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Life Cycle Costing Practices in Ghanaian Public Universities: Case Study of UEW

by

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MASTER OF SCIENCE

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science Degree in Construction Management and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Due to the ever-increasing quest for tertiary education in the country, there have been annual increments in enrolments in the various public universities in Ghana over time, leading to pressure on the limited academic facilities. At a high cost of expanding their infrastructural bases, focus has primarily been centered on the cost of construction much to the neglect of overall life span costs of projects. Using a mixed methodology approach, the study aimed at exploring the use of Life Cycle Costing (LCC) practices in GPUs by assessing the level of understanding of practitioners on the technique, documenting existing practices and barriers effective application as well as identifying pre-requisites for effective implementation of the tool. Through a thorough literature review, a questionnaire was developed and administered to 40 practitioners in the built environment (Architects, Engineers, Quantity Surveyors, Project Managers, Estate Officers and Procurement Officers). The study revealed that there is general knowledge and awareness of the LCC tool though rarely applied consciously in practice as confirmed from literature. The study further identified that the involvement of maintenance personnel at the early stage of projects was the most practiced LCC technique and major barriers to the practice have been with bureaucratic structures in administrative procedures as well as poor maintenance culture. Other factors identified included the difficulty in assessing reliable data for analysis, the unavailability of an abridged standardized LCC approach for local practice, insufficient expertise of professionals, the ever-growing challenge of balancing and satisfactorily meeting multiple institutional stakeholders' needs as well as the effects of inflation on forecasted figures among others. Identified measures for effective implementation of the tool in GPUs are the need to develop institutional design and maintenance standard manuals as well as training of practitioners to gain workable knowledge in the

application of the tool. Serving as an eye-opener to the exploration of LCC practices in Ghana, this research will be useful for management of GPUs and professionals in the Ghanaian Construction Industry (GCI). The study further recommends that future researchers can explore the perception of built environment professionals on the use of LCC within the GCI.

Key words: Life Cycle Costing, Capital Projects, Practices, Public Universities, Ghana.

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LIST OF ABBREVIATIONS

LCC	Life Cycle Costing
WLC	Whole Life Costing
GPUs	Ghanaian Public Universities
GCI	Ghanaian Construction Industry
ISO	International Organization for Standardization
BSRIA	Building Services Research and Information Association
BS	British Standards
ASTM	American Society for Testing Materials
O&M	Operation and Maintenance
UEW	University of Education, Winneba
UCEW	University College of Education, Winneba
NPV	Net Present Value
SPSS	Statistical Package for Social Sciences
RII	Relative Importance Index
Int.	Interviewees
CPD	Continuous Professional Development
BCIS	Building Cost Information Service
SDGs	Sustainable Development Goals

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ACKNOWLEDGEMENT

The LORD is my strength and my shield; my heart trusted in Him and I am helped; therefore my heart greatly rejoices, and with my song I will praise Him. I will bless the LORD at all times; His praise shall continually be in my mouth. (Psalm 28:7, 34:1). This is to express my gratitude to the Lord Almighty for knowledge and strength throughout the period of the research.

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DEDICATION

I dedicate this work to my parents and siblings for their support during the period of this programme. You are truly irreplaceable.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In Ghana, the desire for achieving academic qualifications has been on the rise over the years. Educational institutions at all levels are therefore into expanding infrastructure to create the enabling environment for meeting the teaming demands. These infrastructural expansions encompass the construction of halls of residences, lecture halls, office blocks, commercial and recreational facilities as well as road networks. These physical projects require strategic planning and implementation of best practices to achieve the desired results. According to Yale Facilities Construction & Renovation (2005), universities engage in these physical projects in order to achieve their strategic goals and upgrade the quality of their infrastructure of which considerable funds are committed.

Due to the highly capital-intensive requirements on these projects, innovative capital financing methods have been sought after over the years, with even higher demands placed on better fiscal management practices for the achievement of best value. Managers and users are into finding the very best practices that provide economic advantages over the life span of projects. With the adoption of sustainable principles in the construction industry, the concept of life cycle costing has become necessary in decision making. Stakeholders therefore require professionals to adopt processes that include life cycle costing in the long-term planning of physical projects (U.S. Department of Energy, 2014).

With the launch of the Sustainable Development Goals (SDGs), more emphasis have been placed on moving away from the over-concentration on short-term effects of

decisions taken for developmental projects. Sustainability as a principle involves creating and maintaining conditions for humans and nature co-habit in productive harmony. As construction feeds on nature for the bulk of its material resource inputs, the recent alarm of resource depletion is of great concern for all and sundry within the built environment. This new trend has led to the conscious consideration of sustainable technology, sustainable development and sustainable built environment principles which also incorporates the necessity of conducting life cycle studies on proposed developments as part of value-for-money assessments (Ametepey & Aigbavboa, 2015; Djokoto et al, 2014; Thiébat, 2013; Davis Langdon, 2007).

Life cycle costing (LCC) as a principle is applicable in many spheres of human endeavour for optimum resource allocation and achievement of best value for money. It involves identifying and detailing the initial capital cost and future costs of owning a facility over its lifetime (Rum & Akasah, 2012). Flanagan & Jewell (2005) describe the term to have evolved from cost-in-use, whiles in other settings it is also referred to as Whole Life Costing (WLC) and Whole Life Appraisal.

The terms LCC and WLC have most often than not been used interchangeably. However, whilst LCC concerns the costs related directly to the construction and operation of a facility, WLC includes other costs associated but indirectly related to the acquisition and use of the facility such as land costs, procurement costs and even revenues obtained from commercially-run facilities. Irrespective of the terminology assigned to the practice, the focus remains on the importance of considering all costs associated with the development and use of capital projects within the built environment (Willmott Dixon, 2010).

1.2 STATEMENT OF THE PROBLEM

Ghanaian Public Universities (GPUs) offer a wide range of academic programmes. As the annual turn-out of graduates from the senior high schools increase coupled with the backlog of hopeful applicants and additional academic programmes that are constantly being developed to meet industry requirements, universities are focusing on expanding academic facilities to strategically position them to meet this demand. These infrastructural developments come at a high cost with funding balanced between the government, donor agencies and internal funds.

To ensure that these costs are well managed, these universities have established technical departments- Estate/Works and Physical Development Offices as well as Procurement Units- that handle the development, construction and management-in-use of their facilities. These departments work together to ensure that all capital projects are managed to the highest standards for capital optimization in these institutions. Though the services of these departments bring a lot of relief, the focus has mostly been on the initial costs (Ametepey & Aigbavboa, 2015; Djokoto et al., 2014).

Research has shown that the running cost of some facilities rise as high as 40% of capital cost or even more (Rum & Akasah, 2012). Coupled with the continuously less funding for capital projects (Pearce et al., 2009), the government and Council of the various public universities may have to reconsider their priorities. There must be a paradigm shift from the traditional award of contracts based primarily on the initial construction cost (University of California, 2014) into more proactive requirements and standards for selection. The perspective should be expanded to include the costs of operation, maintenance and replacements to the initial acquisition costs to enable effective value-for-money assessment of projects. This is possible with the use of LCC and related practices to ensure that projects are well assessed for decision making.

1.3 AIM

The aim of the study was to explore the use of Life Cycle Costing (LCC) practices in Ghanaian Public Universities (GPUs).

1.4 OBJECTIIVES

In achieving the aim of the study the following objectives were espoused;

- To document the level of understanding of the LCC tool by practitioners;
- To document existing LCC practices employed in GPUs;
- To identify barriers to the application of LCC practices;
- To determine the prerequisites for effective LCC practice.

