation (IDC) headquartered in Framingham (Massachusetts) used TCO to determine costs and benefits experienced by medium-size to large commercial sites that had migrated Lotus Domino servers from PC LANs to IBM's AS/400 midrange systems (Emigh, 1999). The study compared 15 PC LAN sites to 15 other sites that had migrated from PC LANs to AS/400s. In this study, IDC discovered that the five-year TCO for AS/400s running Domino was 32% less than that of the PC LANs.

2.3.2 Traditional Life Cycle Costing (LCC) Analysis *versus* TCO

Traditionally, calculating the full range of costs for a product has been done using a financial technique called "life-cycle costing" (LCC) or "total cost of operation". The relatively new notion of "total cost of ownership" has been sometimes equated to the life-cycle costing. For this reason, it is worthwhile to examine the difference between the two techniques.

According to Suttell (2005), the National Institute of Standards and Technology (NIST) of the United States of America defines Life Cycle Cost (LCC), in reference to the building industry, as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time. Thus, in general terms, Life Cycle Cost Analysis (LCCA) is an economic evaluation technique that determines the total cost of owning and operating a facility over a period of time.

According to another definition (Barringer and Weber, 1996), "life cycle costs are summations of cost estimates from inception to disposal for both equipment and projects as determined by an analytical study and estimate of total costs experienced during their life". According to the same authors, the objective of life cycle cost analysis (LCCA) is to choose the most cost effective approach from a series of alternatives so the least long term cost of ownership is achieved. In this sense, LCCA helps engineers justify equipment and process selection based on total costs rather than the initial purchase price. Therefore, life cycle costs are the total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span (Barringer and Weber, 1996).

According to both definitions given above, there seems to be no major difference between the TCO and the LCC. In fact there are analysts who consider both notions as synonyms, as two identical tools which represent "a comprehensive way to calculate the complete range of costs" (Steelcase, 1999).

However, it is worthwhile mentioning that the two techniques are often utilized in different industries. Therefore, whereas LCC analysis is more dominant in the building industry TCO is more common in ICT industry. Consequently, their respective computation includes different cost factors. For instance, the LCC analysis of the office workplace requires focusing on a range of cost factors such as (i) the costs of planning and design, (ii) the costs of selection process and purchasing activities, (iii) the costs of delivery and installation, (iv) the costs of orientation and training, (v) the costs of move management and reconfiguration, (vi) the costs of refurbishing maintenance, (vii) the costs of disposal (Steelcase, 1999). In contrast, the TCO of an ICT equipment include different cost factors such as (i) hardware and software acquisition, (ii) retrofitting the building, (ii) professional development, (iii) software, (iv) support, (v) replacement costs, (vi) connectivity, and so on.

According to what precedes, the TCO and LCC analysis are two financial methods with the same goal but which are used in two different industries. This distinction is not without major implications. For instance, while the LCC analysis should be performed early in the building design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs the TCO is a financial tool that can be applied at any time of the life cycle of the IT investment thus making it possible to reduce the TCO at any time of the investment. Despite this practical difference though, as analytical tools, the two techniques are theoretically interchangeable, and for this reason, LCC analysis techniques can be applied in TCO analysis and vice versa.

2.3.3 Weaknesses of TCO

The first critique points the finger to the complexity of TCO computation. This critique is well formulated by Greenbaum according to whom "the main problem with current TCO studies in enterprise software has to do with the extraordinary complexity of enterprises software implementation and ongoing maintenance, and the difficult even the best intentioned researchers have obtaining accurate data from a large enough sample size" (Greenbaum, 2005)". In the same line, according to a study by Forrester Research Inc., a research firm based in Cambridge, Massachusetts, "78% of all IT administrators acknowledge that they can't document whether or not computer costs are rising because they are unable to accurately track TCO" (Emigh, 1999).

Moreover, the same Forrester's report is sharply critical of TCO dismissing it as "hype" in as much as it (TCO analysis) tends to exaggerate the cost of ownership of IT equipment. In fact, concerns over the fact that TCO might show alarming figures constitute the very reason why some IT managers avoid practicing the methodology, suggests James Delmonte, president of JDA Professional Services Inc. in Houston, an IT staffing firm that also performs cost-benefit consulting (Barringer and Weber, 1996). Related to the previous critique is the perceived high cost of performing TCO analysis, although other analysts suggest that TCO need not be lengthy or expensive.

Another critique points at obstacles posed by TCO analysis in an interdepartmental setup. John Malloy, a systems programmer at Partners HealthCare System Inc. in Boston notes that not-for-profit organizations like universities often obtain computer equipments through grants. In this context, "IT staffers are sometimes unwilling to count this [donated] equipment as assets if the IT department isn't managing it and, therefore, can't give a true TCO calculation for the organization" (Barringer and Weber, 1996). For-profit companies can also experience interdepartmental problem in as much as a lot of IT assets get hidden by being expensed through different non-IT departments.

A final problem worth mentioning is the existence of various TCO models which may yield different results for the same investment. In fact, all important IT consultant firms use significantly different models to analyze the TCO. These different models are capable of producing significantly different results. For instance, the TCO per PC-client may vary between US$ 2,000 and US$ 12,000 depending on whether the analyst used a Gartner's, Forrester's or Meta's TCO model (Greenbaum, 2005). The variability of models results in wondering whether or not it is possible to use TCO for any relative measure of value.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter is divided into six main sections. In the first section the researcher indicates the type of the present research which is a descriptive research and is designed accordingly. Consequent sections of this chapter describe the research environment (second section), identify who are the subjects and where are these supposed to get the needed information (third section), spell out the instruments used (questionnaire) in collecting the data (fourth section), then follows the description of the process followed in collecting the data (fifth section) and, finally, describe the statistical instruments used in presenting and analyzing the data (sixth section).

3.1 Type of Research Design

The present study used a descriptive (also called diagnostic) research design. According to Kothari (2003), the determination of whether the research design should be of a descriptive nature or not is based on the combination of three major factors, namely, (i) the nature of the initial problem (to describe specific characteristics of existing phenomenon or to evaluate specific characteristics of a defined target population – the computer network in an educational structure, in the present study–), (ii) the refinement of the problem as formulated in the research question(s) and (iii) the expressed research objectives. As the three factors converge in the present case, the descriptive research design became the most appropriate methodology for the researcher to follow.

Naturally, a descriptive design must focus attention on (i) defining where to collect the data and the period it will take (environment), (ii) determining the subjects defining the sample designing method, (iii) the methods of the data collection (instruments), (iv) determining how the data will be collected, processed and analyzed and (vi) designing how the findings will be reported. These issues are, therefore, addressed in the following sections.

3.2 Research Environment

The research was conducted in Kigali, the capital city of Rwanda. According to the 2002 national census, Kigali has a population of 603,049 people the majority of whom are employed in the informal sector. The whole country, Rwanda, has a population of 8 million people of which 25,000 were using the internet in 2002. According to the same census 1,624 households possessed a computer of which only 923 are connected to the internet. It is against this national background that the study focused on the growth and management of IT investment (particularly a computer network) in tertiary educational institutions. As it has been above mentioned, the three tertiary educational institutions are the Kigali Institute of Education (KIE), the Kigali Institute of Science and Technology (KIST) and the Université Libre de Kigali (ULK). The presentation of the three institutions shall amply be done in the following chapter.

3.3 Subjects and Sources of Information

The subjects of this study were the Financial Managers (with regard to collecting financial information) and Chief Information Officers (with regard to collecting technology-related information). Personal observation focused on end-users (with regard to collecting information concerning the level of efficiency of the computer usage). The end-users included the personnel as well as students who use IT facilities within the selected institutions. In order to facilitate the respondents to easily locate the needed information, the researcher previously identified the possible sources of the information.

Following the model established by Gartner (Gartner, 2003a), the researcher took care of indicating to the respondents the possible source of the needed information. In this regard, it was indicated that information concerning hardware and software could be gathered from network diagrams, inventory and asset management records, depreciation records, lease records, purchase contracts, purchase orders, supplier records, agreements, budgets, and other financial statements. Information concerning the cost of retrofitting the old buildings could be gathered from purchase contracts, purchase orders, supplier records, agreements and all financial statements. In their turn, operations costs could be gathered from Information System (IS) organization charts, Human Resource (HR) salary records, IS budgets, management time surveys, time records, outsourcing contracts, maintenance contracts, IS management and service desk records (Gartner, 2003a). Administration costs could be gathered from training contracts, IS organization charts, HR salary data, training organization charts, training records, time records, IS budgets and purchasing/managing procurement staff records (Gartner 2003a). End-users' operations costs could be gathered from end-user surveys, end-user focus groups, end-user interviews, HR salary data and the training manager (Gartner, 2003a). Finally, downtime costs could be gathered from end-user surveys IS management, HR salary data, network and systems management and service desk records (Gartner 2003a).

Although the researcher didn't have direct access to all these sources of information, indicating them to the respondents may have helped them to quickly answer the questionnaires.

3.4 Instrument

The data was collected using pre-coded questionnaires. After collecting and editing the raw data from the field, the data was captured in Microsoft Excel computer application for further analysis. Quantitative method of analysis was used for analyzing the data. However qualitative information on some occasions was also used for interpretation of quantitative data. This was based on personal observations and on considerable amount of secondary data from the Internet and libraries.

3.5 Data Collection Procedures

After going through the administrative process to obtain from the academic authorities the permission to conduct the research within selected institutions, the same authorities chose for the researcher the appropriate persons who could provide information asked for in the questionnaire.

In KIE, the researcher was directed to the vice-rector in charger of finance and administration. In this institution, in order to respond to the first section of the questionnaire (dealing with the determination of the general –and technical– characteristics of the research environment), the researcher was referred to the IT department whereby the questionnaire was answered by the deputy IT Director. In KIST the researcher was also referred to the vice-rector in charge of finance and administration who ensured both sections of the questionnaire were answered before returning them to the researcher. In this institution, the help of an assistant researcher (a student within the same institution) was invaluably helpful, especially when it came to follow up to make sure the questionnaire was answered to and returned back. In ULK the researcher was referred to the Financial and Administrative Director who, also, ensured the two sections were answered before returning them to the researcher. However, it has been established that the Director referred the questionnaire to the IT department to get the first section answered.

In the three institutions, the researcher had to book an appointment with the indicated person in order to give directives concerning the questionnaire which, at the first glance, looked to be complex. In the three institutions it took between two and three weeks to get the questionnaires answered and returned back. This delay was mainly attributed to the nature of the needed information coupled with the shortage of time on the side of the respondents who, however, manifested their will to provide the needed information. In the institutions where the two sections of the questionnaire were answered separately, it was clear that the first section was answered and returned faster than the second section. Once the questionnaires were returned back to the researcher, there followed the task of entering the data and representing them in a tabular manner. The data concerning research environment was presented in a descriptive form.

3.6 Statistical Instrument

The financial data collected extended over the five past years (from 2001 through 2005) (including a sixth year –Year 0– corresponding to the year of the initial investment). In order to meaningfully be able to add and compare financial data (cash flows) that are incurred at different times during the life cycle of a project, they have to be made time-equivalent. For this purpose, the data were converted to their present value (PV) by discounting them to a common point in time. The NPV discounting method has been chosen among other tools of financial mathematics. The formula to compute the NPV is as follow:

$$NPV=\sum_{i=1}^{n}\frac{A_i}{(1+r)^i}-I_0$$

where

A_i - is cash in flow in period i

r - is the required rate or return used to discount the cash flows

I_0 - is the cash outlay (salvage value at the moment of disposal)

n - is the number of years

Equation 1: Formula for computing the Net Present Value

For the base year (the common point in time) we have chosen **Year 0**, *i.e.*, the year of the initial investment. This choice has been determined by the fact that the budgeting task is done at the beginning of the project. Therefore, it is more meaning to assume that the amount of money spent, say, in Year 5 (2005) for technical support corresponds to its PV in Year 0 (discounted amount). This means that if it had been budgeted for initially (in Year 0), the amount spent in 2005 would correspond to the compounded value of the amount figuring in the budget made in Year 0.

For the interest rate, we have used **11 per cent**. This is the rounded figure of the official interest rate on deposit (10, 50 per cent) provided by the National Bank (Banque Nationale du Rwanda) for December 1999. By doing this, we assume that this rate reflects the institution's opportunity cost of the money invested in IT over time. We didn't want to use each institution's interest rate for the simple reason that, first, it was not known, second, even if it was known, we wouldn't have used it because it tends to be subjective, something that would have made it difficult to compare the data from the three institutions (with, supposedly, three different discount rates).

With regard to the choice a length of time of **six years**, we assumed that this is a reasonable period to replace a computer if we take into consideration the speed at which information technology is evolving. Thus after six years one can meaningfully talk of replacement and disposal costs which are part of the TCO.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

4.0 Introduction

This chapter contains for major sections. The first section consists of a brief presentation of the three selected institutions, namely, the Kigali Institute of Education, the Kigali Institute of Science and Technology and the Université Libre de Kigali. The second section contains tabular representations of the data collected from the field as regard to direct costs (objective one). Before displaying the data into the table, the researcher takes care to explain each cost category and sub-category. While the second section deals with direct costs, the third section is a tabular representation dealing with indirect costs (objective two). The fourth section deals with the computation of the TCO from the results displayed in the previous sections. The graphical representation (using the pie chart) is used in order to represent the importance of each cost category within the overall TCO value.

4.1 Presentation of the Institutions under Study

The first section of the questionnaire sought to gather information concerning the institution under study. In this preliminary section (which describes the research environment more than it is a presentation of the data), we will briefly present the information gathered in this regard.

4.1.1 Kigali Institute of Education (KIE)

Kigali Institute of Education is located in Remera, one of the areas in the outskirts of Kigali City. The institute was started in 1998 and it operates within the installations that hosted the former Institute of Statistics and Applied Economics for Africa and Mauritius (IAMSEA). At KIE there are three Faculties each with several departments. These faculties include the Faculty of Science which runs eight departments (Biology, Chemistry, Computer Science, Computer Services, Geography, Integrated Science, Mathematics, Physical Education and Physics), the Faculty of Arts and Social Sciences with six departments (Communication Skills, English, French, History, Kinyarwanda and Literature) and the Faculty of Education with eight rotates around 2800 every year and the institution employs around 200 academic and non academic staff members.

4.1.3 Université Libre de Kigali (ULK)

L'Universié Libre de Kigali (The Kigali Independent University, in English) was created on 15th March, 1996 by the Rwandan Association for the Promotion of Education and Culture (ARPEC) which later on became the "Association ULK". ULK is temporary located in Kinamba area in central Kigali but it has a plan of relocating to Gisozi, a suburb district of the Kigali City. In 2002, ULK has opened a second campus in Gisenyi, north-western part of the country. ULK has three faculties, namely the Faculty of Economic Science and Management, with its three departments of Economics, Management and Rural Development, the Faculty of Social Sciences with three departments namely Sociology, Administrative Sciences and Demography, and the Faculty of Law. For the 2006 academic year, ULK has 6,407 students in both campuses. The present research was limited to the current site of the Kigali campus.

4.2 Presentation of the Results as Regard to Objective One

The first objective of the research was to determine the direct costs of the computer network in the selected institutions. According to the model we have adopted (cfr. *supra* –conceptual framework–), the direct costs include the direct annual IS expenses for acquiring (i) hardware and (ii) software assets, (iii) retrofitting the facilities in order to build a network, (iv) technical services and service desk labor fees (technical support and operations) and (v) administration and professional development fees.