1.5 SIGNIFICANCE OF STUDY

The use of LCC as a project evaluation tool has been promoted by academia as a means of achieving best value for money rather resorting to least cost (Higham et al., 2015). Though the application of LCC has far reaching benefits, its knowledge and application in the Ghanaian Construction Industry has not been documented. The adoption and appropriate use of its principles will enable public universities to reap the benefits of true value for money for the numerous capital projects they are undertaking and those planned for. This study seeks therefore to explore the level of knowledge and application of the tool among practitioners and will fill a gap in the knowledge on the use of LCC practices in Ghana, particularly in GPUs. The study will further recommend measures for implementing LCC practices effectively in GPUs.

1.6 SCOPE OF THE STUDY

Universities the world over are moving from the single, central campus system into multi-campuses for various reasons. The story is not different in Ghana, with most universities operating the multi-campus system. The scope of the study focused on the University of Education, Winneba (UEW). Due to the current drive towards this area, UEW, with an already established multi-campus system (about 24 years) has been considered for the purpose of this research. Findings gathered can suitably be adjusted for decision-making in other Public Universities.

1.7 LIMITATION OF STUDY

The sampled respondents for the study was limited to technical staff of the university from among the development office, procurement unit and estate department in addition to those from agency consultants contracted for similar roles. The time for the study was also limited making it practically difficult to expand the scope of the study to cover all of the nine GPUs.

1.8 RESEARCH METHODOLOGY

The methodology involved the use of both quantitative and qualitative approaches. Data was gathered through administering structured questionnaires as well as one-on-one interviews. The study also involved the review of literature based on the objectives of the study to provide a platform for developing appropriate themes for the investigations on the case study, from which questionnaires were developed. A detailed discussion of the research methodology adopted has been presented in Chapter Three of this study.

1.9 ORGANIZATION OF THE STUDY

This research was organised into five main chapters;

- Chapter One introduced the research topic with the statement of the problem, the aim and objectives of the study and proposed research methodology to be adopted for the study;
- Chapter Two presented a review of existing literature on the study area. It focuses on discussing studies conducted in the area of life cycle costing approaches within the brackets of sustainable construction;
- Chapter Three involved a detailed description of the chosen research methodology on how data was collected and analysed for discussion;
- Chapter Four was devoted to the analysis of data gathered and further discussions on the findings; and
- Chapter Five covered the conclusions and recommendations on findings made and directions/proposals for further research on the subject area.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The Construction Industry globally experiences periodic changes; a review of past changes showing that they were traditionally driven by powerful external stimuli such as political leadership or war. The current global changes and corrections being experienced by the construction industry are quite unique. They are driven primarily by increased capital expenditures; limited access to capital, informing effective utilization of available resources; reduced availability of raw materials; increasingly disappointing schedule performance and an increase in the technical complexity of construction projects (Pearce et al., 2009).

Both University of California (2014) and University of Michigan (2013) report that Public University projects represent long-term investments due to the continuous development and re-development in a quest to meet the academic mission of the institution. All this is done with limited public funds and the objective to mitigate the overall project cost is highly rated. Decisions on the scope, cost and time for the project are greatly influenced at the planning stages early in the project. Existing strategic plans of the establishment must therefore be used to coordinate systems for setting priorities for investments targetted (Office of Financial Management, 2008).

2.2 UNIVERSITY EDUCATION

Universities, the world over, are established as institutions of higher learning for training, research and the award of academic degrees to scholars. Globally, prospective students at all levels of higher learning are expected to complete secondary/high school education with training in the requisite areas (for undergraduate hopefuls) or have a

recognised Bachelor's degree (and/or Master's degree for PhD applicants) prior to the enrolment to a graduate programme.

2.2.1 UNIVERSITY EDUCATION IN GHANA

The current structure of Ghanaian education involves pre-school education (crèche, nursery and kindergarten), basic school education (primary and junior high), secondary education (senior high schools and technical/vocational schools/colleges) and tertiary education (nursing and teacher training colleges, polytechnics and universities). University Education forms a prime component of tertiary education in Ghana. Aside the full-fledged universities, there are numerous University Colleges with affiliations with prime universities. Other recognized and accredited professional institutes also exist to offer professional training and certification for various fields of endeavours.

2.2.2 GHANAIAN PUBLIC UNIVERSITIES

Amidst the numerous Universities in Ghana, there are nine (9) recognized public universities within Ghana spread across seven regions that offer academic degree programmes at various levels. They include the University of Ghana (UG, Legon), Kwame Nkrumah University of Science and Technology (KNUST, Kumasi), University of Cape Coast (UCC, Cape Coast), University of Education, Winneba (UEW, Winneba), University for Development Studies (UDS, Tamale), University of Professional Studies (UPS, Accra), University of Mines and Technology (UMaT, Tarkwa), University of Health and Allied Sciences (UHAS, Ho), and University of Energy and Natural Resources (UENR, Sunyani).

2.2.3 UNIVERSITY OF EDUCATION, WINNEBA

2.2.3.1 History

The University of Education, Winneba (UEW) was established in September 1992 under the PNDC Law 322 as a University College of Education, Winneba (UCEW). UEW merged seven (7) Diploma-awarding Colleges of Education located within different towns under one mother institution. The colleges included the Advanced Teacher Training College, the National Academy of Music and the Specialist Training College, all in Winneba; the School of Ghana Languages in Ajumako; the College of Special Education in Akwapim-Mampong; the St. Andrews Agricultural Training College, Mampong-Ashanti; and the Advanced Technical Training College, Kumasi.

The University of Education Act, Act 672 was enacted on May 14, 2004 to upgrade the status of the UCEW to the status of a full University and to provide for related matters. The UEW currently operates across four (4) towns. The Winneba campus (made up of the North, Central and South campuses) is the seat of the Vice-Chancellor and central administrative affairs, with three (3) satellite campuses across Ajumako (40km from Winneba), Kumasi (320km from Winneba) and Asante-Mampong (371km from Winneba).

2.2.3.2 Special Mandate and Mission

The UEW has been charged with the special mandate of producing proficient educators who will lead a new nationwide vision of education focused on redirecting Ghana's efforts in the lines of rapid socio-economic development. In this, the UEW is expected to play a key role in producing intellectuals with knowledge receptive to the realities and necessities of contemporary Ghana as well as the West African sub-region.

The Mission of the UEW is “to train competent professional teachers for all levels of education as well as conduct research, disseminate knowledge and contribute to educational policy and development”. Its vision is “to be an internationally reputable institution for teacher education and research” and to ensure the accomplishment of this, UEW maintains core values such as “Academic Excellence, Good Corporate Governance and Service to the Community, Gender Equity, Social Inclusiveness and Teamwork”.

To ensure that the design, procurement and management of its facilities are well managed under competent professionals and resourced departments, the UEW has Works and Physical Development, Procurement and Estate Departments. These departments have their respective head offices at the Winneba (North) campus with offices operating on the other three campuses. Together, they plan, procure, construct and maintain facilities on the various campuses. The fluidity with which these departments have worked together and coordinated works across all the four (4) campuses since its establishment is worth noting as an influencing factor for the choice of the UEW as case study for this research.