4.2.1 Hardware Acquisition

The hardware cost category within the direct costs accounts for all of the capital expenditure relating to hardware assets covering the end users and educational functions. Included are typical software costs that are bundled with the original equipment acquisition where the software cannot be separated from the asset as part of the original purchase price. Also included are devices used by IS personnel for personal productivity functions. Hardware costs

Table 3: Direct cost of the computer network as regard to hardware acquisition in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1.Acquisition cost	21,365.79	20,560.80	25,709.27	24,473.68	23,669.27	102,640.00	218,418.81
2. Spares	22,326.45	22,557.57	30,811.65	34,932.24	30,823.21	86,540.00	227,991.12
3. Supplies	10,851.90	13,067.97	12,514.72	21,030.80	19,722.89	78,450.00	155,638.28
4. Upgrades	16,188.90	16,732.01	20,650.75	27,210.12	48,654.00	24,630.00	154,065.78
Total hardware	**70,733.04**	**72,918.35**	89,686.39	107,646.84	122,869.37	**292,260.00**	**756,113.99**

Table 4: Direct cost of the computer network as regard to hardware acquisition in ULK (in US$)

Year	2005	2004	2003	2002	2001		Total
1. Acquisition cost	22,077.39	23,737.18	28,011.92	29,402.52	31,336.78	132,450.00	237,613.27
2. Spares	14,415.83	15,743.51	15,394.86	15,687.84	15,704.43	48,980.00	125,926.47
3. Supplies	14,409.90	14,577.08	15,738.43	15,452.36	16,398.20	47,200.00	123,775.97
4. Upgrades	9,737.06	11,446.83	12,090.74	14,047.60	12,875.29	14,280.00	74,477.52
Total hardware	**60,640.18**	**65,504.60**	**71,235.95**	**74,590.32**	**76,314.70**	**242,910.00**	**591,195.75**

4.2.2 Software Acquisition

The software category within the direct costs accounts for all of the capital expenditures relating to software including operating systems, all server and client applications, database utilities, educational applications, messaging and groupware applications (e-mail, groupware, communication and connectivity software). It has been noticed that although all the costs are tallied on an annual basis in most cases software is expensed only in the year it is acquired. Site licenses and access agreements are expensed over the duration of the agreement, and software that is licensed under an annual subscription has the annual subscription fee recorded as an annual expense. The main purpose of software maintenance/support agreement is to obtain updates and upgrades.

Software costs were gathered into five sub-categories including (i) personal productivity applications, (ii) business support applications, (iii) data management and development tools, (iv) communication applications and (v) others (Gartner, 2003a: 6-7).

The first sub-category (personal productivity) includes the annualized capital expenditure for all the server and client applications and application foundations including personal productivity software. The second sub-category (business support applications) the cost of business software including contact management, sales automation, order processing, financial, accounting, institution's resource planning, technical design and other vertical applications. The third sub-category (data management and development tools) include the annualized capital expenditures for all database licenses on servers and clients. It also includes the costs for database utilities, data mining, business intelligence tools, report writers, etc. The fourth sub-category (communication applications) includes the annualized capital expenditures on new and upgraded e-mail, groupware and collaboration software. The fifth sub-category (others) includes the annualized expenditures for new and upgrades software foundations or middle ware such as internet/intranet, web-site maintenance, transaction processing (e-applications processing) software that facilitate the institution's operations.

Table 5: Direct costs of the computer network as regard to software acquisition in KIE (in US$)

	2005	2004	2003	2002	2001	Year 0	Total
onal productivity tions	1,363.90	1,535.47	6,140.40	3,645.88	5,766.40	33,560.00	52,012.05
Business /vertical tions	913.22	2,108.80	2,558.50	4,222.40	6,505.22	28,450.00	44,758.14
ıta management ·elopment tools	2,016.20	1,383.90	5,789.52	2,679.60	5,622.24	25,400.00	42,891.46
Communication tions	1,565.52	909.42	3,077.51	5.68	1,261.40	20,540.00	27,359.53
r	1,429.13	2,444.89	2,521.95	12,456.08	3,180.53	27,400.00	49,432.58
ftware ition	**7,287.97**	**8,382.48**	**20,087.88**	**23,009.64**	**22,335.79**	**135,350.00**	**216,453.76**

Table 6: Direct costs of the computer network as regard to software acquisition in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Personal productivity applications	7,489.59	7,051.30	8,450.36	13,560.40	12,884.30	54,350.00	103,785.95
2. Business support/vertical applications	4,862.60	6,023.26	5,270.51	7,519.12	6,487.20	31,900.00	62,062.69
3. Data management and development tools	4,803.30	5,733.30	3,801.20	4,969.44	10,181.30	42,450.00	71,938.54
4. Communication applications	-	6,062.80	-	6,739.60	-	43,200.00	56,002.40
5. Other	8,242.70	6,787.70	9,283.70	13,195.00	10,902.10	33,400.00	81,811.20
Tot. software acquisition	**25,398.19**	**31,658.36**	**26,805.77**	**45,983.56**	**40,454.90**	**205,300.00**	**375,600.78**

Table 7: Direct costs of the computer network as regard to software acquisition in ULK (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Personal productivity applications	5,320.00	3,347.72	3,589.21	3,434.76	3,712.12	15,760.00	35,163.31
2. Business support/vertical applications	4,120.00	2,715.08	4,407.93	4,051.88	2,892.21	13,600.00	31,787.10
3. Data management and development tools	4,780.00	3,117.07	3,808.51	3,353.56	4,838.37	19,300.00	39,197.51
4. Communication applications	5,320.00	3,387.26	3,128.68	4,628.40	4,288.76	16,200.00	36,953.10
5. Other	4,720.00	3,136.84	2,266.10	4,027.52	3,585.98	9,320.00	27,056.44
Total software acquisition	24,260.00	15,703.97	17,200.43	19,496.12	19,317.44	74,180.00	170,157.96

4.2.3 Retrofitting

The retrofitting category within the direct costs accounts for all the capital expenditures that must be spent to wire existing physical facilities in order to support the network technology. Retrofitting is not traditionally part of the TCO analysis. But since the majority, if not all, of educational institutions are hosted in old buildings that have not undergone any major renovation to support technology, this category constitutes one of the major costs that those institutions have to face and thus have to anticipate. Wiring existing buildings involve additional costs, including, in some cases, the cost of removing asbestos and lead, upgrading the electrical system and improving the ventilation and air conditioning systems. Therefore, retrofitting costs were gathered into four sub-categories including (i) site alteration, (ii) transmission system, (iii) electrical system and (iv) ventilation system (CoSN, 1999).

The first sub-category (site alteration) includes the annualized capital expenditure for labor and contract costs for the necessary transformation of the site. The site includes buildings, offices, campuses, etc. with dedicated connections to the network. The second sub-category (transmission system) accounts for the total annualized capital expenditures for acquiring necessary assets utilized in constructing transmission facilities or network circuits. These include media utilized to build circuit facilities such as analog telephone lines, Integrated Services Digital Network (ISDN), Asynchronous transfer mode (ATM), leased and access lines typically supplied by the telephone company or transmission authority. Network-connected devices (PCs, terminals, workstations, servers, mainframes, etc.) that support end users' operations are not included in here. They are included in the hardware cost category. The third sub-category (electrical system) accounts for the total annualized costs for upgrading electrical capacity to support technology. It includes costs for installing additional electrical outlets in the building, acquiring electrical power generators, beef up electrical safety system, changing the lighting system in the offices, etc. The fourth sub-category (ventilation system) accounts for the total annualized costs for improving the cooling and ventilation systems.

Table 8: Direct cost of the computer network as regard to retrofitting in KIE (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. site alteration	3,142.90	4,158.29	5,497.12	17,433.64	21,894.30	132,320.00	184,446.25
2. transmission system	1,719.70	6,069.39	8,421.12	10,897.04	12,830.24	143,290.00	183,227.49
3. electrical system	1,405.41	1,383.90	10,160.90	12,577.88	14,749.37	127,320.00	167,597.46
4. ventilation system	1,903.53	4,151.70	3,823.13	9,338.00	12,091.42	83,210.00	114,517.78
Total retrofitting	**8,171.54**	**15,763.28**	**27,902.27**	**50,246.56**	**61,565.33**	**486,140.00**	**649,788.98**

Table 9: Direct cost of the computer network as regard to retrofitting in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. site alteration	28,268.31	24,976.10	20,146.36	21,883.40	42,662.35	188,500.00	326,436.52
2. transmission system	29,021.42	22,775.04	28,779.47	15,752.80	23,128.67	139,460.00	258,917.40
3. electrical system	26,163.16	24,521.39	25,365.70	24,238.20	25,498.30	151,300.00	277,086.75
4. ventilation system	31,452.72	19,460.27	20,051.33	14,088.20	28,381.50	177,900.00	291,334.02
Total retrofitting	**114,905.61**	**91,732.80**	**94,342.86**	**75,962.60**	**119,670.82**	**657,160.00**	**1,153,774.69**

Table 10: Direct cost of the computer network as regard to retrofitting in ULK (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. site alteration	12,850.31	15,222.90	15,826.15	18,846.52	19,731.90	100,340.00	182,817.78
2. transmission system	7,631.91	6,346.17	9,086.33	11,035.08	11,559.83	67,320.00	112,979.32
3. electrical system	5,378.51	7,763.02	8,676.97	8,379.84	8,766.73	70,290.00	109,255.07
4. ventilation system	7,869.11	9,423.70	10,606.81	10,742.76	12,794.20	57,930.00	109,366.58
Total retrofitting	**33,729.84**	**38,755.79**	**44,196.26**	**49,004.20**	**52,852.66**	**295,880.00**	**514,418.75**

4.2.4 Operations and Technical Support

The support and operations cost category within the direct costs accounts for the technical staff resources including in-house staff, contractors, and outsourced management and support contracts. Support and operations costs were gathered into four sub-categories including (i) technical services, (ii) planning and process management, (iii) database management and administration and (iv) service desk (Gartner, 2003a: 10-12).

The first sub-category (technical services) includes costs of operations staff and management contracts in various technical services activities including **level 2 problem resolution** (which accounts for labor and contract costs for support staff intervening on issues that cannot be resolved through standard service desk operator solutions), **level 3 problem resolution** (which accounts for labor and contract costs for technicians and administrative labor spent identifying and resolving advanced support issues including failure, fault, and accessibility problems with the network, computers, printers, network communication equipment, operating systems and applications), **traffic management and planning** (which accounts for labor and contract costs for proactively monitoring, interpreting, planning and balancing the load placed on the network communication infrastructure), **performance tuning** (which accounts for labor and contract costs for proactively monitoring, interpreting, planning and balancing the performance of servers, networked systems, and applications), **user administration** (which accounts for labor and contract costs for controlling user accessibility to network and application resources handling tasks such as adding new users and resources, logically moving users to new groups, password management, or changing user profiles), **operating system support** (which accounts for labor and contract costs for time spend managing the operating system including settings, upgrades service pack installation, driver updates, and licensing), **maintenance labor** (which accounts for labor and contract costs for routine tasks that are performed on a scheduled or interval basis to maintain the availability and performance of servers, clients, printers, and network communication devices), **software deployment** (which accounts for labor and contract costs for deploying new or upgrading exiting custom or purchased software. Software deployment includes utilities, applications, and messaging software), **application management** (which accounts for labor and contract costs for on-going management of software applications including configuration control, access management, launch, monitoring usage, and the metering of available licenses), **hardware configuration/reconfiguration** (which accounts for the labor and contract cost for reconfiguring existing solutions within the network, including adding hardware subcomponents, upgrades, physical moves, or configuration changes. Items included are system upgrades, performance enhancements, topology changes, switched networks changes, other physical or logical changes, and setups to the hardware settings), **hardware deployment** (which accounts for labor and contract costs for installing and deploying new hardware including servers, clients, peripherals, network communication devices, and networks. The labor allocation for the disposal of displaced or retired hardware is also included here), **disk and file management** (which accounts for labor and contract costs for installing and deploying new hardware including servers, clients, peripherals, network communication devices, and networks. The labor allocation for the disposal of displaced or retired hardware is also included here), **storage capacity planning** (which accounts for labor and contract costs for monitoring, managing, and optimizing online and off-line storage capacity to assure enough capacity is available. Includes file deletion and purging. This category does not include database management and administration), **backup archiving and recovery** (which accounts for labor and contract costs for the backup of network and desktop data, restoring lost or damaged files or data, and the archiving and retrieval of data) and **repository management** (which accounts for labor and contract costs for managing the central disk or tape repository including tape library management and off-site storage monitoring and management).

The second sub-category (planning and process management) accounts for the costs of operations staff and outsource contracts for performing any of various planning and process management activities including **account management** (which accounts for labor and contract costs for working with and managing the relationship between IS and the business units. Typical tasks include business unit alignment, application and infrastructure requirements, business case development, and project management), **systems research, planning and product management** (which accounts for labor and contract costs for identifying infrastructure needs, reviewing configurations, setting standards, researching options, as well as identifying and documenting planned changes. Documentation of existing architectures and configurations, simulation and modeling of new systems, TCO Lifecycle Management, and standards development by IS personnel are tasks that are included here), **evaluation and purchase** (which accounts for labor and contract costs for evaluation and testing of servers, clients, networks, applications, and systems prior to purchase and rollout, and the direct IS labor associated in supporting procurement efforts, including the support of legal and purchasing departments), **security and virus protection** (which accounts for labor and contract costs for proactively detecting or preventing security violations, security restriction, access management, or virus infection, and defining the process for recovery from such violations or intrusions should they occur) and **business recovery** (which accounts for labor and contract costs for creating business recovery and management plans including backup and restore procedures, tape management, hot-site and cold-site planning, record keeping, and business recovery team management and organization).

The third sub-category (database management and administration) includes the costs of operations staff performing database management and administration tasks which include index management, replication, log administration, data recovery, optimization, and other maintenance tasks.

The fourth sub-category (service desk) accounts for the costs of operations staff performing service desk activities, particularly tier 0 and tier I resources. Tier 0 refers to call taking and logging without providing problem assistance or resolution. Tier I refers to first and second level non-dispatched problem assistance or resolution delivered via phone, e-mail or on-line communication. Tier II and tier III support is allocated to technical services in the operations category.

Table 11: Direct cost of computer network as regard to operations and technical support in KIE (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Technical services	14,403.97	14,623.21	14,649.24	14,697.20	15,497.20	16,230.00	90,100.82
2. Planning and process management	10,923.06	11,394.11	11,900.68	12,439.84	12,821.23	10,200.00	69,678.92
3. Database mgt and adimin.	15,299.40	14,563.90	15,424.10	17,287.48	19,065.16	21,670.00	103,310.04
4. Service desk	10,786.67	11,644.53	11,198.92	10,718.40	10,118.23	9,200.00	63,666.75
Total Tech. Support & op.	**51,413.10**	**52,225.75**	**53,172.94**	**55,142.92**	**57,501.82**	**57,300.00**	**326,756.53**

Table 12: Direct cost of computer network as regard to operations and technical support in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Technical services	16,212.62	22,630.06	20,007.47	25,439.96	33,544.23	35,320.00	153,154.34
2. Planning and process management	18,519.39	21,312.06	25,548.45	28,484.96	30,156.47	32,430.00	156,451.33
3. Database management and administration	16,657.37	17,819.36	19,371.50	26,081.44	25,534.34	30,230.00	135,694.01
4. Service desk	17,374.90	18,794.68	17,317.39	25,626.72	28,462.59	29,300.00	136,876.28
Total Technical Support and Operations	**68,764.28**	**80,556.16**	**82,244.81**	105,633.08	117,697.63	127,280.00	582,175.96

Table 13: Direct cost of computer network as regard to operations and technical support in ULK (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Technical services	10,982.36	11,413.88	12,010.33	12,407.36	12,947.37	13,260.00	73,021.30
2. Planning and process management	11,106.89	11,848.82	12,712.09	11,627.84	11,974.29	11,230.00	70,499.93
3. Database management and administration	9,292.31	10,478.10	10,380.20	9,094.40	9,397.43	2,320.00	50,962.44
4. Service desk	8,865.35	9,799.33	10,431.37	10,718.40	9,947.04	9,030.00	58,791.49
Total Technical Support and Operations	**40,246.91**	**43,540.13**	**45,533.99**	**43,848.00**	**44,266.13**	**35,840.00**	**253,275.16**

4.2.5 Administration and Professional Development

The administration and professional development cost category within the direct costs accounts for the direct labor expenses and fees associated with providing administrative services to the IS organization and infrastructure. Administrative and professional development costs were gathered into two sub-categories, namely, (i) finance and administration and (ii) end-user training (Gartner. 2003a).