2.3 THE BUILT ENVIRONMENT

The built environment, made up the physical and conceptual products as well as the professionals that formulate the ideas, develop and implement solution-based designs need to be equitably harmonised. Due to the high costs involved in developing the environment, stakeholders are very interested in professionals and products that are sustainable and offer the best value for money as they meet predetermined and defined needs and requirements (Pearce et al., 2009; Haapio & Viitaniemi, 2008; Guckert & King, 2006).

2.3.1 CAPITAL PROJECTS

Capital projects move our world with over $10 trillion spent annually for infrastructural development. In spite of the wide range of projects undertaken worldwide, how projects are delivered have not changed much over the years, with certain practices dating far to the 1920s (Pearce et al., 2009).

According to Office of Financial Management (2008), there must be some key considerations when developing a construction project. Some of these include the budget, design, schedule, risk assessment and level of in-house management skills on the chosen project. University of California (2014) classifies capital projects into four distinct phases being the Pre-Design, Preliminary Plans, Working Drawings and Bidding and Construction Phases. Yale Facilities Construction & Renovation (2005) on the other hand presents a five-phase categorization, thus, Identification, Planning, Design, Construction and the Closeout phases. The phases however vary slightly on project basis since most capital projects are customized with components tailored to meet specific goals and contracting procedures adopted (Pearce et al., 2009).

2.3.1.1 Public Works Contracting

The decision on the type of procurement method to be chosen has become more complex in recent years due to the multitude of alternative public works procurement procedures that have been developed. Most popular amongst the many adopted include the Design and Build, Construction Management and Agency Construction Management. These alternative methods have promised to offer improvements over the common traditional methods in the areas of cost effectiveness, improved project control and reduced cases of construction disputes (Office of Financial Management, 2008).

The choice of a method determines the assignment of risks to parties involved at each phase of the project (University of California, 2014), hence, the importance of refining contracting within and across construction projects has been emphasized due to the gradual swing in the balance of control towards the contractor (Pearce et al., 2009).

2.3.1.1.1 Design and Build

This remains the most popular of the alternative methods for construction projects. Some players in the industry see it as the perfect solution to the limitations encountered in the use of the other methods. With this method, the firm engages a Design and Build Contractor who comes out with the complete design and also constructs it (Office of Financial Management, 2008). The Contractor agrees to design and construct the facility for an agreed fixed price based on submitted proposals and design concepts (Yale Facilities Construction & Renovation, 2005).

There are some variations to this procedure based on the preferences of the client organisation. It may be *direct or competitive* where the contractor is solely selected or enters into a competition with other design and bid contractors who submit their bids to the client respectively. *Develop and construct* also involve the client involving consultants to develop an initial design for which contractors develop it together with price bids for submission. *Package deal* involves contractors bidding with their own developed systems and products whilst *Novation design and build* involves the contractor taking over a previous contract, completing the design and constructing it for the client (Office of Financial Management, 2008).

2.3.1.1.2 Construction Management

This system is quite similar to the traditional method with the Construction manager playing the role of the General Contractor. He holds the risk responsibility of subletting

portions of the works to trade contractors whilst he guarantees the performance of the project to agreed cost and time to the client (Office of Financial Management, 2008). This framework best fits a construction project where there are complex design requirements and the client wants to complement the expertise of its in-house staff. It is considered as the most cost effective approach as the Construction Manager is involved much earlier to assist in ensuring that the design is buildable and affordable to the client (Yale Facilities Construction & Renovation, 2005).

2.3.1.1.3 Agency Construction Management

This arrangement incorporates a range of services offered by a consulting firm on behalf of a client organization. The services offered can be used to extend or supplement the expertise of the firm in terms of its in-house management structures. It is recommended that selection of consultants is strongly based on their technical qualifications and not on low-bid criteria. The consultant performs predesign and design assignments, supervises the construction process and coordinates project information systems between the Client and the General Contractor (Office of Financial Management, 2008).

2.3.1.2 Capital Project Costs

Though the issue of limited funds for capital projects is very clear and innovative efforts are being implemented to manage project budgets, results seem to point the other direction. A survey of prominent client organizations across three continents revealed that over 50% of clients still expect budget overruns in future projects and 20% of this group anticipates the overruns going into double digits (Pearce et al., 2009).

Budgets for capital projects usually have two basic components being the Construction costs and the costs attributing to Project Administration, Fees and Administrative costs. Mostly about 65-80% of cost of a project is spent at the construction phase with larger projects having higher percentages (approaching 80%) of the project's budget allocation. On the other hand, 20-35% of the budgeted costs go into Project Management, Fees and Administrative costs with this cost being higher for relatively small projects or unique and complex projects (University of California, 2014).

The requesting units, sections and departments for construction projects are always responsible for budgeting and providing funding allocation for works stated in the procurement plan. The finance unit incorporates it into the budget for approval considerations (University of Michigan, 2013) and rigorous processes and controls are used to ensure effective utilization of these resources (Yale Facilities Construction & Renovation, 2005). All these are done in the face of continuous rise in costs of goods and services which make it difficult to predict budgets for construction projects (Pearce et al., 2009).

2.3.1.3 Effective Management of Capital Projects

After the approval of funding for the proposed project, goals and objectives must be clearly defined with identified approaches and agreed by stakeholders involved. Once this is done, the scope of work must be adequately developed to meet the defined goals (Yale Facilities Construction & Renovation, 2005).

Success in managing capital projects depends largely on ability to adopt cross-project capabilities to enhance delivery whilst reducing risk. There is the need for effective Risk management as research has shown that most organizations are able to recognize

potential risks, yet, with only a few having comprehensive monitoring and controlling systems implemented to manage them.

It is recommended that measures such as improved knowledge management, reuse of proven designs, properly coordinated supply relations, customised risk management measures, coordinated human resource management and a gradual shift from the strict vertical to more integrated horizontal organizational approach across projects are implemented in the management of capital projects (Pearce et al., 2009).

2.3.2 EDUCATIONAL INFRASTRUCTURE

The aim of a university is to put up well-constructed facilities that last longer without frequent renovation (Yale Facilities Construction & Renovation, 2005). Infrastructure produces an enablement for growth by facilitating business, movement and exchange of ideas and people (Smart Infrastructure Facility, 2014). Construction projects for educational institutions therefore stem from their capability of contributing to the academic mission of the institution, improvement of existing infrastructure and enhancement of access routes (University of California, 2014).

There is concern on how new projects interface with existing campus infrastructure to ensure effective physical coordination and integration (University of California, 2014). Educational institutions therefore have technical departments that coordinate the project processes and procedures. Various units are therefore not allowed to procure works and external consultants on their own. Needs are submitted to appropriate authorities and the needs of the requesting department assessed to identify how it affects the core academic mission. Approved requests are then forwarded to the respective technical departments for processing (University of Michigan, 2013).

There are some differences in the scope of public university infrastructure from that of private projects. Though autonomous, public universities depend to some extent on the central government in meeting all their financial needs (University of Edinburgh, 2010). The major difference therefore remains the public procurement requirements of the state which governs the mode of acquisition of the desired development (University of California, 2014).

2.4 SUSTAINABILITY

2.4.1 THE CONCEPT OF SUSTAINABILITY

For centuries the built environment has depended largely on the availability of natural resources. It has however become evident that the hitherto abundance of resources are gradually showing signs of global degradation (Ametepey & Aigbavboa, 2015). Many definitions of sustainability are available but the general concept surrounds meeting the needs of humans whilst preserving nature to ensure that meeting future needs are not compromised. This is addressed by the effective balance of the three main dimensions of what has now been accepted as the 'triple bottom-line' which encompasses the environment, society and economy (Ametepey & Aigbavboa, 2015; Thiébat, 2013).