The first sub-category (finance and administration) cost category accounts for finance and administration labor and fees, including costs for **supervisory management** (which accounts for labor and contract costs for resources and services primarily responsible for exclusive supervisory efforts, particularly middle and executive managers (Chief Information Officer and Management Information System Director, etc.), **IS administrative assistance** (which accounts for labor and contract costs for administrative support personnel, particularly direct assistants to middle and executive management, as well as general department administrative support personnel), **asset management** (which accounts for labor and contact costs for managing depreciation records and lease contracts, and performing asset inventories – physical or automatic management –, asset identification and tracking, asset database management, change recording, and reconciliation), **budgeting and chargeback** (which accounts for labor and contract costs for budgeting and chargeback tasks including the management of central IS and business unit IS capital and operational budgets, and the assignment and accounting of appropriate chargeback systems), **auditing** (which accounts for labor and contract costs for auditing tasks including the review of IS contracts, relationships, asset records, the processes and compliance to written policies), **purchasing, procurement and contract management** (which accounts for labor and contract costs for procurement of end-user and IS hardware and software, services, and training, and legal personnel and services that draft and negotiation purchasing agreements, site licenses, and other procurement related contracts), and **vendor management personal** (which accounts for labor and contract costs for working with and managing hardware, software, application, and service vendors, including IS labor time spent in vendor meetings, writing Requests For Proposals (RFPs), reviewing proposals, dealing with vendor issues, and other vendor management related tasks outside of the product research and evaluation tasks listed under Operations).

The second sub-category (end-user training) accounts for the IS staff and contracts for performing tasks that include **end-user training course development** (which accounts for labor and contract costs for the development of end-user training courseware and CBT. Includes other end-user training tasks not related to instruction time, such as coordination and

end-user training (which accounts for labor and contract costs for instructional delivery of end-user courses). Note: the time/cost of end-user attending training is not included here but in the und-user Operations category.

Table 14: Direct cost of the computer network as regard to administration and professional development in KIE (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Finance and administration	14,060.03	14,010.34	14,839.30	15,907.08	16,533.35	17,490.00	92,840.10
2. End-user training	17,558.73	17,661.20	19,766.24	21,680.40	23,155.70	23,380.00	123,202.27
Total Administration and Professional Development	**31,618.76**	**31,671.54**	**34,605.54**	**37,587.48**	**39,689.05**	**40,870.00**	**216,042.37**

Table 15: Direct cost of the computer network as regard to administration and professional development in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Finance and administration	26,714.65	32,554.60	31,908.15	29,962.80	35,202.07	34,260.00	190,602.27
2. End-user training	28,914.68	29,977.91	31,798.50	34,672.40	35,544.45	37,020.00	197,927 94
Total Administration and Professional Development	**55,629.33**	**62,532.51**	**63,706.65**	**64,635.20**	**70,746.52**	**71,280.00**	**388,530.21**

Table 16: Direct cost of the computer network as regard to administration and professional development in ULK (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Finance and administration	9,327.89	9,410.52	10,204.76	10,612.84	10,118.23	9,430.00	59,104.24
2. End-user training	14,943.60	17,331.70	18,428.51	19,772.20	20,804.09	21,780.00	113,060.10
Total Administration and Professional Development	**24,271.49**	**26,742.22**	**28,633.27**	**30,385.04**	**30,922.32**	**31,210.00**	**172,164.34**

4.3 Presentation of the Results as regard to Objective Two

The second objective of this study was to determine the indirect costs involved in the performance of networking operations as regard to (i) end-users' operations and (ii) downtime.

4.3.1 End-users' Operations

The end-user operations cost category within the indirect cost expresses the productivity losses resulting from IS operations effectuated by end-users (instead of performing their habitual tasks) or from the unavailability of the IS services. The end-user operations costs were gathered into five sub-categories, namely, (i) peer support, (ii) causal learning, (iii) formal learning, (iv) application development, and (v) file and data management (Gartner, 2003a: 22-24).

The first sub-category (peer support) cost category accounts for the annual labor expenses for end users supporting each other in lieu of obtaining technical support from service desk or IS personnel. Typical tasks performed by the end users include troubleshooting and repair, support, maintenance, installation, training, and backup management. Particularly, these tasks are performed extensively by end users in remote offices that are not staffed by dedicated IS personnel or covered by support contracts. Peer support is the reliance on a knowledgeable resource, typically the unofficial "expert" in providing support answers and in resolving technical issues. Peer support often involves assistance of one or more peers to resolve key issues, increasing per incident costs further.

The second sub-category (casual learning) accounts for the annual labor expenses of end users training and supporting themselves in lieu of formal training and support programs. Time includes reading manuals, using online help, trial and error, and other self-learning methods to learn programs and resolve issues. The third sub-category (formal learning) accounts for the annual labor expenses for all the course time spent by end-users on computer system and all application training. The fourth sub-category (file and data management) accounts for the annual labor expenses for the end-user time spent managing files and data including end-user-performed file system maintenance, organization, optimization, backup and recovery. The fifth sub-category (application development) accounts for the annual labor expense of end users performing development and customization of non-business/mission critical applications (infrastructure software) such as notes scripts, access databases, and office scripts.

The end-user IT expenses are determined using end-user surveys. Each of the sub-categories requires hours spent performing a specific task over a given period (a week or a month). Using an average burdened salary for all users, the labor hours collected from the survey responses are translated into annual person hours, and multiplied by annual burdened salaries to obtain annual costs (Gartner, 2003). Thus,

Annual end-users' operations costs = annual person hours * annual burdened salaries

where

burdened salaries = unburdened salaries * the burdened rate

Equation 2: Formula for computing the annual end-users' operations costs

Unburned salaries are obtained from Human Resources (using job level averages) and the burden rate is sourced from accounting (specific for a target end-user population).

4.3.2 Downtime

The downtime cost category within the indirect costs expresses the annual losses in productivity from planned and unplanned outages of the network resources, including client computers, shared servers, printers, applications, communication resources, and connectivity. In other words, these are losses in productivity due to users' inability to use the system. The cost is only measured as lost wages (productivity). As such, downtime is typically computed as follow (Gartner, 2003a: 26):

Annual downtime hours * % productivity impact to users when downtime occurs * end-user burdened salary

Equation 3: Formula for Computing the Downtime Cost

Notice that only downtime that causes loss of productivity is considered. However, a more aggressive estimate of true downtime costs would include an estimate of lost business revenue due to downtime.

Table 17: Indirect cost of the computer network as regard to end-users' operations and downtime in KIE (in US$)

Year	2005	2004	2003	2002	2001	Total
1. Peer support	18,288.12	18,807.86	19,393.43	19,837.16	20,290.52	109957.09
2. Casual learning	21,045.57	24,046.91	22,843.75	24,124.52	21,714.10	133004.85
3. Formal learning	15,068.13	15,657.84	13,918.24	14,283.08	13,947.48	89144.77
4. File and data management	18,928.56	19,394.37	19,429.98	19,585.44	19,668.83	115547.18
5. Application development	13,431.45	13,384.29	13,472.33	13,398.00	11,902.21	76788.28
6. Downtime	27,349.16	29,852.70	36,908.19	39,211.48	44,158.01	224279.54
Total End-user Operations and Downtime	**114,110.99**	**121,143.97**	**125,965.92**	**130,439.68**	**131,681.15**	**748721.71**

Table 18: Indirect cost of the computer network as regard to End-users' operations and downtime in KIST (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Peer support	22,439.12	32,864.33	31,776.57	39,455.08	46,095.16	43,210.00	215840.26
2. Casual learning	27,473.69	31,183.88	35,416.95	37,335.76	4,081.53	31,200.00	166691.81
3. Formal learning	30,361.60	26,452.26	30,168.37	30,985.92	37,148.23	37,800.00	192916.38
4. File and data management	11,403.39	13,773.10	12,660.92	15,704.08	15,524.23	27,350.00	96415.72
5. Application development	13,763.53	12,204.68	14,057.13	12,439.84	16,506.32	21,430.00	90401.5
6. Downtime	78,495.41	128,175.50	130,395.78	134,645.84	119,535.67	14,250.00	605498.2
Total End-user Operations and Downtime	183,936.74	244,653.75	254,475.72	270,566.52	238,891.14	175,240.00	**1367763.87**

Table 19: Indirect cost of the computer network as regard to End-users' Operations and Downtime in ULK (in US$)

Year	2005	2004	2003	2002	2001	Year 0	Total
1. Peer support	11,225.49	11,558.86	13,662.39	13,300.56	13,199.65	13,290.00	76236.95
2. Casual learning	13,739.81	14,300.30	15,285.21	12,464.20	11,938.25	14,320.00	82047.77
3. Formal learning	12,435.21	12,870.27	13,611.22	13,990.76	15,163.83	15,460.00	83531.29
4. File and data management	12,233.59	12,119.01	11,491.32	10,783.36	10,298.43	10,570.00	67495.71
5. Application development	10,330.06	10,036.57	8,676.97	7,324.24	12,334.69	11,940.00	60642.53
6. Downtime	30,527.64	31,005.95	36,571.93	38,691.80	40,833.32	43,230.00	220860.64
Total End-user Operations and Downtime	90,491.80	91,890.96	99,299.04	96,554.92	103,768.17	108,810.00	**590814.89**

4.4 TCO Computation (Analysis) and Graphical Representation (Interpretation)

The formula to compute the TCO is as follow:

$$TCO = H + S + R + S\&O + A\&PD + EO + D$$

where

TCO = Total Cost of Ownership in present-value (PV)

H = PV Hardware acquisition

S = PV Software acquisition

R = PV Retrofitting

S&O = PV of Support and Operations

A&PD= PV Administration and Professional Development

D = PV Downtime

Equation 4: Formula for computing the TCO

According to the above given formula, and using the data obtained previously, we can now compute the total cost of ownership of the computer network over the chosen six years for the three institutions.

Table 20: The Cost of Ownership of the Computer Network for the Five Years in KIE (in US$)

Total hardware acquisition					756,113.99
Total software acquisition					216,453.76
Total retrofitting					649,788.98
Total Technical Support and Operations					326,756.53
Total Administration and Professional Development					216,042.37
Total End-user Operations and Downtime					748,721.71
TCO					**2,913,877.34**

A graphical representation (with the aid of a pie chart) of the above figures displays the proportional importance of each cost category. The first pie chart represents only the direct cost (without the cost of end-users' operations and downtime).

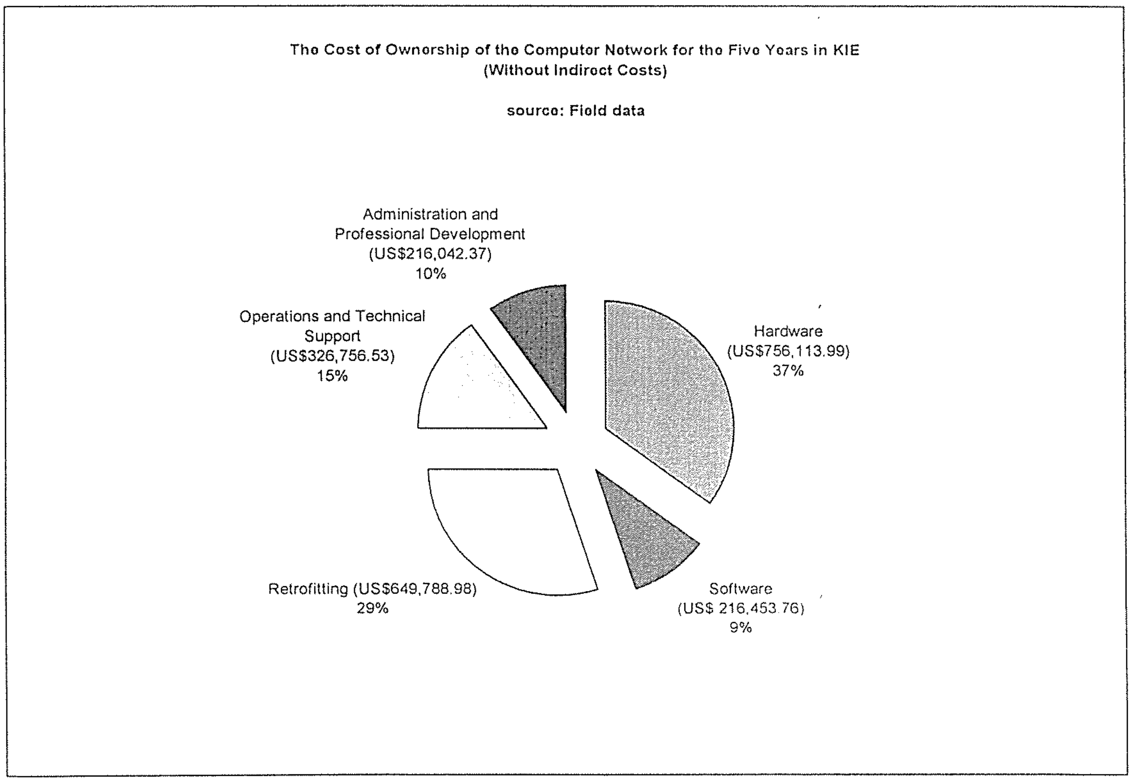


Figure 5: Pie Chart of the TCO in KIE exclusive of indirect costs

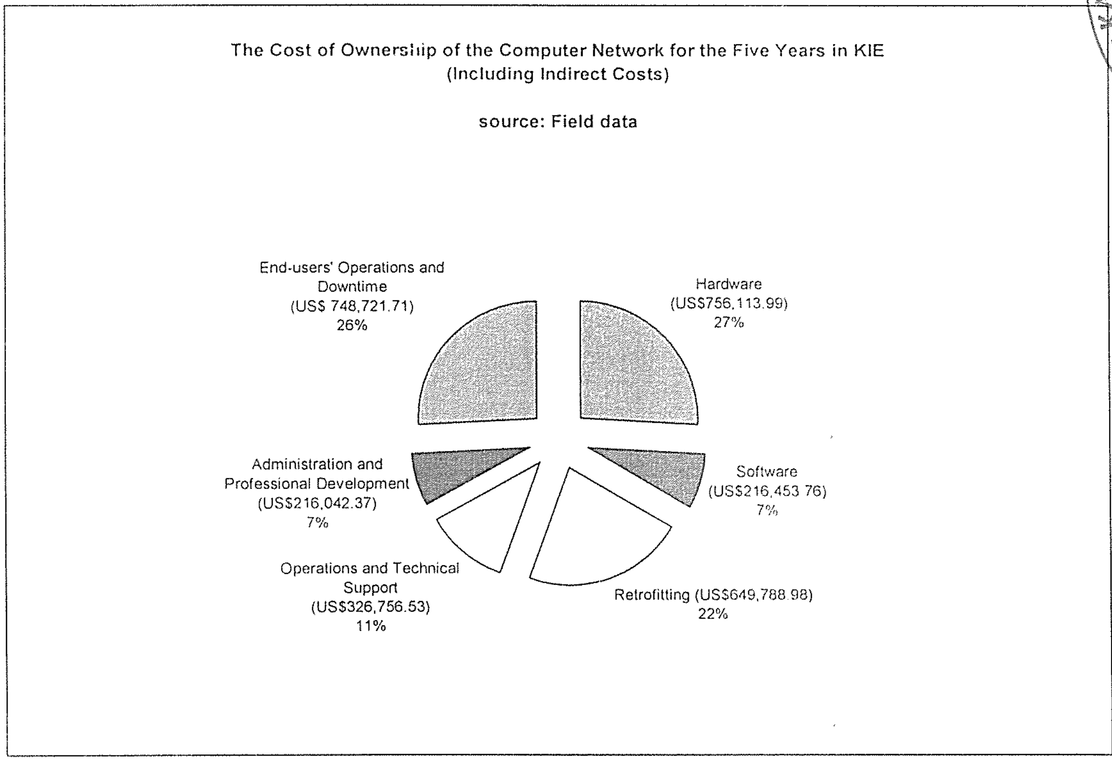


Figure 6: Pie Chart of the TCO in KIE inclusive of indirect costs

Table 21: The Cost of Ownership of the Computer Network for Five Years in KIST (in US$)

hardware acquisition					1,314,029.71
software acquisition					375,600.78
retrofitting					1,153,774.69
Technical Support and Operations					582,175.96
Administration and Professional Development					388,530.21
End-user Operations and Downtime					1,367,763.87
					5,181,875.22

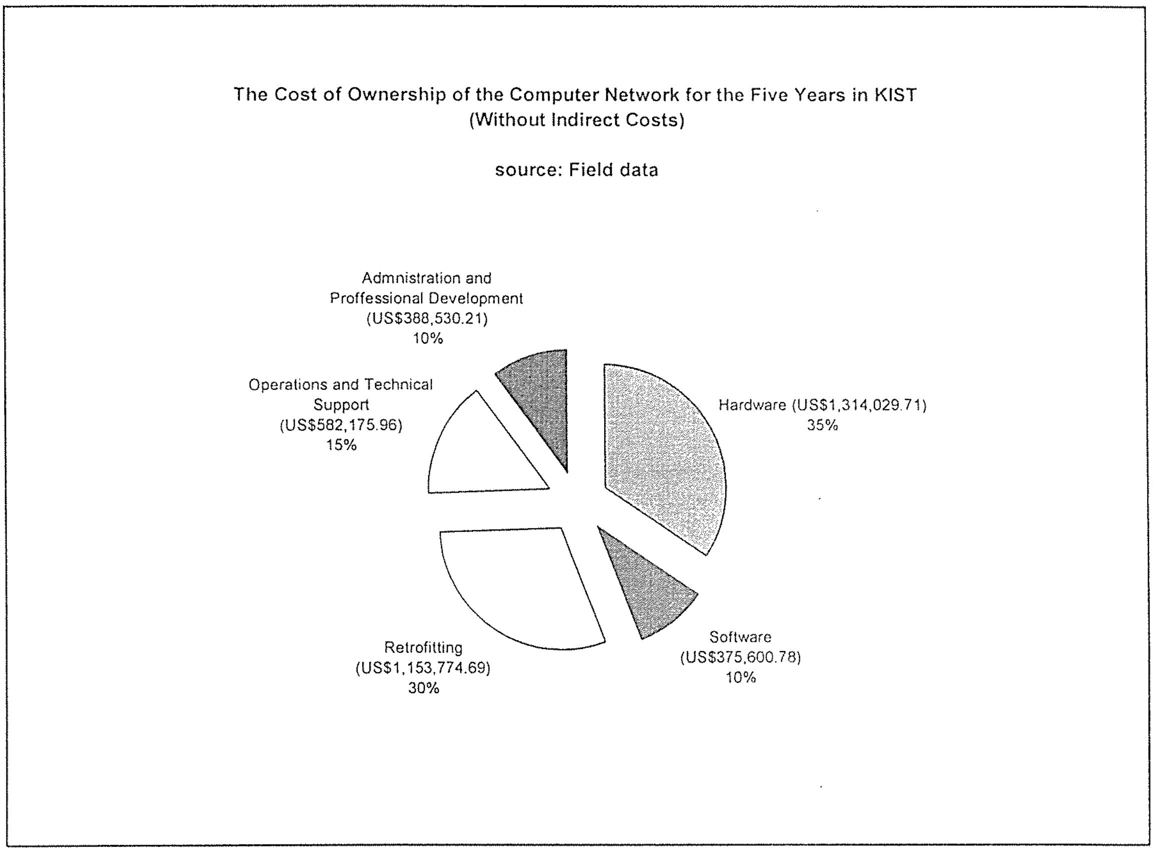


Figure 7: Pie Chart of the TCO in KIST exclusive of indirect costs

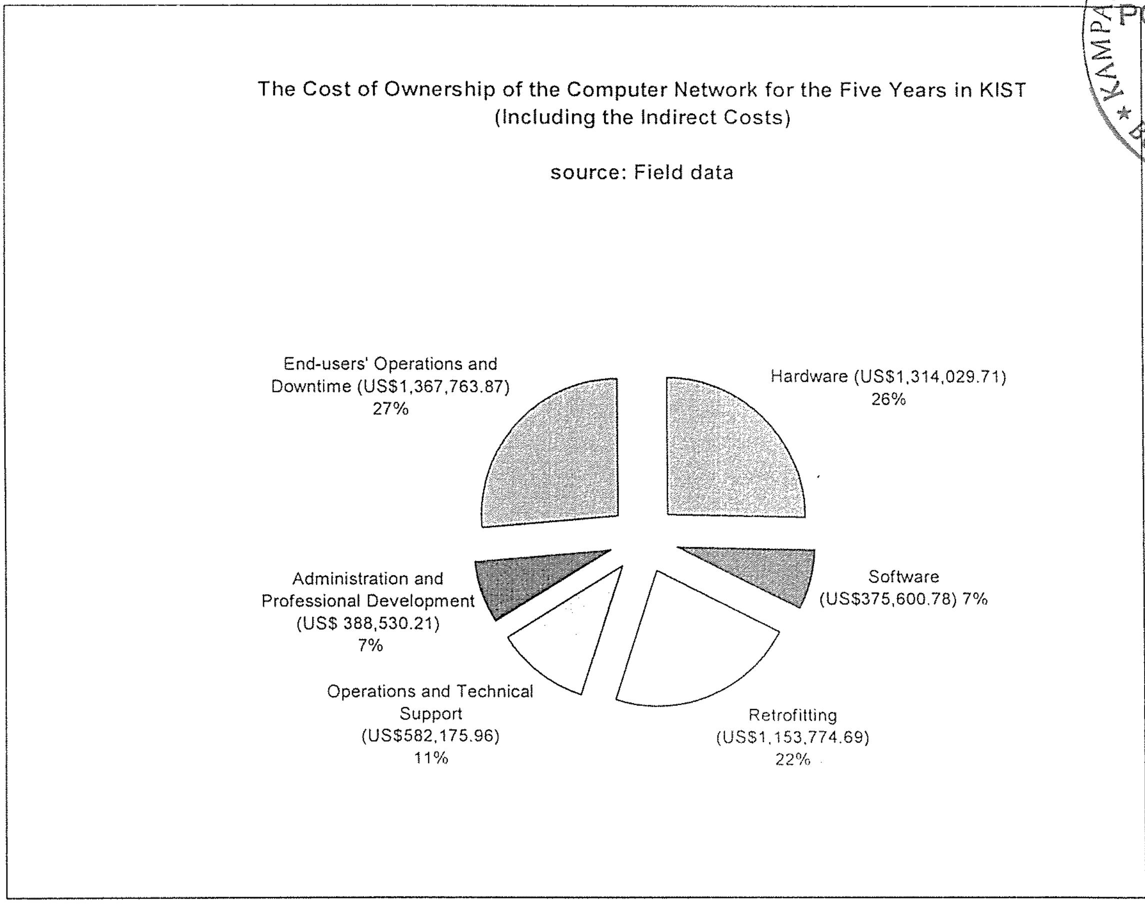


Figure 8: Pie Chart of the TCO in KIST inclusive of indirect costs

Table 22: The Cost of Ownership of the Computer Network for Five Years in ULK (in US$)

Total hardware acquisition					591,195.75
Total software acquisition					170,157.96
Total retrofitting					514,418.75
Total Technical Support and Operations					253,275.16
Total Administration and Professional Development					172,164.34
Total End-user Operations and Downtime					590,814.89
TCO					**2,292,026.85**

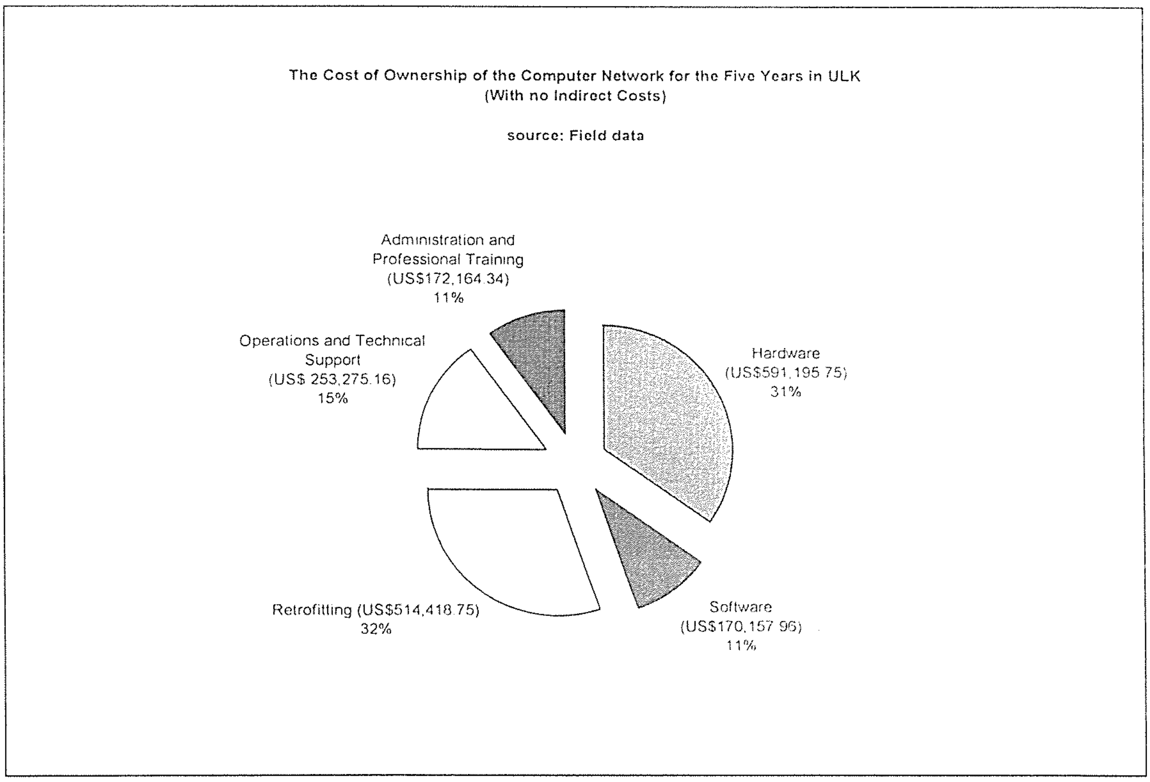


Figure 9: Pie Chart of the TCO in ULK exclusive of indirect costs

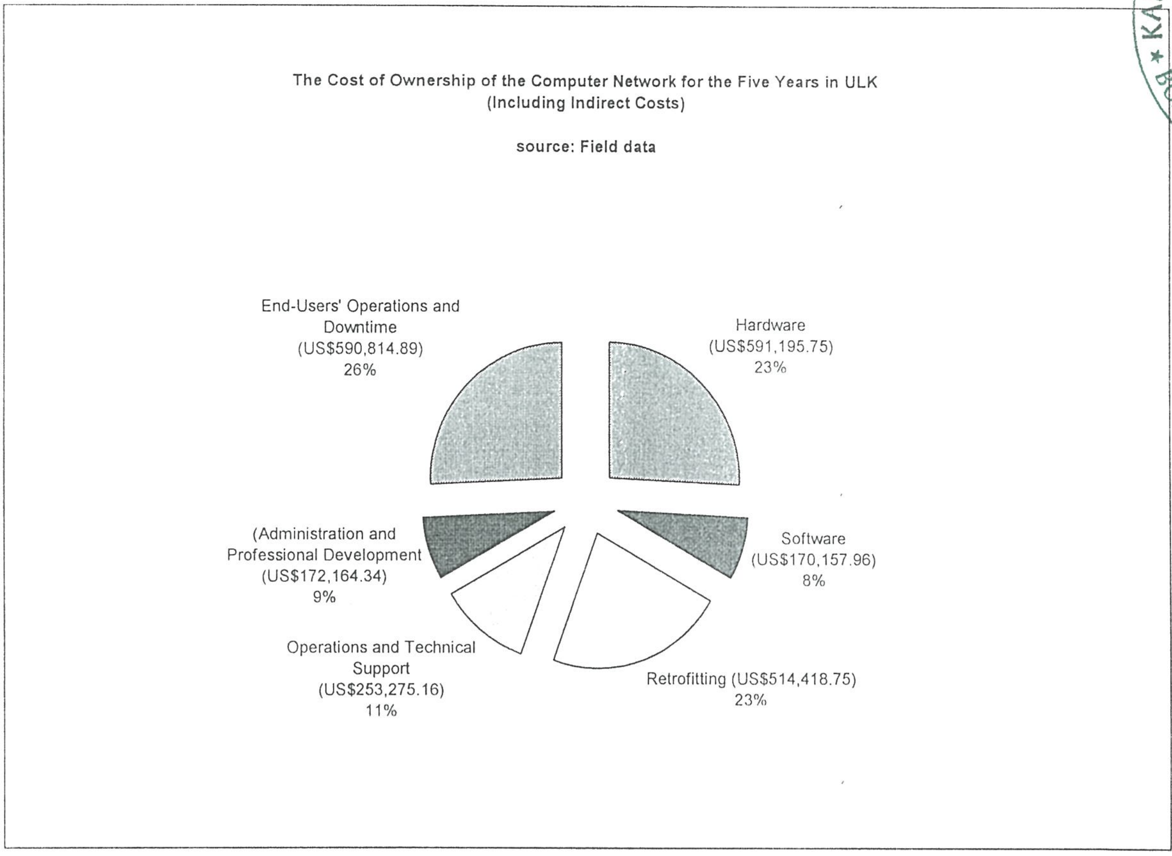


Figure 10: Pie Chart of the TCO in ULK inclusive of indirect costs

CHAPTER FIVE

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

This final chapter contains three major sections. The two first sections are dedicated to the discussion of the findings of this study as regard to, on the one hand, objective one (direct costs – which include hardware and software acquisition costs, costs of retrofitting old buildings, costs related to technical support and operations and the cost of administration and staff training) and, on the other hand, objective two (indirect costs – which include the cost of end-users' operations and the cost related to the system downtime). The third section is a general conclusion which gives a brief summary of the study as well as a number of remarks which contained the recommendations given above in a compressed form.