2.4.2 SUSTAINABLE CONSTRUCTION

From the 1990s the construction industry began to recognize the impact of its activities on the environment. Focus has since then been on how buildings should be designed, constructed and operated to reduce this impact (Haapio & Viitaniemi, 2008). In applying the concept of sustainability to construction, there must be a balance between constituents of the triple bottom line (Environment, Economy and Society), Iron triangle (Time, Quality and Cost) and the Sustainable Design approach polygon (Environment, Society, Time, Quality and Cost) to ensure that construction projects can be deemed sustainable over their life cycle (Thiébat, 2013). The difficulty in achieving

this balance has led to the lasting conflict in balancing affordability and sustainable development (Green, 2009).

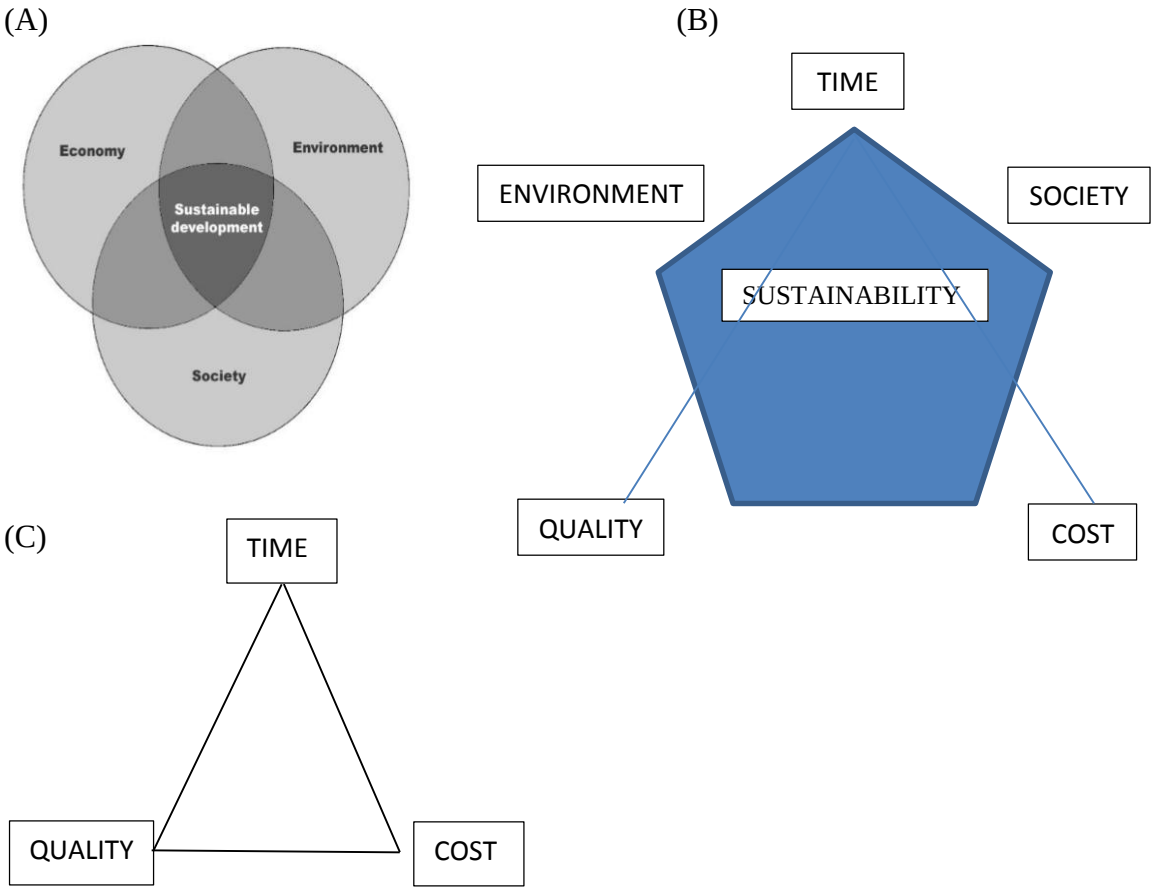

Fig 2.1 The concept of sustainability - (a) Triple bottom line, (b) Sustainable Design approach polygon and (c) Iron triangle *(Source: Thiébat, 2013)*

In Ghana, with approximately 25 million population, resource depletion is projected to reach a crisis situation unless the application of sustainable principles becomes a reality. However, in a free-market economy, its application in Ghana must be moved by market-based solutions instead of central government regulations (Ametepey & Aigbavboa, 2015).

Research has shown that in Ghana, the prime barriers to sustainable construction are the lack of consumers' demand for sustainable facilities, insufficient strategy to push sustainable construction, relatively higher initial cost involved, lack of general public

awareness of the concept and lack of support from government and public clients (Djokoto et al., 2014).

Other studies have pushed strongly for the employment of life cycle costing for effective balance of sustainability requirements for projects. In this, even greater emphasis on operational costs is placed on energy costs for consideration at the design stage in the choice of efficient and environmentally-friendly renewable energy sources for buildings (Tsai et al., 2014; Davis Langdon, 2007).

2.5 LIFE CYCLE COSTING

2.5.1 INTRODUCTION

In the 1970s there was the growing awareness in both the UK and the USA on the necessity in considering the costs that accrue in the use of buildings and of developing sound financial techniques and principles to effectively evaluate the whole life costs of facilities in use. By the late 1970s the tool was actively encouraged by the Federal Government of the United States due to their increasing concern about the costs in use of big investments made across the United States. Hitherto, primary concerns had been on the investment inputs made into federally-funded projects. It was in the late 1970s that attention was given to the reduced control over project costs after their commissioning, leading to a reform to require conducting a life cycle cost assessment of a project before commencement (Hoar, 1988).

In modern times there is an increase in the demand for more sustainable and longer term decision-making in the management process of construction projects. A broader use of decision support methods like LCC, however, still seems to be missing (Ludvig et al., 2010). Life cycle costing (LCC) as a principle is applicable in many spheres of human endeavour for optimum resource allocation and achievement of best value for

money. It involves identifying and detailing the initial capital cost and future costs of owning a facility over its lifetime. This early stage project evaluation tool (Higham et al., 2015) is described to have evolved from cost-in-use into life cycle cost. The concept is also referred to as Whole Life Costing and Whole Life Appraisal which considers all related costs, revenues and functionality over the period from acquisition through ownership and to the disposal of the facility (Flanagan & Jewell, 2005).

The terms whole life costing (WLC) and life cycle costing (LCC) have often been used interchangeably- and there has been confusion with their meanings. The UK supplement to the ISO 15686, "Standardised Method for Life Cycle Costing for Construction Procurement", clarifies this ambiguity. Generally, LCC estimates those costs directly related to the construction and operation of the building whilst WLC adds up other costs like land, income generated from the use of the building and associated support costs related to the activity within the building. The expertise of practitioners in the construction industry are well suited to conduct LCC analysis based on which clients can now estimate whole life costs (Willmott Dixon, 2010). The diagram in Fig. 2.2 below illustrates the relationship between LCC and WLC.

LCC provides a critical insight to the overall costs and resources both in the short and long terms that will be needed to accomplish a program or project. It offers a more detailed estimate of a project (Office of Acquisition and Project Management, 2014) when the perspective is expanded to cover the costs of operation, repair, maintenance, major overhauls/replacements and final disposal of the project (Tsai et al, 2014; Rum & Akasah, 2012).