5.1 Discussion and Recommendations as Regard to Objective One

The first objective of the research was to determine the direct costs a computer network in selected institutions. The direct costs include the direct annual IS expenses for acquiring (i) hardware and (ii) software assets, (iii) retrofitting the physical site in order to build a network, (iv) technical services and service desk labor and fees (operations and support) and (v) overhead and training fees (administration and professional development).

5.1.1 Hardware

The first important aspect worth mentioning about the obtained results is that the computed TCO of computer networks within the studied institutions is strikingly low (around US$ 1500 on average in the three institutions) compared to the TCO in the business world which can run as high as US$11,000 per year per one networked computer (IDC, 1997). In fact, the figure yielded by the business setup analysis might discourage any educational institution administrator who would like to invest in an IT project. Therefore, it is somewhat encouraging to find out that the TCO for educational institution is lower than the TCO in the corporate world. This considerable difference results from varying factors of which we can mention the following:

(i) The surveyed educational institutions purchase less-expensive PCs at larger discounts than businesses do. In fact, most of the schools purchase components and locally assemble the components instead of buying branded equipments which are more expensive in purchasing and servicing.

(ii) Some educational hardware and software packages are priced lower than business hardware and software applications.

(iii) Educational institutions typically use their computers for a longer period (up to 10 years) compared to businesses (around 3 years, according to IDC (1997)).

The following recommendations emanate from the above made considerations:

(i) In acquiring IT material, educational institutions should prefer buying locally assembled equipments rather than buying branded ones. Although the former are sometimes acquired without any supporting guarantee, their cost of acquisition is relatively low and if provided with an adequate support they do function as efficiently as the branded equipment despite the existing disparity between the costs of the two categories.

(ii) Concerning the branded equipments, it is worthwhile for the institution's administrator to effectuate a previous survey about the different offers and find out whether or not there are vendors who procure IT equipments at a discounted price for educational institutions. In this regard it is not surprising to find out that the cheaper option is granted by a foreign vender, meaning, in acquiring IT equipment, one must go beyond the domestic market to conduct a survey of different offers on the global market. In this regard, the use of the internet resources can be of a great importance.

(iii) A longer life cycle of any equipment depends much on the quality of the service and the compatibility with the new technology. For educational institutions to retain their IT equipments for a long period and without getting outdated, it is important, on the one hand, to provide them with an adequate service support, and on the other, to target the latest equipments for the initial acquisition. Acquiring the most advanced technology (despite being relatively expensive) will guarantee a longer period in service before it gets obsolete.

One of the big challenges IT decision makers face when they try to standardize computers in an educational institution is the impact of donated computers. Often, well-meaning local businesses and NGOs may offer to donate older computers to educational institutions and those that desperately need technology often agree to accept them.

Experienced IT managers, however, recognize that these computers will often create more headaches than they are worth (Barringer and Weber, 1996), as in fact it happened one to KIST in relation to IT equipments donated by GTZ. While the computers may be free, there are usually substantial costs associated with upgrading them to the standards of the institution's network. For instance, sometimes institutions can run into problems when software licenses are not transferred properly. Therefore, when the computers are extremely old, it will turn out that the donors have simply transferred their hardware disposal problem to the beneficiary.

It is therefore advisable to have a policy in place specifying what kind of computer an institution is willing to accept. This can also protect the institution technology staff if it turns out that the administrative authorities are accepting sub-standard computers for the institutions and then expecting the technical staff to support them.

Occasionally a potential donation could be large enough that it would, in fact, create a new standard for an institution. Further, a thin client network such as the one used in libraries may enable an institution to manage a mix of older-model computers on the same network. However, because the variety of operating systems and hardware models will always tend to increase the costs of providing support, IT managers and administrators should be well aware of the potential negative impact of a donated computer before they agree to accept one.

5.1.2 Software

According to the data gathered from the surveyed institutions, the cost of software represents less than 10 per cent of the total technology budget in the three institutions, a figure which is proportionately low compared to costs incurred for software acquisition by ordinary for-profit businesses which spent around 30 per cent (IDC, 1997). The low cost of software acquisition in educational institutions can be attributed to the following factors, among others:

(i) Educational institutions budget only for basic application software without including the costs of software that are considered purely instructional such as the electronic curriculum materials.

(ii) The relative homogeneity of computer software used within and outside the surveyed educational institutions. This is mostly due to the relative low level of development of the software industry and the quasi absence of non-Microsoft software in the developing world.

(iii) Direct connections to the internet helps saving online subscription fees and telecommunication costs. The use of the resources of the World Wide Web (many of which are available for free) also reduces subscription fees.

From the above mentioned factors, the following recommendations can be made:

(i) Limiting the diversity of software titles that an educational institution uses is one way to help control other parts of the TCO equation, by limiting the number of staff that will be needed to support the applications and the amount of training the number of staff that will be needed to support the applications and the amount of training staff members will be needed. However, this may entail trade offs in terms of meeting users' needs for particular kinds of application or instructional offerings.

(ii) TCO can be controlled if the end-users are encouraged to use the same version of software if they work at home and if software packages are upgraded at the same time across the institution. Money can be saved, too, when the installation and upgrading of software can be controlled centrally over the network. But, as mentioned above, this software homogeneity may entail trade offs in terms of meeting varying end-users' needs.

(iii) The use of the resources of the World Wide Web (many of which are available for free) also reduces subscription fees. However, there may be hidden costs associated with the use of free web resources, in terms of the amount of time it may take lecturers and students to identify those resources and organize them for any efficient use.

5.1.3 Retrofitting

The cost of renovation of older building occupies a considerable share in the TCO of the surveyed institutions (around 30 per cent) of the total cost of IT technology. Actually, it has been argued that modernizing an older building costs twice than the investment in wiring a new construction (CoSN, 2001). This relatively high cost can be attributed to the fact that:

(i) Wiring existing buildings involve additional costs, including, in some cases, the cost of lead removal and the cost of upgrading the electrical and the ventilation systems.

(ii) It has been also found out that institutions with wireless solutions spent relatively less on retrofitting than those which opted for wiring older building.

By way of recommendation,

(i) Concerning the first remark, the best time to wire a building is when it is under construction, or in the case of an existing building, when it is being expanded or renovated. In fact, up to 15 per cent (one half) of the total cost of technology systems related building modifications could be saved if both initiatives are planned and implemented at the same time.

(ii) Educational institutions can avoid some of the costs of retrofitting older building if they are able to take advantage of wireless solutions. A part from being cost saving, wireless solutions represent the advantage of easily extending networks to "portable classrooms", or to buildings that will be wired in the future. In addition, wireless solutions offer more flexibility in as much as they allow deploying computers and connectivity right to a lecture room when it needs them. In this regard, the three studied institutions are moving in the direction of wireless connectivity to manage their costs and increase the flexibility of their network. Nevertheless, at the present day, the bandwidth capabilities of wireless solutions are less than those of the best wired solutions, which means, institutions will need to carefully evaluate how they intend to use a network and whether a particular solution is technologically feasible and will meet their bandwidth needs.

5.1.4 Operations and Technical Support

After computers are installed and networked, an institution will need people to help maintain its network and other hardware, and to help users solve the problem they encounter with their computers and software packages. With regard to operations and technical support, the results obtained lead us to the following remarks:

(i) Surveyed educational institutions have low levels of support, usually one person for every 600 computer users, compared to 1:50 ratio in the business environment (CoSN, 2001). As a result, this cost category represents less than 15 % of the TCO in the three surveyed institutions, a figure that is low compared to a figure between 30 and 40 % of the total IT investment dedicated by educational institutions in the developed world (California Department of Education, 2001).

(ii) One consequence the lack of sufficient support staff was lengthy equipment downtime when computers and other equipment were not available for use. In all the three institutions, repairs for some equipment reportedly took as long as two weeks or more. This reveals that when an educational PC fails it can get taken out of service for several days, a situation contrasting with the business setup whereby a computer is usually repaired or replaced within an hour or two.

The previous remarks lead us to the following recommendations:

(i) The number of support staff required will depend on several variables, including the number of workstations and the variety of operating systems and software applications that must be supported. The state of Maryland, for instance, completed a four-year technology plan in late 1998 with a funding projection that assumed that there would be one support person for every 500 computer users (Maryland State Board of Education, 2003). In another guide to school networking published by the state of Washington, the "fully-staffed" model assumed that each full-time technician would support between 100 and 250 users (Washington State, 1998). Highly standardized networks can reduce the number of support staff required by a factor of 10, according to some estimates—from one staff person for every 50 to 70 computers to one for every 500 to 700 (Arizona Society of Technology Directors, 1997). These varying figures reveal that there exist a big range of recommended levels of support.

An interesting factor in this regard is that some analysts would argue that there is no correlation between the level of technical support and technology users' satisfaction. Some institutions provide relatively good tech support, but users' expectations are also high and in their view, the support falls short of what is needed. Conversely, some institutions provide sub-standard levels of support, but users apparently have such low expectations that they report that they are satisfied. A determination of technological support needs, therefore, should be tied to an institution's own technology goals. An institution that is attempting to be "state-of-the-art" will likely have greater needs for regular support than will a district where technology is merely an after-thought. As in business, though, managing rising tech support costs will probably be a major challenge for many institutions' technology directors.

(ii) When an educational institution network crashes, lecturers may resort to going back to teaching "the old fashioned way" until it is fixed. If a lecturer room or a computer lab malfunctions, students are simply expected to "double up" on the computers that are still working. This can work as a temporally solution and help reduce the TCO of computer networks. However, it has to been noted that equipment downtime may result in the loss of productivity, on the one hand, and the loss of interest in the use of technology when this becomes unreliable following lengthy downtime period, on the other hand.

Following the above mentioned considerations, it remains clear that a critical part of monitoring technology support needs is benchmarking. The best way to track the adequacy of the technology support is by maintaining records on such things as the amount of time the network is down or the number of computers that need repairs. Unless institutions attempt to measure the results that their budget for technology support is able to achieve, they will have no way of discerning whether they are doing an adequate job, and whether additional financial resources can make a qualitative difference. The technology plan should state how lecturers obtain technical support, the expected response time, the number of full-time staff needed for technical support, whether students will be involved in providing technical support, and how they will do so. If technical support will be provided in-house, institutions are strongly encouraged to establish the maximum number of machines that each technical support person can maintain and ensure that as the amount of technology expands, the level of technical support is maintained according to the pre-determined ratio.

Another way of tackling the challenges of providing adequate tech support and managing growing networks is through the adoption of the so-called "thin client" network and Application Service Providers (California Department of Education, 2001).

In a thin-client network, very little computing power resides in the desktop device. Most of the applications run on a centralized server. This approach requires a very reliable network and substantial bandwidth but means that less money will have to be spent on desktop computers or appliances. This type of network may be appropriate, for instance, to access the library database. Moreover, institutions that want to evaluate this approach will want to review what kinds of applications they want or need to run and whether they will be appropriate for this kind of network infrastructure. Software programs that incorporate extensive multimedia features or involve the manipulation of large amounts of administrative data may be more difficult to support. Furthermore, in this type of network setup, institutions will probably have to be prepared to devote more resources to network configuration and management.

The Application Service Provider approach involves putting a third party in charge of an institution's applications and running them on the third-party's servers. This will probably involve tradeoffs in the amount of flexibility an institution will be able to enjoy, but should provide savings in the costs of providing technology support and network management. TCO experts believe this approach is well suited for customers who want more predictable costs when their network grows and in instances when it is hard for a customer to retain qualified technology support people (California Department of Education, 2001). In fact, many institutions may complain that it is hard to find technology support staff when they can earn higher salaries in private business. TCO specialists advise, however, that contracts with Application Service Providers should be carefully written to provide protections in case problems occur down the road (CoSN, 2001). Institutions will also want to review how their own data will be managed and protected in these kinds of arrangements, and whether those controls are adequate.

5.1.5 Administration and Professional Development

With regard to operations and technical support, the results obtained lead us to the following remarks:

(i) All the three surveyed institutions dedicate less than 10 per cent of their technology budget for staff development, a figure that is much less than the required percentage which varies between 20 and 30 per cent (Education Week (1998).

(ii) None of the three educational institutions possesses a clear training program for lecturers; moreover, there is no clear tool for measuring lecturers' IT proficiency and their capability to improve the use of IT media in the lecture room.

From the above mentioned remarks we recommend the following:

(i) Staff development is the budget item that is most critical to any educational institution's ability to achieve its technology goals. Inadequate staff training will lead to under-utilization of computers and a loss of return on the institution's investment in technology. If teachers and other staff members do not understand how to use new technologies and incorporate them into the classroom, the institution's technological investment will not achieve its desired results. The importance attached by developed countries staff development in technology proves the importance of this point. For instance, already 10 years ago, the US Department of education recommended that schools districts devote 30 per cent of their technology budgets for staff training and development (U.S. Department of Education, 1996). Likewise, the Massachusetts software Council noted that many businesses match every dollar they spend on computer hardware and software with another dollar for training (Fryer, 1998). The same study recommended that at least one-fourth of a school's technology budget be set aside for staff training. The previous examples can help in setting IT staff training budgetary standards by administrators of educational institutions.

(ii) Despite the possible budgetary benchmarks, staff training is not a one-size-fits-all sort of proposition in an educational institution. Individual lecturers and staff members can vary widely in their previous experience with technology and their readiness to learn. Therefore, it is recommended that the institution shapes its staff training programs in such a way that they fit the different levels of technological proficiency. In this respect, firms have developed tools which are available to help institutions to define and measure the technological capabilities of their staff (National Educational Technology Standards, 2000).

On the other hand, distinction must be made between lecturer's individual technological capabilities and the ability to integrate new technologies into the lecture room experience. In other words, the fact that lecturers are proficient in the use of technology doesn't necessary mean that they make full use of their potentialities in their lecture room experience. This has to be enforced especially when not all students can access a computer at home.

(iii) Furthermore, educational institutions must not forget to provide adequate staff development for its own technology staff. In fact, if those staff members are not encouraged to increase their own knowledge about new and evolving technologies, the institution will not be able to make the best possible decisions when it comes to planning for and purchasing new technology. In fact, institution that devote adequate resources to staff development should also see a correspond drop in the cost of providing technology support because staff members will be in a better position to address their own problems without having to seek help from outside.

5.2 Discussion and Recommendations as regard to Objective Two

The second objective of the research was to determine the indirect costs of computer networks. The indirect costs include the cost annual cost of lost productivity related to End-Users' operations and downtime.

5.2.1 End-users' Operations

In the three surveyed institutions considerable IS tasks are performed by end users. This is due mainly to two major reasons:

(i) IT support team is not always available when needed leaving end users to provide management and support for themselves; moreover, sometimes, IT support team's services do not meet end users' expectations. This situation leads to the fact that surveyed educational institution heavily rely on technologically savvy students or teachers to help with support.

(ii) In all the surveyed institutions there is no direct way to capture how much time end users spend supporting themselves and each other.

By way of recommendation,

(i) Falling back on technologically savvy lecturers or students to help with support can be beneficial for an educational institution. However, this can mean that lecturers and students are pulled away from their primary duties. Moreover, when support is inadequate, the institution will lose some of the value of its investment in technology when hardware is not repaired quickly. Therefore, the decision to adopt this apparently "cheap formula" should be balanced with the consideration of the possible lost productivity on behalf of the involved end-users. In fact, the self technical support by students and/or teachers shouldn't constitute a hindrance to their usual activities. For instance, repairing broken down equipments by students as a class exercise and under the supervision of a professional can cut the cost without resulting into loss of productivity. It is also advisable for institutions to capture the (indirect) cost of end-users support operations.

(ii) With regard to capturing the cost of end users' operations it is recommended to regularly conduct valid surveys in which statistically significant sample must be used and in which samples must be representative of the entire organization being analyzed.

5.2.2 Downtime

With regard to the indirect cost related to downtime, it is worthy recalling that downtime cost occurs following user(s) waiting for a service desk problem to be resolved from an infrastructure issue due to planned maintenance, or unplanned failures (e-mail inaccessibility, network outages, database outages, etc). From the experience of the surveyed institutions we have been able to retain the following remarks with regard to downtime:

(i) The surveyed institutions do not possess effective way to track the cost of system reliability and downtime, and, consequently, are unaware of the detrimental impact it can have on the organization's productivity. In addition to this, losses in business revenue (different from losses of productivity) due to the system downtime are not measured. Moreover, service desk problem reports are not structured to record downtime impacts for specific issues.

(ii) Related to downtime is the issue of slowness of the connection due to low-bandwidth connectivity. In fact, in the three institutions the cost of connecting to the Internet constitutes a relatively small proportion of the total costs of the institution's technology. This is due to the perception that whatever bandwidth is made available, an educational institution will find ways to put it to use.

By way of recommendation,

(iii) With advances in technology, it is relatively easy to capture the measurements of downtime. The question is posed to IT professionals and end-users themselves to consistently keep records of the system downtime. Among the useful tools that can be used in this regard figures the reliability calculation method used in the Life Cycle Analysis. Reliability is an engineering discipline to ensure that a component, assembly, plant, or process performs its intended function, without failure, for the required time duration when installed and operated correctly in a specified environment (Barringer & Associates (2003a). If the reliability determination method allows controlling the cost of *un*reliability, likewise, as an analytical tool, it can help IT professionals to control and reduce the TCO by reducing the cost of downtime.

(iv) Educational institutions may decide to purchase a cheap but low-bandwidth connectivity. Before making this decision, educational institutions must be aware that there will be a tradeoff in terms of the speed with which students and staff can communicate, connect to the Internet, and download graphic and video-intensive files. This, in turn, could have an impact on how staff members and students spend their available time. Educational institutions would, therefore, be well advised to assume that their future bandwidth needs will increase, and to plan a connectivity solution that can grow as those needs grow.

5.3 General Conclusion

This study strived to identify the major cost factors enshrined in the TCO of a computer network in a tertiary educational institution. We discovered that apart from the initial acquisition and installation, there are other additional and continuous costs which must be taken into account. In fact, computers and networks will require ongoing maintenance, technical support, and, in the case of computers and peripherals, regular replacement. In addition, lecturers and other staff members, especially the IT support staff, will continue to require new training as new pieces of hardware and new software applications are introduced. Moreover, as environmental and safety regulations become more and more enforced in our society today, educational institutions must be aware that one day they will have to pay a fee to dispose of their IT equipments (such as computers) when they can no longer be used.

The experience of the surveyed institutions has led us to the conclusion that most educational institutions' budgeting practices often do not allow setting aside money for all those additional costs associated with owning a computer network over a lengthy period of time. When an institution has just installed and interconnected a dozens of brand-new multimedia computers, it is quite easy to relax and forget about budgeting for those additional costs related to maintenance, technical support, professional training, replacement, and so on.

Apart from poor budgeting practices, other factors can explain the failure of educational institutions to properly control the costs of their IT investment. For instance, educational institutions frequently get only the initial phase of their technological projects funded by a large, and often extraordinary, infusion of funds from a bond measure, a state grant, a donation, or even an NGO funded program. In this case, an institution which receives a discretionary grant in one year is likely to lose any of the funds it has not spent by the end of the fiscal year. As a result, educational institutions are compelled to purchase computers and associated equipments at once, but they are not allowed to save money to maintain or replace those equipments once they have become obsolete. This can make it harder for educational institutions to come up with sources of funds for their ongoing technology operating expenses. The following testimony by an IT research firm proves the above mentioned difficulty.

> "[IT] program components that were hardest to fund (…) were those heavily dependent on staff positions (maintenance, training, and technical support). Staffing was difficult to fund because some funding sources could not be used for staffing and because some sources were not well suited for this purpose. For example, bonds and special levies passed by the districts we reviewed could only be used for capital expenditures. [institutions] officials also pointed out difficulties both in using one-time grants for ongoing staff positions and in attracting funding for staff from outside supporters" (GAO, 1998).

To deal with a budgetary imbalance due to increasing and unplanned-for cost of technology, many IT managers and IT related-decisions makers in educational institutions are often tempted over time to cut computer support and training costs to improve their bottom line. However, this practice ends up being counterproductive because, instead of effectively reducing the cost of IT (perceived comprehensively to include direct and indirect costs) the practice increases it by increasing the indirect costs linked with end-users' operations who try to technically support themselves and with the loss of productivity due to the system downtime or unreliable connectivity. In fact, cuts in end-user training budgets result in an increase in user-induced outages, diminished technology utilization, poor productivity and peer support that disrupt normal operations.

Consequently, time wasted on system failures and unproductive user's activities increases the TCO by increasing the indirect cost. For instance, in one research, the Gartner Group, an IT consultant firm, has reported that when support budgets are trimmed too aggressively, "every $1 in budgeted savings can actually lead to $4 worth of lost productivity" (Sitrix Systems Inc., 2000). But, as educational institutions and teachers are essentially judged on the basis of the performance of their students, avoiding productivity losses should be the most important factor in their budgeting decisions. Consequently, the decision to maintain professional training and technical support costs at a very low level to the extent that it results into loss of productivity is unacceptable in any educational institution.

The previously made considerations indicate that there is a need for IT managers and institutions' decision makers to think differently. Concerning the lack of appropriate budgeting practices, we suggested that educational institutions must purchase new computers on a planned (and reasonably short) life cycle and replace them on the same cycle. Another way of reducing the cost of IT equipment replacement and other related problems is to negotiate lease agreements with a reliable vendor under which computers will be replaced on a regular schedule (School District of Hillsborough County (2006). This method will help solving problems related to the cost of replacement of old equipments as well as it will increase the advantages related to standardization. Another way of reducing this difficulty is to acquire the newest equipments which can sustain a longer life cycle. For instance, in the event an institution's IT manager is unable to predict when they will have the financial resources available to replace their computers, it is recommend that he/she purchases computers with as much processing power and memory as the institution can afford. In that way, the hardware will be better prepared to handle new or expanded software packages as they become available on the market.

In addition to the previous consideration, there is a need for change in the decision making process with regard to IT equipment because the kind of centralized decision-making that generally leads to reductions in the TCO is not always easy to sell to the top management. In fact, IT department would have to convince the rest of the institution authorities to change its IT equipment buying habits. For instance, the decision to centralize the purchase of computers for the sake of standardization, despite being beneficial for the overall institution, may become unpopular because it would imply IT department taking the power of choice away from the end-users who normally include renowned university professors who think of their power to select their own PC or laptop technology as an unquestionable right. Therefore, TCO reduction initiatives in educational institutions should be supported by the institution's top administration if they are to succeed. For this to happen, administrators must recognize that there may be a price to pay in the costs of long-term maintenance and support if individual department and/or end-users are permitted to make their own decisions on which technology to buy or how technology will be deployed within their department.

All in all, understanding the full range of costs associated with technology investments will assist educational institutions' leaders in planning for the future. The TCO analysis is designed to help such institutions make sound budgetary decisions, conduct technology planning in an organized way, establish a baseline for future analysis and maximize benefits from their investments in technology, in this case, in a computer network.

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APPENDICES

Appendix 1: Research Instruments

Questionnaire

Marcellin Mugabe
Kampala International University
School of Postgraduate Studies
Masters of Business Administration and Management
P.O. Box: 20000 Kampala, Uganda

August 5, 2006

Dear respondent,

I am Marcellin Mugabe, a student at the School of Postgraduate Studies of the Kampala International University, academic year 2005/2006. I am currently conducting a research on **"Assessing the Cost-Components of the Total Cost of Ownership (TCO) of Computer Networks in Tertiary Educational Institutions" Case Study of Three Institutions in Kigali, Rwanda** as a final requirement for the award of Masters in Business administration and Management.

The research seeks to evaluate important cost factors involved in the determination of the TCO of computer networks in tertiary educational institutions. The TCO will be evaluated, on the one hand, in terms of **directs costs** related to networking itself gathered into seven sub-categories (hardware, software, retrofitting, support, operations, administration and professional development), and on the other hand, in terms of **indirect costs** gathered into two categories (end-user operations and downtime).

I kindly request your assistance by answering this questionnaire. The information provided will be used strictly for the research purpose. Any information given will be treated with confidentiality.

With regards,

____

Marcellin Mugabe

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Section 1

Questionnaire to determine the general characteristics of the research environment

*****

Names of the Respondent (optional): ....
Position in the institution: ....
Institution: ....

*****

Question	Answer[2]		
	Yes	No	Quantity
Total number of students on the campus?			
Total number of lecturers?			
Total number of administrative staff?			
List of Faculties[3] 1. .... 2.	List of Departments 1.1... 1.2... 1.3. etc. 2.1... 2.2... 2.3. etc.		
How many people are formally employed in the IT service (department)?			
How many computers operating within the institution (including personal laptops)?			
How many of the computers are branded?			
How many of the computers are locally assembled?			
How long (on average) do computers stay in use in the institution?			
How many separate building on the campus?			

[2] Please, leave the answer-box blank if you don't know the answer.
[3] Please, use the backside of the paper or a separate sheet of paper to complete this information.

Extension of the area covered by buildings on the campus (specify the measurement)?			
How may classrooms/lecture rooms?			
Is there a local area network (LAN) in this institution?			
Are there computers in classrooms?			
Are the computers in classrooms connected to the LAN?			
How many computer-labs on the campus?			
Are computers in the computer lab connected to the LAN?			
Overall number of computers connected to the LAN?			
Does the institution have an intranet?			
If yes, do lecturers paste academic (didactic) information on the intranet?			
Is the institution connected to the internet?			
How many computers within the institution are connected to the internet?			
How many network printers within the institution?			
How many ordinary printers?			
How many network scanners within the institution?			
How many ordinary scanners?			
Do you share data thought the network within institution?			
Do you have the VoIP service within the institution?			
Does the institution have a domain name?			
Does the institution offer a customized e-mail service (with the domain name extension)			

Which and how many of the following network devices is the institution using?

Item	Total number
Server (communication management controller -CMC-)	
Network personal terminal (PC used by the network staff)	
Router	
Bridge	
Bridge/router	
Modem	
Channel service unit (CSU)	
Data service unit (DSU)	
Multiplexor (MUX)	
Network Switch	
Hub	
Antenna	
Amplifier	
Switch	
Network (ordinary) scanner	
Network (ordinary) printer	
Other (specify)	

What type of physical medium does the network use within the organization?

i) Usual telephone cables? ☐
ii) Coaxial cables? ☐
iii) Fiber optic cables? ☐
iv) Wireless (electromagnetic waves)? ☐
v) Electrical wires? ☐
vi) If the institution has internet services, who is your internet service provider (ISP) ....

What type of network connection does the institution use?

i) Peer-to-peer network? ☐
ii) Client/server network? ☐
iv) Other type of network ....

What kind of network structure (typology) does your institution use?

i) Bus topology? ☐
ii) Ring topology? ☐
iii) Star topology? ☐
iv) Token ring topology? ☐
v) Hybrid? ☐
vi) Other topology ....

What king of technology is your institution using?

Ethernet? ☐
Fast Ethernet? ☐
Token ring? ☐
FDDI (fiber distributed data interface)? ☐
ATM (Asynchronous Transfer Mode)? ☐

Section 2

Form to determine the direct costs (part 1-5) and indirect costs (part 6) of the computer network

Names of the Respondent (optional): ....

Position in the institution: ....

Institution: ....

Part 1: Determine the direct cost of the computer network as regard to **hardware acquisition**

The hardware cost category within the direct costs accounts for all of the capital expenditure relating to hardware assets covering the end users and educational functions. Included are typical software costs that are bundled with the original equipment acquisition where the software cannot be separated from the asset as part of the original purchase price. Also included are devices used by IS personnel for personal productivity functions. Hardware costs were gathered into four sub-categories including the (i) acquisition cost, (ii) expenses for upgrades, (iii) expenses for spare parts and (iv) supplies.

Year	2005	2004	2003	2002	2001	Year 0
1. Acquisition cost						
2. Spares						
3. Supplies						
4. Upgrades						

Enjoyed any educational discount on any of the products? Yes☐ No☐

1. The first sub-category (acquisition cost) includes the annualized acquisition amount of server, client, peripheral and network hardware.
2. The second sub-category (spares) includes the total annualized capital expenditures for spare assets including such components as disk drives, processors, motherboards, network cards, removable media devices, and other server, client, peripheral, or network replacements or components.
3. The third sub-category (supplies) includes the total annualized capital expenditures for consumable IS supplies as diskettes, recordable/rewritable DC, programmable CD-ROMs, backup tapes, removable media and any other computer supplies for clients, servers, peripherals, and network assets.
4. Finally, the last sub-category (upgrades) accounts for upgrades made to clients, servers, peripherals and network assets. These include upgrades to hard drives, processor,

memory, network connectivity, removable media, and uninterrupted power supplies. Such upgrades are not included in the original purchases bundle or are purchased after original installation.

Part 2: Determine the direct costs of the computer network as regard to **software acquisition**

The software category within the direct costs accounts for all of the capital expenditures relating to software including operating systems, all server and client applications, database utilities, educational applications, massaging and groupware applications (e-mail, groupware, communication and connectivity software). It has been noticed that although all the costs are tallied on an annual basis in most cases software is expensed only in the year it is acquired. Site licenses and access agreements are expensed over the duration of the agreement, and software that is licensed under an annual subscription has the annual subscription fee recorded as an annual expense. The main purpose of software maintenance/support agreement is to obtain updates and upgrades. Software costs were gathered into five sub-categories including (i) personal productivity applications, (ii) business support applications, (iii) data management and development tools, (iv) communication applications and (v) others.

'ear	2005	2004	2003	2002	2001	Year 0
. Personal productivity applications						
. Business support/vertical applications						
. Data management and development tools						
. Communication applications						
Other						

Enjoyed any educational discount on any of the products? Yes☐ No☐

1. The first sub-category (personal productivity applications) includes the annualized capital expenditure for all the server and client applications and application foundations including personal productivity software.
2. The second sub-category (business support applications) the cost of business software including contact management, sales automation, order processing, financial, accounting, institution's resource planning, technical design and other vertical applications.
3. The third sub-category (data management and development tools) include the annualized capital expenditures for all database licenses on servers and clients. It also includes the costs for database utilities, data mining, business intelligence tools, report writers, etc.
4. The fourth sub-category (communication applications) includes the annualized capital expenditures on new and upgraded e-mail, groupware and collaboration software.
5. The fifth sub-category (other) includes the annualized expenditures for new and upgrades software foundations or middle ware such as internet/intranet, web-site

maintenance, transaction processing (e-applications processing) software that facilitate the institution's operations.