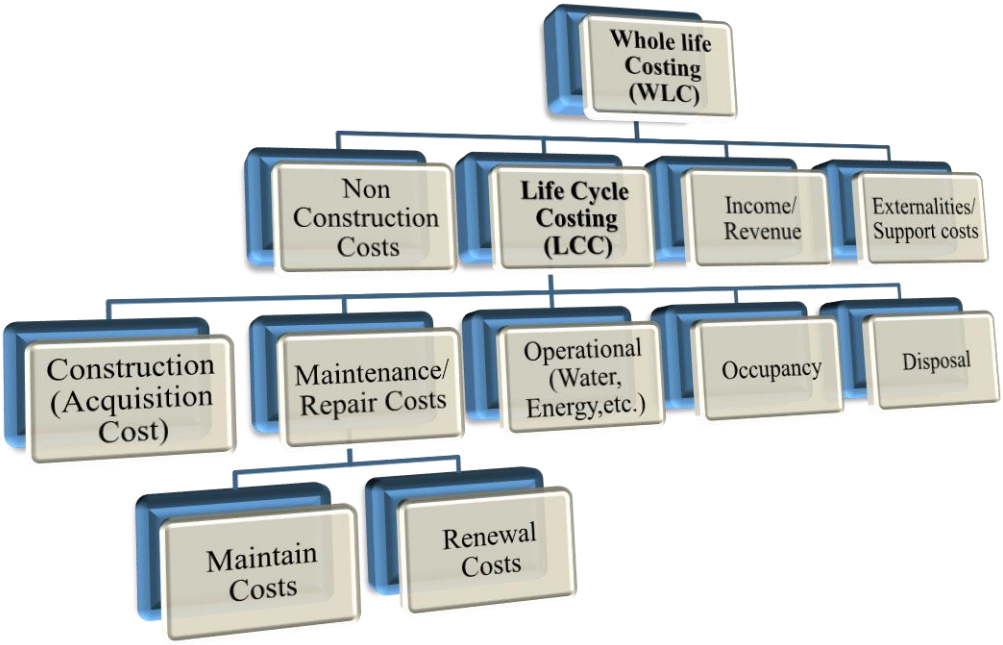

Fig 2.2 Relationship between WLC and LCC *(Source: BS ISO 15686-5:2008 and BSRIA BG67/2016)*

2.5.2 DEFINITION OF LCC

Life cycle costing can be defined as an approach/technique used in early-stage project evaluation that seeks to determine the overall life span cost of a project by considering planning, design and procurement costs; assessing life costs of components/materials, energy and other related inputs, future maintenance, replacements and eventual replacement/disposal costs of its proposed design (Higham et al., 2015; Kirk & Dell'Isola, 2003; Norman, 1990; Hoar, 1988). The BS ISO 15686-5:2008 also defines the term as "a methodology for the systematic economic evaluation of the life cycle costs over the period of analysis, as defined in the agreed scope" (ISO, 2008).

A review of other definitions from literature also emphasised the importance of determining the present values of all the costs taken into consideration in the estimation of the whole life cost of any project.

2.5.3 PRINCIPLES OF LCC

The ISO (International Organization for Standardization) has clearly outlined principles that govern the effective implementation and practice of LCC for capital projects. The principles are illustrated in figure 2.3 below;

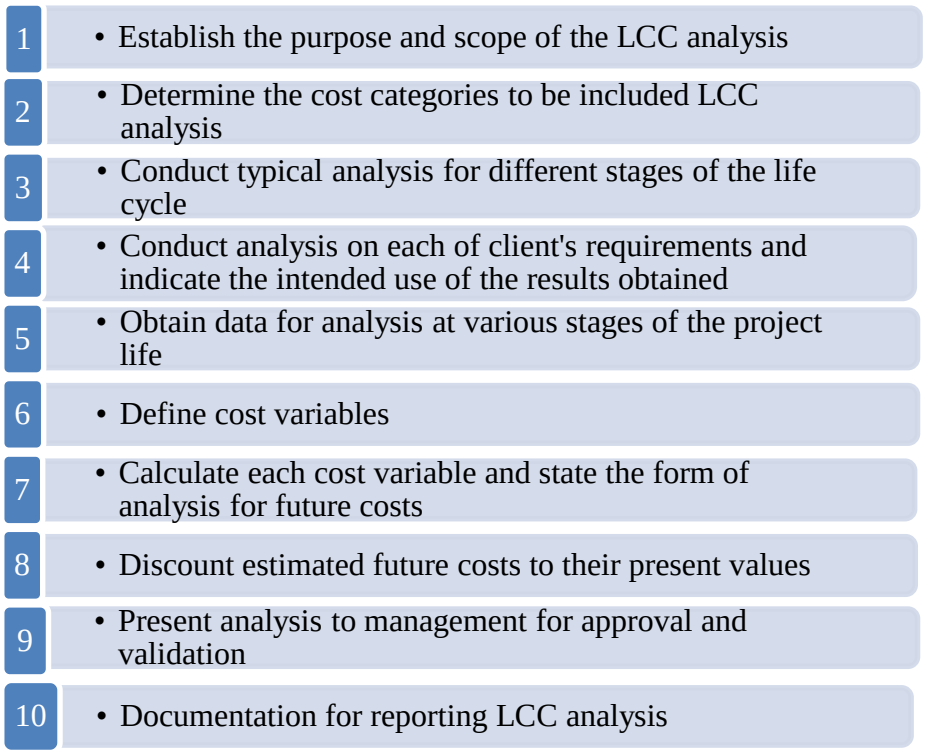

Fig 2.3 LCC Process *(Source: ISO, 2008)*

2.5.4 PRE-REQUISITES OF LCC PRACTICE

In order to establish and manage an effective LCC system, life cycle decisions must be institution-based, focusing on established standards and requirements for the institution, and not customer-based (Guckert & King, 2006). Among the pre-requisites for the establishment and implementation of an effective LCC practice are discussed below.

2.5.4.1 LCC Process

Churcher and Tse (2016), in the revised BSRIA (Building Services Research and Information Association) standard for Life Cycle Costing (BG67/2016), present a more summarized step-by-step approach for conducting life cycle costing for capital projects.

The 5-step approach include Defining the Problem, Developing the models, Calculations, Conducting Sensitivity Analysis and interpreting results.

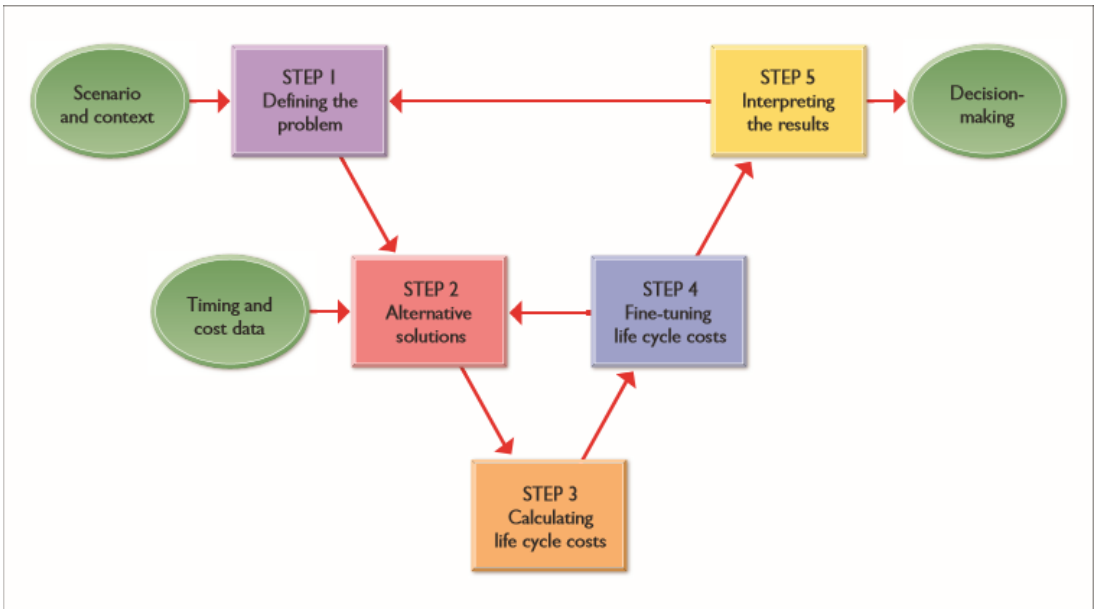

Fig 2.4 Step-by-step process for life cycle costing *(Source: Churcher & Tse, 2016)*