Part 3: Determine the direct cost of the computer network as regard to **retrofitting**

Year	2005	2004	2003	2002	2001	Year 0
1. site alteration						
2. transmission system						
3. electrical system						
4. ventilation system						

1. The first sub-category (site alteration) includes the annualized capital expenditure for labor and contract costs for the necessary transformation of the site. The site includes buildings, offices, campuses, etc. with dedicated connections to the network.
2. The second sub-category (transmission system) accounts for the total annualized capital expenditures for acquiring necessary assets utilized in constructing transmission facilities or network circuits. These include media utilized to build circuit facilities such as analog telephone lines, Integrated Services Digital Network (ISDN), Asynchronous transfer mode (ATM), leased and access lines typically supplied by the telephone company or transmission authority. Network-connected devices (PCs, terminals, workstations, servers, mainframes, etc.) that support end users' operations are not included in here. They are included in the hardware cost category.
3. The third sub-category (electrical system) accounts for the total annualized costs for upgrading electrical capacity to support technology. It includes costs for installing additional electrical outlets in the building, acquiring electrical power generators, beef up electrical safety system, changing the lighting system in the offices, etc.
4. The fourth sub-category (ventilation system) accounts for the total annualized costs for improving the cooling and ventilation systems.

Part 4: Determine the direct cost of computer network as regard to **Technical Support** and **Operations**

Year	2005	2004	2003	2002	2001	Year 0
1. Technical services						
2. Planning and process management						
3. Database management and administration						
4. Service desk						

1. The first sub-category (Technical Services) includes costs of operations staff and management contracts in various technical services activities including
   - **level 2 problem resolution** (which accounts for labor and contract costs for support staff intervening on issues that cannot be resolved through standard service desk operator solutions)
   - **level 3 problem resolution** (which accounts for labor and contract costs for technicians and administrative labor spent identifying and resolving advanced support issues including failure, fault, and accessibility problems with the network, computers, printers, network communication equipment, operating systems and applications)
   - **traffic management and planning** (which accounts for labor and contract costs for proactively monitoring, interpreting, planning and balancing the load placed on the network communication infrastructure), **performance tuning** (which accounts for labor and contract costs for proactively monitoring, interpreting, planning and balancing the performance of servers, networked systems, and applications)
   - **user administration** (which accounts for labor and contract costs for controlling user accessibility to network and application resources handling tasks such as adding new users and resources, logically moving users to new groups, password management, or changing user profiles)
   - **operating system support** (which accounts for labor and contract costs for time spend managing the operating system including settings, upgrades service pack installation, driver updates, and licensing)
   - **maintenance labor** (which accounts for labor and contract costs for routine tasks that are performed on a scheduled or interval basis to maintain the availability and performance of servers, clients, printers, and network communication devices)
   - **software deployment** (which accounts for labor and contract costs for deploying new or upgrading exiting custom or purchased software. Software deployment includes utilities, applications, and messaging software)
   - **application management** (which accounts for labor and contract costs for on-going management of software applications including configuration control, access management, launch, monitoring usage, and the metering of available licenses)
   - **hardware configuration/reconfiguration** (which accounts for the labor and contract cost for reconfiguring existing solutions within the network, including adding hardware subcomponents, upgrades, physical moves, or configuration changes. Items included are system upgrades, performance enhancements, topology changes, switched networks changes, other physical or logical changes, and setups to the hardware settings)
   - **hardware deployment** (which accounts for labor and contract costs for installing and deploying new hardware including servers, clients, peripherals, network communication devices, and networks. The labor allocation for the disposal of displaced or retired hardware is also included here)
   - **disk and file management** (which accounts for labor and contract costs for installing and deploying new hardware including servers, clients, peripherals, network communication devices, and networks. The labor allocation for the disposal of displaced or retired hardware is also included here)
   - **storage capacity planning** (which accounts for labor and contract costs for monitoring, managing, and optimizing online and off-line storage capacity to assure

enough capacity is available. Includes file deletion and purging. This category does not include database management and administration)

- **backup archiving and recovery** (which accounts for labor and contract costs for the backup of network and desktop data, restoring lost or damaged files or data, and the archiving and retrieval of data) and
- **repository management** (which accounts for labor and contract costs for managing the central disk or tape repository including tape library management and off-site storage monitoring and management).

2. The second sub-category (Planning and process Management) accounts for the costs of operations staff and outsource contracts for performing any of various planning and process management activities including
   - **account management** (which accounts for labor and contract costs for working with and managing the relationship between IS and the business units. Typical tasks include business unit alignment, application and infrastructure requirements, business case development, and project management)
   - **systems research, planning and product management** (which accounts for labor and contract costs for identifying infrastructure needs, reviewing configurations, setting standards, researching options, as well as identifying and documenting planned changes. Documentation of existing architectures and configurations, simulation and modeling of new systems, TCO Lifecycle Management, and standards development by IS personnel are tasks that are included here)
   - **evaluation and purchase** (which accounts for labor and contract costs for evaluation and testing of servers, clients, networks, applications, and systems prior to purchase and rollout, and the direct IS labor associated in supporting procurement efforts, including the support of legal and purchasing departments)
   - **security and virus protection** (which accounts for labor and contract costs for proactively detecting or preventing security violations, security restriction, access management, or virus infection, and defining the process for recovery from such violations or intrusions should they occur) and
   - **business recovery** (which accounts for labor and contract costs for creating business recovery and management plans including backup and restore procedures, tape management, hot-site and cold-site planning, record keeping, and business recovery team management and organization).

3. The third sub-category (Database Management and administration) includes the costs of operations staff performing Database Management Administration tasks which include index management, replication, log administration, data recovery, optimization, and other maintenance tasks.

4. The fourth sub-category (Service Desk) includes for the costs of operations staff performing service desk activities, particularly tier 0 and tier I resources. Tier 0 refers to call taking and logging without providing problem assistance or resolution. Tier I refers to first and second level non-dispatched problem assistance or resolution delivered via phone, e-mail or on-line communication. Tier II and tier III support is allocated to technical services in the operations category.

Part 5: Determine the direct cost of the computer network as regard to **administration** and **professional development**

Year	2005	2004	2003	2002	2001	Year 0
1. Finance and administration						
2. End-user training						

1. The first sub-category (finance and administration) cost category accounts for finance and administration labor and fees, including costs for

- **supervisory management** (which accounts for labor and contract costs for resources and services primarily responsible for exclusive supervisory efforts, particularly middle and executive managers (CIO's, MIS directors, etc.)
- IS administrative assistance (which accounts for labor and contract costs for administrative support personnel, particularly direct assistants to middle and executive management, as well as general department administrative support personnel)
- **management** (which accounts for labor and contact costs for managing depreciation records and lease contracts, and performing asset inventories – physical or automatic management –, asset identification and tracking, asset database management, change recording, and reconciliation)
- **budgeting and chargeback** (which accounts for labor and contract costs for budgeting and chargeback tasks including the management of central IS and business unit IS capital and operational budgets, and the assignment and accounting of appropriate chargeback systems)
- **auditing** (which accounts for labor and contract costs for auditing tasks including the review of IS contracts, relationships, asset records, the processes and compliance to written policies)
- **purchasing, procurement and contract management** (which accounts for labor and contract costs for procurement of end-user and IS hardware and software, services, and training, and legal personnel and services that draft and negotiation purchasing agreements, site licenses, and other procurement related contracts), and
- **vendor management personal** (which accounts for labor and contract costs for working with and managing hardware, software, application, and service vendors, including IS labor time spent in vendor meetings, writing request for proposals (RFP), reviewing proposals, dealing with vendor issues, and other vendor management related tasks outside of the product research and evaluation tasks listed under Operations).

2. The second sub-category (end-user training) accounts for the IS staff and contracts for performing tasks that include

- **end-user training course development** (which accounts for labor and contract costs for the development of end-user training courseware and CBT. Includes other end-user training tasks not related to instruction time, such as coordination) and

- **end-user training** (which accounts for labor and contract costs for instructional delivery of end-user courses). Note: the time/cost of end-user attending training is not included here but in the und-user Operations category.

Part 6: Determine the indirect cost of the computer network as regard to **end-user operations** and **downtime**

Year	2005	2004	2003	2002	2001	Year 0
1. Peer support						
2. Casual learning						
3. Formal learning						
4. File and data management						
5. Application development						
6. Downtime						

1. The first sub-category (peer support) cost category accounts for the annual labor expenses for end users supporting each other in lieu of obtaining technical support from service desk or IS personnel. Typical tasks performed by the end users include troubleshooting and repair, support, maintenance, installation, training, and backup management. Particularly, these tasks are performed extensively by end users in remote offices that are not staffed by dedicated IS personnel or covered by support contracts. Peer support is the reliance on a knowledgeable resource, typically the unofficial "expert" in providing support answers and in resolving technical issues. Peer support often involves assistance of one or more peers to resolve key issues, increasing per incident costs further.
2. The second sub-category (casual learning) accounts for the annual labor expenses of end users training and supporting themselves in lieu of formal training and support programs. Time includes reading manuals, using online help, trial and error, and other self-learning methods to learn programs and resolve issues.
3. The third sub-category (formal learning) accounts for the annual labor expenses for all the course time spent by end-users on computer system and all application training.
4. The fourth sub-category (file and data management) accounts for the annual labor expenses for the end-user time spent managing files and data including end-user-performed file system maintenance, organization, optimization, backup and recovery.
5. The fifth sub-category (application development) accounts for the annual labor expense of end users performing development and customization of non-business/mission critical applications (infrastructure software) such as notes scripts, access databases, and office scripts.

The end-user IT expenses are determined using end-user surveys. Each of the sub-categories requires hours spent performing a specific task over a given period (a week or a month). Using an average burdened salary for all users, the labor hours collected from the survey responses are translated into annual person hours, and multiplied by annual burdened salaries to obtain annual costs (Gartner, 2003). Thus,

> Annual end-user operations costs = annual person hours * annual burdened salaries
> Where
> burdened salaries = unburdened salaries * the burdened rate

6. The downtime cost category within the indirect costs expresses the annual losses in productivity from planned and unplanned outages of the network resources, including client computers, shared servers, printers, applications, communication resources, and connectivity. In other words, these are losses in productivity due to users' inability to use the system. Downtime is typically computed as follow:

> Downtime = annual downtime hours * % productivity impact to users when downtime occurs * end-user burdened salary

DETAILED TCO COST CATEGORIES IN KIGALI INSTITUTE OF SCIENCE AND TECHNOLOGY (KIST)

HARDWARE ACQUISITION (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Hardware (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 Acquisition cost	123,350.00	73,146.55	132,940.00	87,607.46	130,870.00	95,665.97	120,920.00	98,187.04	40,600.00	36,580.60	235,890.00	627,077.62
2 Spares	38,830.00	23,026.19	46,350.00	30,544.65	36,670.00	26,805.77	141,470.00	114,873.64	32,760.00	29,516.76	100,450.00	325,217.01
3 Supplies	21,680.00	12,856.24	17,990.00	11,855.41	22,200.00	16,228.20	30,450.00	24,725.40	23,870.00	21,506.87	68,780.00	155,952.12
4 Upgrades	32,205.00	19,097.57	34,740.00	22,893.66	27,630.00	20,197.53	34,450.00	27,973.40	30,800.00	27,750.80	87,870.00	205,782.96
Total hardware acquisition	216,065.00	128,126.55	232,020.00	152,901.18	217,370.00	158,897.47	327,290.00	265,759.48	128,030.00	115,355.03	492,990.00	1,314,029.71
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*219,004.95*

SOFTWARE ACQUISITION (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Software (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 Personal productivity applications	12,630.00	7,489.59	10,700.00	7,051.30	11,560.00	8,450.36	16,700.00	13,560.40	14,300.00	12,884.30	54,350.00	103,785.95
2 Business support/vertical applications	8,200.00	4,862.60	9,140.00	6,023.26	7,210.00	5,270.51	9,260.00	7,519.12	7,200.00	6,487.20	31,900.00	62,062.69
3 Data management and development tools	8,100.00	4,803.30	8,700.00	5,733.30	5,200.00	3,801.20	6,120.00	4,969.44	11,300.00	10,181.30	42,450.00	71,938.54
4 Communication applications	-	-	9,200.00	6,062.80	-	-	8,300.00	6,739.60	-	-	43,200.00	56,002.40
5 Other	13,900.00	8,242.70	10,300.00	6,787.70	12,700.00	9,283.70	16,250.00	13,195.00	12,100.00	10,902.10	33,400.00	81,811.20
Total software acquisition	42,830.00	25,398.19	48,040.00	31,658.36	36,670.00	26,805.77	56,630.00	45,983.56	44,900.00	40,454.90	205,300.00	375,600.78
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*62,600.13*

RETROFITTING (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Retrofiting (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 site alteration	47,670.00	28,268.31	37,900.00	24,976.10	27,560.00	20,146.36	26,950.00	21,883.40	47,350.00	42,662.35	188,500.00	326,436.52
2 transmission system	48,940.00	29,021.42	34,560.00	22,775.04	39,370.00	28,779.47	19,400.00	15,752.80	25,670.00	23,128.67	139,460.00	258,917.40
3 electrical system	44,120.00	26,163.16	37,210.00	24,521.39	34,700.00	25,365.70	29,850.00	24,238.20	28,300.00	25,498.30	151,300.00	277,086.75
4 ventilation system	53,040.00	31,452.72	29,530.00	19,460.27	27,430.00	20,051.33	17,350.00	14,088.20	31,500.00	28,381.50	177,900.00	291,334.02
Total retrofitting	193,770.00	114,905.61	139,200.00	91,732.80	129,060.00	94,342.86	93,550.00	75,962.60	132,820.00	119,670.82	657,160.00	1,153,774.69
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*192,295.78*

TECHNICAL SUPPORT AND OPERATIONS (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Tot. TechSup.&Op. (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 Technical services	27,340.00	16,212.62	34,340.00	22,630.06	27,370.00	20,007.47	31,330.00	25,439.96	37,230.00	33,544.23	35,320.00	153,154.34
2 Planning and process management	31,230.00	18,519.39	32,340.00	21,312.06	34,950.00	25,548.45	35,080.00	28,484.96	33,470.00	30,156.47	32,430.00	156,451.33
3 Database management and administration	28,090.00	16,657.37	27,040.00	17,819.36	26,500.00	19,371.50	32,120.00	26,081.44	28,340.00	25,534.34	30,230.00	135,694.01
4 Service desk	29,300.00	17,374.90	28,520.00	18,794.68	23,690.00	17,317.39	31,560.00	25,626.72	31,590.00	28,462.59	29,300.00	136,876.28
Total Technical Support and Operations	115,960.00	68,764.28	122,240.00	80,556.16	112,510.00	82,244.81	130,090.00	105,633.08	130,630.00	117,697.63	127,280.00	582,175.96
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*97,029.33*

ADMINISTRATION AND PROFESSIONAL DEVELOPMENT (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Tot. Adm&Prof.Dev (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 Finance and administration	45,050.00	26,714.65	49,400.00	32,554.60	43,650.00	31,908.15	36,900.00	29,962.80	39,070.00	35,202.07	34,260.00	190,602.27
2 End-user training	48,760.00	28,914.68	45,490.00	29,977.91	43,500.00	31,798.50	42,700.00	34,672.40	39,450.00	35,544.45	37,020.00	197,927.94
Total Administration and Professional Development	93,810.00	55,629.33	94,890.00	62,532.51	87,150.00	63,706.65	79,600.00	64,635.20	78,520.00	70,746.52	71,280.00	388,530.21
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*64,755.04*

END USER OPERATIONS AND DOWNTIME (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Tot.E-U.Op&Dwntme (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
1 Peer support	37,840.00	22,439.12	49,870.00	32,864.33	43,470.00	31,776.57	48,590.00	39,455.08	51,160.00	46,095.16	43,210.00	215,840.26
2 Casual learning	46,330.00	27,473.69	47,320.00	31,183.88	48,450.00	35,416.95	45,980.00	37,335.76	4,530.00	4,081.53	31,200.00	166,691.81
3 Formal learning	51,200.00	30,361.60	40,140.00	26,452.26	41,270.00	30,168.37	38,160.00	30,985.92	41,230.00	37,148.23	37,800.00	192,916.38
4 File and data management	19,230.00	11,403.39	20,900.00	13,773.10	17,320.00	12,660.92	19,340.00	15,704.08	17,230.00	15,524.23	27,350.00	96,415.72
5 Application development	23,210.00	13,763.53	18,520.00	12,204.68	19,230.00	14,057.13	15,320.00	12,439.84	18,320.00	16,506.32	21,430.00	90,401.50
6 Downtime	132,370.00	78,495.41	194,500.00	128,175.50	178,380.00	130,395.78	165,820.00	134,645.84	132,670.00	119,535.67	14,250.00	605,498.20
Total End-user Operations and Downtime	310,180.00	183,936.74	371,250.00	244,653.75	348,120.00	254,475.72	333,210.00	270,566.52	265,140.00	238,891.14	175,240.00	1,367,763.87
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*227,960.65*

DETAILED TCO COST CATEGORIES IN KIGALI INSTITUTE OF EDUCATION (KIE)

HARDWARE ACQUISITION (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Hardware (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
Acquisition cost	36,030.00	21,365.79	31,200.00	20,560.80	35,170.00	25,709.27	30,140.00	24,473.68	26,270.00	23,669.27	102,640.00	218,418.81
Spares	37,650.00	22,326.45	34,230.00	22,557.57	42,150.00	30,811.65	43,020.00	34,932.24	34,210.00	30,823.21	86,540.00	227,991.12
Supplies	18,300.00	10,851.90	19,830.00	13,067.97	17,120.00	12,514.72	25,900.00	21,030.80	21,890.00	19,722.89	78,450.00	155,638.28
Upgrades	27,300.00	16,188.90	25,390.00	16,732.01	28,250.00	20,650.75	33,510.00	27,210.12	54,000.00	48,654.00	24,630.00	154,065.78
Total hardware acquisition	119,280.00	70,733.04	110,650.00	72,918.35	122,690.00	89,686.39	132,570.00	107,646.84	136,370.00	122,869.37	292,260.00	756,113.99
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*126,019.00*

SOFTWARE ACQUISITION (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Software (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
Personal productivity applications	2,300.00	1,363.90	2,330.00	1,535.47	8,400.00	6,140.40	4,490.00	3,645.88	6,400.00	5,766.40	33,560.00	52,012.05
Business support/vertical applications	1,540.00	913.22	3,200.00	2,108.80	3,500.00	2,558.50	5,200.00	4,222.40	7,220.00	6,505.22	28,450.00	44,758.14
Data management and development tools	3,400.00	2,016.20	2,100.00	1,383.90	7,920.00	5,789.52	3,300.00	2,679.60	6,240.00	5,622.24	25,400.00	42,891.46
Communication applications	2,640.00	1,565.52	1,380.00	909.42	4,210.00	3,077.51	7.00	5.68	1,400.00	1,261.40	20,540.00	27,359.53
Other	2,410.00	1,429.13	3,710.00	2,444.89	3,450.00	2,521.95	15,340.00	12,456.08	3,530.00	3,180.53	27,400.00	49,432.58
Total software acquisition	12,290.00	7,287.97	12,720.00	8,382.48	27,480.00	20,087.88	28,337.00	23,009.64	24,790.00	22,335.79	135,350.00	216,453.76
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*36,075.63*

RETROFITTING (in US$)

Year	2005		2004		2003		2002		2001		Year 0	Total Retrofitting (discounted)
	Actual	PV	Actual	PV	Actual	PV	Actual	PV	Actual	PV		
site alteration	5,300.00	3,142.90	6,310.00	4,158.29	7,520.00	5,497.12	21,470.00	17,433.64	24,300.00	21,894.30	132,320.00	184,446.25
transmission system	2,900.00	1,719.70	9,210.00	6,069.39	11,520.00	8,421.12	13,420.00	10,897.04	14,240.00	12,830.24	143,290.00	183,227.49
electrical system	2,370.00	1,405.41	2,100.00	1,383.90	13,900.00	10,160.90	15,490.00	12,577.88	16,370.00	14,749.37	127,320.00	167,597.46
ventilation system	3,210.00	1,903.53	6,300.00	4,151.70	5,230.00	3,823.13	11,500.00	9,338.00	13,420.00	12,091.42	83,210.00	114,517.78
Total retrofitting	13,780.00	8,171.54	23,920.00	15,763.28	38,170.00	27,902.27	61,880.00	50,246.56	68,330.00	61,565.33	486,140.00	649,788.98
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		
											annual mean	*108,298.16*

TECHNICAL SUPPORT AND OPERATIONS (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot. TechSup.&Op. (discounted)
1 Technical services	24,290.00	14,403.97	22,190.00	14,623.21	20,040.00	14,649.24	18,100.00	14,697.20	17,200.00	15,497.20	16,230.00	90,100.82
2 Planning and process management	18,420.00	10,923.06	17,290.00	11,394.11	16,280.00	11,900.68	15,320.00	12,439.84	14,230.00	12,821.23	10,200.00	69,678.92
3 Database management and administration	25,800.00	15,299.40	22,100.00	14,563.90	21,100.00	15,424.10	21,290.00	17,287.48	21,160.00	19,065.16	21,670.00	103,310.04
4 Service desk	18,190.00	10,786.67	17,670.00	11,644.53	15,320.00	11,198.92	13,200.00	10,718.40	11,230.00	10,118.23	9,200.00	63,666.75
Total Technical Support and Operations	86,700.00	51,413.10	79,250.00	52,225.75	72,740.00	53,172.94	67,910.00	55,142.92	63,820.00	57,501.82	57,300.00	326,756.5[illegible]
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 54,459.42

ADMINISTRATION AND PROFESSIONAL DEVELOPMENT (in US$).

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot. Adm&Prof.Dev (discounted)
1 Finance and administration	23,710.00	14,060.03	21,260.00	14,010.34	20,300.00	14,839.30	19,590.00	15,907.08	18,350.00	16,533.35	17,490.00	92,840.10
2 End-user training	29,610.00	17,558.73	26,800.00	17,661.20	27,040.00	19,766.24	26,700.00	21,680.40	25,700.00	23,155.70	23,380.00	123,202.27
Total Administration and Professional Development	53,320.00	31,618.76	48,060.00	31,671.54	47,340.00	34,605.54	46,290.00	37,587.48	44,050.00	39,689.05	40,870.00	**216,042.37**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 36,007.06

END USER OPERATIONS AND DOWNTIME (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot.E-U.Op&Dwntme (discounted)
1 Peer support	30,840.00	18,288.12	28,540.00	18,807.86	26,530.00	19,393.43	24,430.00	19,837.16	22,520.00	20,290.52	13,340.00	109,957.09
2 Casual learning	35,490.00	21,045.57	36,490.00	24,046.91	31,250.00	22,843.75	29,710.00	24,124.52	24,100.00	21,714.10	19,230.00	133,004.85
3 Formal learning	25,410.00	15,068.13	23,760.00	15,657.84	19,040.00	13,918.24	17,590.00	14,283.08	15,480.00	13,947.48	16,270.00	89,144.77
4 File and data management	31,920.00	18,928.56	29,430.00	19,394.37	26,580.00	19,429.98	24,120.00	19,585.44	21,830.00	19,668.83	18,540.00	115,547.18
5 Application development	22,650.00	13,431.45	20,310.00	13,384.29	18,430.00	13,472.33	16,500.00	13,398.00	13,210.00	11,902.21	11,200.00	76,788.28
6 Downtime	46,120.00	27,349.16	45,300.00	29,852.70	50,490.00	36,908.19	48,290.00	39,211.48	49,010.00	44,158.01	46,800.00	224,279.54
Total End-user Operations and Downtime	192,430.00	114,110.99	183,830.00	121,143.97	172,320.00	125,965.92	160,640.00	130,439.68	146,150.00	131,681.15	125,380.00	**748,721.71**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 124,786.95

DETAILED TCO COST CATEGORIES IN UNIVERSITE LIBRE DE KIGALI (ULK)

HARDWARE ACQUISITION (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Total Hardware (discounted)
1 Acquisition cost	37,230.00	22,077.39	36,020.00	23,737.18	38,320.00	28,011.92	36,210.00		34,780.00	31,336.78	132,450.00	237,613.27
2 Spares	24,310.00	14,415.83	23,890.00	15,743.51	21,060.00	15,394.86	19,320.00	15,687.84	17,430.00	15,704.43	48,980.00	125,926.47
3 Supplies	24,300.00	14,409.90	22,120.00	14,577.08	21,530.00	15,738.43	19,030.00	15,452.36	18,200.00	16,398.20	47,200.00	123,775.97
4 Upgrades	16,420.00	9,737.06	17,370.00	11,446.83	16,540.00	12,090.74	17,300.00	14,047.60	14,290.00	12,875.29	14,280.00	74,477.52
Total hardware acquisition	102,260.00	60,640.18	99,400.00	65,504.60	97,450.00	71,235.95	91,860.00	74,590.32	84,700.00	76,314.70	242,910.00	**591,195.75**
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		

annual mean 98,532.63

SOFTWARE ACQUISITION (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Total Software (discounted)
1 Personal productivity applications	3,690.00	5,320.00	5,080.00	3,347.72	4,910.00	3,589.21	4,230.00	3,434.76	4,120.00	3,712.12	15,760.00	35,163.81
2 Business support/vertical applications	3,610.00	4,120.00	4,120.00	2,715.08	6,030.00	4,407.93	4,990.00	4,051.88	3,210.00	2,892.21	13,600.00	31,787.10
3 Data management and development tools	4,420.00	4,780.00	4,730.00	3,117.07	5,210.00	3,808.51	4,130.00	3,353.56	5,370.00	4,838.37	19,300.00	39,197.51
4 Communication applications	4,100.00	5,320.00	5,140.00	3,387.26	4,280.00	3,128.68	5,700.00	4,628.40	4,760.00	4,288.76	16,200.00	36,953.10
5 Other	3,220.00	4,720.00	4,760.00	3,136.84	3,100.00	2,266.10	4,960.00	4,027.52	3,980.00	3,585.98	9,320.00	27,056.44
Total software acquisition	19,040.00	24,260.00	23,830.00	15,703.97	23,530.00	17,200.43	24,010.00	19,496.12	21,440.00	19,317.44	74,180.00	**170,157.96**
PVIF 11%, n		0.59		0.66		0.73		0.81		0.90		

annual mean 28,359.66

RETROFITTING (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Total Retrofiting (discounted)
1 site alteration	21,670.00	12,850.31	23,100.00	15,222.90	21,650.00	15,826.15	23,210.00	18,846.52	21,900.00	19,731.90	100,340.00	182,817.78
2 transmission system	12,870.00	7,631.91	9,630.00	6,346.17	12,430.00	9,086.33	13,590.00	11,035.08	12,830.00	11,559.83	67,320.00	112,979.32
3 electrical system	9,070.00	5,378.51	11,780.00	7,763.02	11,870.00	8,676.97	10,320.00	8,379.84	9,730.00	8,766.73	70,290.00	109,255.07
4 ventilation system	13,270.00	7,869.11	14,300.00	9,423.70	14,510.00	10,606.81	13,230.00	10,742.76	14,200.00	12,794.20	57,930.00	109,366.58
Total retrofitting	56,880.00	33,729.84	58,810.00	38,755.79	60,460.00	44,196.26	60,350.00	49,004.20	58,660.00	52,852.66	295,880.00	**514,418.75**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 85,736.46

TECHNICAL SUPPORT AND OPERATIONS (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot. TechSup.&Op. (discounted)
1 Technical services	18,520.00	10,982.36	17,320.00	11,413.88	16,430.00	12,010.33	15,280.00	12,407.36	14,370.00	12,947.37	13,260.00	73,021.30
2 Planning and process management	18,730.00	11,106.89	17,980.00	11,848.82	17,390.00	12,712.09	14,320.00	11,627.84	13,290.00	11,974.29	11,230.00	70,499.93
3 Database management and administration	15,670.00	9,292.31	15,900.00	10,478.10	14,200.00	10,380.20	11,200.00	9,094.40	10,430.00	9,397.43	2,320.00	50,962.44
4 Service desk	14,950.00	8,865.35	14,870.00	9,799.33	14,270.00	10,431.37	13,200.00	10,718.40	11,040.00	9,947.04	9,030.00	58,791.49
Total Technical Support and Operations	67,870.00	40,246.91	66,070.00	43,540.13	62,290.00	45,533.99	54,000.00	43,848.00	49,130.00	44,266.13	35,840.00	**253,275.16**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 42,212.53

ADMINISTRATION AND PROFESSIONAL DEVELOPMENT (in US$).

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot. Adm&Prof.Dev (discounted)
1 Finance and administration	15,730.00	9,327.89	14,280.00	9,410.52	13,960.00	10,204.76	13,070.00	10,612.84	11,230.00	10,118.23	9,430.00	59,104.24
2 End-user training	25,200.00	14,943.60	26,300.00	17,331.70	25,210.00	18,428.51	24,350.00	19,772.20	23,090.00	20,804.09	21,780.00	113,060.10
Total Administration and Professional Development	40,930.00	24,271.49	40,580.00	26,742.22	39,170.00	28,633.27	37,420.00	30,385.04	34,320.00	30,922.32	31,210.00	**172,164.34**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 28,694.06

END USER OPERATIONS AND DOWNTIME (in US$)

Year	2005 Actual	2005 PV	2004 Actual	2004 PV	2003 Actual	2003 PV	2002 Actual	2002 PV	2001 Actual	2001 PV	Year 0	Tot.E-U.Op&Dwntme (discounted)
1 Peer support	18,930.00	11,225.49	17,540.00	11,558.86	18,690.00	13,662.39	16,380.00	13,300.56	14,650.00	13,199.65	13,290.00	76,236.95
2 Casual learning	23,170.00	13,739.81	21,700.00	14,300.30	20,910.00	15,285.21	15,350.00	12,464.20	13,250.00	11,938.25	14,320.00	82,047.77
3 Formal learning	20,970.00	12,435.21	19,530.00	12,870.27	18,620.00	13,611.22	17,230.00	13,990.76	16,830.00	15,163.83	15,460.00	83,531.29
4 File and data management	20,630.00	12,233.59	18,390.00	12,119.01	15,720.00	11,491.32	13,280.00	10,783.36	11,430.00	10,298.43	10,570.00	67,495.71
5 Application development	17,420.00	10,330.06	15,230.00	10,036.57	11,870.00	8,676.97	9,020.00	7,324.24	13,690.00	12,334.69	11,940.00	60,642.53
6 Downtime	51,480.00	30,527.64	47,050.00	31,005.95	50,030.00	36,571.93	47,650.00	38,691.80	45,320.00	40,833.32	43,230.00	220,860.64
Total End-user Operations and Downtime	152,600.00	90,491.80	139,440.00	91,890.96	135,840.00	99,299.04	118,910.00	96,554.92	115,170.00	103,768.17	108,810.00	**590,814.89**
PVIF 11 %, n		0.59		0.66		0.73		0.81		0.90		

annual mean 98,469.15