2.5.4.1 LCC Standards

2.5.4.1.1 ISO 15686-5:2008

The ISO (International Organization for Standardization) is a global federation of standards bodies from ISO member bodies. The ISO 15686-5 was developed by the Technical Committee (ISO/TC 59). ISO 15686 is on "Buildings and constructed assets-Service-life planning" which comes in ten (10) parts with part 5 focusing on "Life-cycle costing". Part 5 of the standard focuses on defining terminologies of life cycle costing, principles, forms of calculations, how LCC forms part of whole life costing and how to conduct reports and analysis for LCC.

After the release of the ISO 15686, the British Standards Institution (BSI) published a "Standardized Method of Life Cycle Costing for Construction Procurement" as an abridged supplement for practice of the technique in the UK construction industry. It was also meant to develop a standard cost structure in the UK that aligns the ISO data

with the more appreciated BCIS (Building Cost Information Service) standard form of cost analysis (ISO, 2008; Green, 2009).

The second supplementary guide to the ISO 15686-5, first published in March 2016, is the BS 8544 which provides a focus and standardized methodology conducting life cycle costing analysis for maintenance costs to ensure a more established cost management of capital projects. BS 8544 seeks to make a distinction between renewal and maintain costs (under maintenance costs) as detailed in the BSRIA BG67/2016. It also provides guidelines and recommendations on planning, optimisation, budgeting, implementation and monitoring of established life cycle programmes for renew and/or maintain works (Churcher & Tse, 2016). These abridged standards demonstrate the commitment of the UK construction industry towards ensuring ease of implementation of the technique.

2.5.4.1.2 BSRIA BG 67/2016

The BSRIA, founded in 1955 is a UK-based non-profit distributing, member-based association that is into tests, instruments, research and consultancy, providing specialist services in construction and building services. The BG67/2016 on Life Cycle Costing supersedes the previous version of BG5/2008 on Whole Life Costing. This new standard presents a simple process for practical computation of life cycle costs with sample calculations showing how the different stages are interrelated to enable users make reasonable deductions from results (Churcher & Tse, 2016).

2.5.4.1 Data

Due to the importance of projected costs which form a key component of the LCC analysis, various authors have recommended Net Present Value (NPV) as the most suitable approach for implementing LCC in the construction industry. The NPV

method discounts projected future costs to ensure equity in comparison of financial options (Cole & Sterner, 2000). The NPV model from the ASTM (American Society for Testing Materials) is shown below (Rum & Akasah, 2012);

$$\mathrm{NPV} = \mathrm{C} + \mathrm{R} - \mathrm{S} + \mathrm{A} + \mathrm{M} + \mathrm{E}$$

Where,

C= initial/investment costs (also known as first costs)

R= replacement costs

S= the resale value expected at the end of the project life

A= annually recurring operating, maintenance and repair cost (excluding energy costs)

M= non-annually recurring operating, maintenance and repair costs (excluding energy costs)

E= energy costs

Peculiar about this model from the others is how energy costs are separated from the other running costs. This is because recent global trends have shown an increase in consumption for Heating, Ventilation and Air Conditioning (HVAC), thus the need to pay attention to the effects of decisions related to HVAC in buildings.

Due to the laborious computations involved in LCC analysis, using computer-aided LCC software provide relatively simple and rapid results for quicker and more accurate decision-making (Alexander, 1987). They are more flexible for review of estimates for building statistics, tenancy-lease schedules, revenue and expenditure, maintenance staff wages and the like (Hutcheson, 1993).

2.5.4.1 Personnel

The dire need for professional well skilled and equipped in the implementation of LCC cannot be overemphasised (Higham et al., 2015). Universities for example must have technical committees that define and set directions for policies relating to infrastructure. Reports on reviews of manuals, standards and newer modes of achieving value for money should be submitted regularly to the central management board for consideration and more informed decision-making. Training of professionals in the application of LCC is primary to the achievement of its numerous benefits documented (University of Edinburgh, 2010).

2.5.5 LCC PRACTICES

Generally, there is an incoherent opinion among project managers about what LCC involves and its impact on construction processes. This influences the practices of LCC among different kinds of managers (Ludvig et al., 2010). Irrespective of the phase of the project, LCC can be estimated for the building by assessing the overall cost of the building either under construction or already in service (Rum & Akasah, 2012).

2.5.5.1 Pre-Building Phase

LCC enables effective identification of initial costs, future maintenance costs and key factors contributing to the cost of the building at the design stage to enable the determination of a more accurate forecast of the total cost (Rum & Akasah, 2012). A decision has to be taken early in the project's life on whether it will be long term or otherwise. This must be taken with sound consideration of funding availability and or budgetary allocation for the purpose. In this phase, the application of integrated life cycle design enables the allocation of costs to sections and elements in the structure to ensure an adequate cost budgeting (Office of Financial Management, 2008). Maintenance issues need to be considered for incorporation in decision-making at the

design stage (Williamson et al., 2010). As the design advances, a detailed LCC analysis can be done by inputting actual manufacturers' cost of inputs and the life expectancy data for each (Willmott Dixon, 2010).

2.5.5.2 Building Phase

Majority of the LCC decisions and practices are operationalized at the Pre-Building and Post-Building Phases. However, the application of sustainable construction at the Building Phase ensures that the continuous process of reducing the whole life cycle cost of the building is achieved.

2.5.5.3 Post-Building Phase

Maintenance comprises any activity or measures that cover the technical and management tasks undertaken to preserve, maintain or recover something to its original condition. During the operational phase of the facility, periodic assessments must be carried out on the severity of repairs required. These assessments will aid in classifying the repairs into either routine maintenance (from maintenance manuals) or renovation of buildings that are in poor condition but still have reasonable remaining life to ensure continuous used of the facility (Office of Financial Management, 2008).

Works under maintenance can be classified under six (6) subheadings; Maintenance of the main facility, Maintenance of the Fittings/Fixtures/Finishing, Maintenance of the external works, Maintenance of the Mechanical, Plumbing and Electrical Services, Adaptation and Modernization, and Redecorations (Flanagan & Jewell, 2005).

At this phase, one of the most burdening decisions faced by owners and facilities managers regarding maintenance is the determination and monitoring of the timings of diverse types of maintenance issues (Rum & Akasah, 2012).

The figure below summarizes the stages of life cycle costing practices for capital projects as presented in the BS ISO 15686-5:2008.

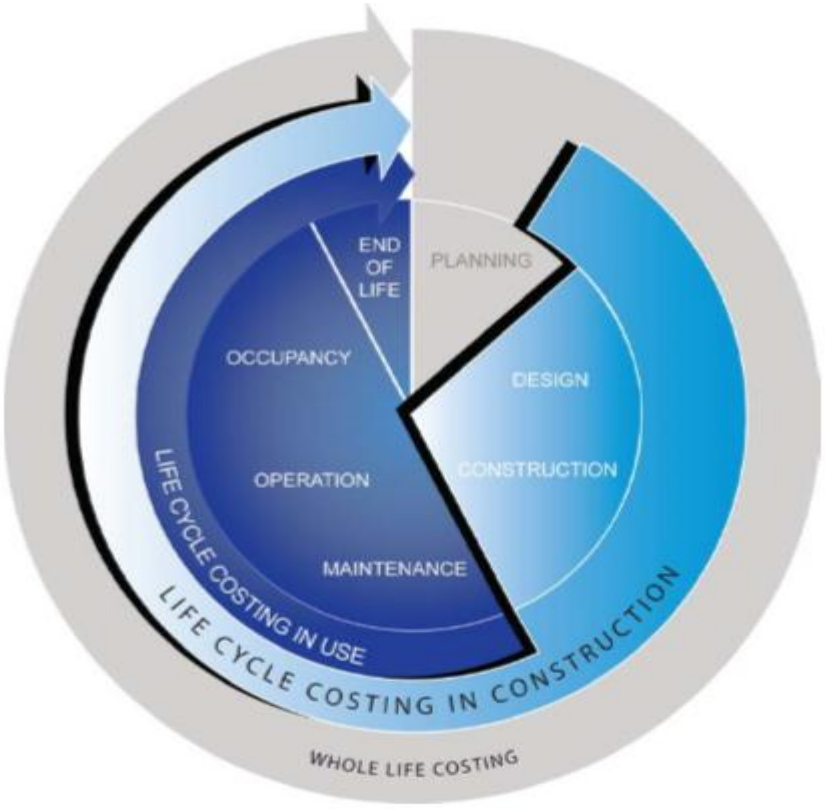

Fig. 2.5 Stages of LCC and WLC *(Source: ISO, 2008)*

2.5.6 LCC PRACTICES IN EDUCATIONAL INSTITUTIONS

A network of processes, practices and structured phases are used in the management of projects in educational institutions. Irrespective of the different sources of funding within an institution for various projects, LCC must be applied to assess the whole life value of the project (Rum & Akasah, 2012). Notable practices in some of these institutions have been discussed below.

In the University of California, the 10 year (2012-2022) Capital Financial Plan requires the budget for each project to cover its entire useful life. This is implemented by covering the incremental operational costs, maintenance and renewal costs in the

facility in the initial budget. It is also makes it mandatory for each project to contribute to the general campus utility and road infrastructure which might be outside the direct scope of the project by adding a 4 percent fee of the construction cost to cover for these necessaries. It is also the long-term goal of the university to establish a defined capital renewal plan for each of their major assets, starting with recently constructed buildings towards the old facilities (University of California, 2012).

In the University of Edinburgh, there is the existence of an effectively running Estate Committee that regulates planning, development and control of infrastructural projects. Its policy document, the 10 year Estate Strategy (2010-2020), provides indicative maintenance imperatives aimed at tracking and controlling capital projects over the period. The strategy includes major maintenance and operational costs to the construction costs whilst considering funding sources. A closer look at the Estate Strategy reveals a couple of vital features that makes it easy for life cycle decisions to be taken. Some of these include the assessment of economic situations, investments made by government (for central government-funded projects), sustainability and social responsibility, technology, the level of regulatory burden on the project as well as the strategic target indicators (University of Edinburgh, 2010).

It is highly recommended that educational institutions develop and maintain institutional maintenance manuals. Also, broad consultative decision-making must be arrived at to set baselines for design and construction standards for the institution. It is however important that these standards are not based on sentimental preferences but on sound LCC principles. Since technology is not static, these standards should be periodically revised on pre-determined dates. Technical departments involved in cost-related decisions must be conscious of the LCC that the institution is willing to pay for to streamline decisions taken (Guckert & King, 2006).

2.5.7 BENEFITS OF USING LCC

It is a general assertion that the use of LCC in formulating the price of a project at the early stage enables stakeholders to make better financial decisions in terms of the long-term design life of a proposed project. Through the assessment of whole life cost undertaken, the design team can offer more informed cost-related advice to client and other stakeholders at the early stage (Higham et al., 2015).

LCC estimation enables the client to ascertain and budget for future cost-in-use of a project (Kirk & Dell'Isola, 2003), including cost planning, budgeting, tendering and cost reconciliation (Kelly & Hunter, 2009). For clients who intend to have a long-term use of their asset, the use of LCC analysis helps to promote this cause by ensuring that the design team considers the long-term benefits of all design and specification choices they make in the early stage of the project (Opoku, 2013).

In the age of sustainable buildings, conducting an LCC exercise goes a long way to enhance its sustainability credentials. Mostly in developed countries, owners of facilities use the consideration of environmental and economically sustainable options to their competitive advantage (Kelly & Hunter, 2009). The usability of the LCC tool has however been questioned due to its overemphasis on cost analysis at the expense of qualitative decisions that cannot be priced. Recommendation is however made for the joint use of the tool with others to ensure a wholesome sustainability analysis (Haapio & Viitaniemi, 2008).

2.5.8 BARRIERS TO THE APPLICATION OF LCC

Though benefits of using the tool has been well documented in research works, a couple of factors have led to its low utilization in the construction industry across the

globe. A review of literature exposed the under-discussed factors as substantial barriers to the effective implementation of LCC tool in the management of projects.

2.5.8.1 Bureaucratic structures in public institutions

As the whole LCC process involves a broader level of consultation, teamwork and correspondence, Cole & Sterner (2000) identified the bureaucratic structures of public sector institutions as a key inhibiting factor to the successful implementation and use of LCC. However, the overriding desire for revenue-generating projects influences choices to be made at the early stage when clients consider payback periods as against long-term sustainability of design decisions taken (Higham et al., 2015).

2.5.8.2 Insufficient expertise of practitioners

Another major reason that limits the effective application of LCC involve the inadequate awareness, understanding and expertise in the use of the technique among clients and practitioners. In order to streamline the use and application of the tool in practice, it is recommended that an abridged standardised method of its application be developed for use by practitioners (Higham et al., 2015; Olubodun et al., 2010).

2.5.8.3 Difficulty in assessing reliable data

The magnitude of the difficulty associated with assessing reliable data for forecasted estimates, on which LCC is based, cannot be overemphasised. This leads to over-reliance on assumptions resulting in the inaccuracy of the LCC estimates which affects the decision-making based on long-term forecasts (Higham et al., 2015; Cole & Sterner, 2000; Clift & Bourke, 1999).

2.5.8.4 Difficulty in satisfying multiple stakeholder needs

For the design team and facilities managers, there is the glaring challenge of providing substantial satisfaction for different institutional stakeholders whose needs mostly vary. Thus, built environment professionals most often than not have to deal with the herculean task of effectively balancing the needs of all stakeholders and still achieve optimality in the functionality of the facility (Guckert & King, 2006).

2.5.8.5 Fragmented nature of the project team

Though the tool has gradually gained acceptance in the construction industry, the fragmented nature of construction team members has been identified as a notable inhibitor to the implementation of LCC. In most public settings where the various project teams are contracted separately, effective coordination of works mostly come short of the expected standards to ensure that project decisions on life cycle costs are shared across board (Bull, 1993).

A review of literature further revealed that apart from very few advanced countries where public-funded projects are keen on the use of LCC, majority of its users are private clients. This is because of the division of most public funds separately for capital projects budgets and ongoing revenue/expenditure budgets (Cole & Sterner, 2000) leading to the difficulty in preventing clients' budgets from focusing mainly on short-term expenditures (Higham et al., 2015). This issue is even made worse when the design team has to do with a tight budget or underfunding, making it difficult to balance life cycle costs as against cheaper initial cost options (Guckert & King, 2006).

2.6 SUMMARY

A review of sampled literature has revealed that substantial work has been done on documenting the benefits of practising Life Cycle Costing (LCC) for capital projects. In spite of this, majority of building owners and managers globally are either not aware or not implementing LCC. With the handful of the practitioners of LCC, access to reliable data poses a high risk to the accuracy of deductions based on which long term decisions are made whilst clients (especially public institutions) rarely budget for the life cycle of projects with focus more on the initial capital expenditure (acquisition costs).

With more practitioners becoming aware of LCC as an early stage project evaluation technique, Ghanaian Public Universities undertaking a lot of expansive infrastructural works can adopt the standards, principles and practices of LCC to ensure true value for money for their projects. There is a lot more to learn from both public and private universities in the USA and UK on their adaptation to the use of LCC for their capital projects and management of existing infrastructure.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the approach by which this study was undertaken. It details the method chosen for selecting the sample size, sources of data used and how information was collected from these sources. It also describes how questionnaires were designed, distributed and how information gathered were analysed and presented for discussions and deductions.

3.2 REVIEW OF METHODOLOGY

The research methodology is a systematic way to solve the research problem. Aside knowing the methods to be used, the researcher needs to understand the logic behind the methods, how the problem has been defined, the formulation of the hypothesis, type of data to be collected and method of collection, the chosen technique for analysing data and its presentation (Kothari, 2004).

3.2.1 RESEARCH METHOD

Research methods generally are the tools adopted to collect data for a study (Kothari, 2004). For the purpose of this research, both Quantitative and Qualitative Approaches have been adopted. Amongst the methods used, structured questionnaires were used to collect both quantitative and qualitative data for this study. This was followed up with interviews to gather qualitative data for further analysis and drawing of conclusions.

Quantitative research comprises collecting quantitative data from precise measurements using organized, reliable and validated data mechanisms. Nature of data gathered is in variable formats and their analysis involve establishment of statistical relationships

(Gaur & Gaur, 2006). Qualitative data on the other hand involves gathering data that are based on the subjective assessments of the opinions of participants to the study. Results generated from this kind of data are either in non-quantitative forms or in other formats that are not usually subjected to rigorous quantitative analysis (Kothari, 2004).

3.2.2 RESEARCH STRATEGY

A strategy is an action plan designed to accomplish a specific goal. Among the available strategies are Surveys, Case Studies, Experiments, Phenomenology, Ethnography, Grounded Theory, Action Research and Mixed Methods (Denscombe, 2010).

A case study approach was adopted for this research. A questionnaire survey was used to gather data for the purpose of this study. As has been done in previous studies that have researched into the construction industry practice, a questionnaire survey has been recommended as the most appropriate data collection tool for this type of study (Fellows & Liu, 2008; Creswell, 2003). This was followed up with one-on-one unstructured interviews to gather in-depth information on responses received from the survey. As described in the study scope in Chapter One of this study, the University of Education, Winneba (UEW) was selected from the list of Ghanaian Public Universities (GPUs). According to Denscombe (2010), a case should not be selected randomly but based on certain known attributes. Thus, with GPUs currently moving towards building multi-campuses to serve various courses and communities, the UEW was selected as the Case Study due to its well-managed multi-campus system which has survived over 20 years of its existence. An in-depth study of LCC practices in the UEW has been conducted to assist in drawing valid conclusions and generic recommendations for application to other intitutions.

3.3 RESEARCH POPULATION AND SAMPLE SIZE

3.3.1 RESEARCH POPULATION

Since the use of the Life Cycle Costing (LCC) tool for capital projects is mainly practiced by built environment professionals, the study population was made up of technical staff related to projects from acquisition, through construction to management and disposal. This comprised of university staff from the Works and Physical Development Office, Procurement Unit as well as the Estate Department from the four campuses. It was also made up of staff from outsourced agency consultants whose services have been used for construction consultancy projects for the UEW within the last ten years (2006-2016) of the study date. The population was not definite due to the difficulty in gathering exactly the number of practitioners working in relation to projects with the UEW especially with the staff of all the outsourced consultants within the specified period.

3.3.2 SAMPLE SIZE DETERMINATION

Accurate findings for a study cannot only be derived from data collected from each and every member of the study population. It is based on this principle that sampling is adopted by researchers to derive a sub-group from the population for purposes of a study (Denscombe, 2010). Though representative of the population, the sample size must not be extremely large, nor too small but optimum (Kothari, 2004).

The Purposive Non-Probability Sampling technique was used in the selection of respondents for the study. Due to the aim of this study, it was deemed to be more effective if the sample was limited to respondents that influence decision making from the various categories. This could only be achieved by choosing only technical staff and excluding administrative staff from within the respective categories.

A total of 60 respondents were 'hand-picked' from both the in-house and outsourced agency consultants. This comprised of all technical staff from the three departments (Development, Estate and Procurement) from each of the four campuses (Winneba, Ajumako, Kumasi and Asante-Mampong), making a total of 38 respondents. Out of the 11 identified consultants having worked with the UEW over the focus period, two professionals were selected each, making 22 more. The total of 60 respondents obtained satisfied the central limit theorem of 30, and was deemed acceptable for the purposes of analysis for the study.

3.4 DATA COLLECTION

3.4.1 SOURCE OF DATA

It has been found that data at hand is often not sufficient for dealing with any real life problem, thus, the need to collect appropriate data for a research study. Both primary and secondary sources of data have been employed in this study. Primary data sources are those collected directly from the subjects of study either through experiments or surveys and are original in nature (Kothari, 2004), whilst commonly used secondary data sources include journals, organisational reports, periodicals, books, etc. (Gaur & Gaur, 2006). Primary data for this study was restricted to questionnaire surveys and interviews whilst secondary data sources included official reports from organisations and institutions, published books, conference proceedings, technical reports and journal articles.

3.4.2 METHOD OF DATA COLLECTION

Social researchers make use of four main methods: questionnaires, observation, interviews and documents for sourcing data. Other methods include Focus Group Interviews, Delphi Techniques and Experimentation (Denscombe, 2010). This research focused on the use of both questionnaires and interviews in the collection of data for the basis of analysis. To

achieve this, sampled respondents were reached with structured questionnaires to collect first-hand data for analysis. This was followed up with one-on-one interviews of up to five senior technical staff in the UEW. Both nominal and ordinal quantitative data were gathered and analysed for the study through close-ended questions. Qualitative data was also collected through the inclusion of one open-ended question in the structured questionnaire, of which respondents formulated their own responses. The interview involved an unstructured discussion separately with each of the interviewees and matters raised were written down for grouping and further analysis.

3.5 DESIGN AND DEVELOPMENT OF QUESTIONNAIRES

3.5.1 DESIGN OF QUESTIONNAIRES

Questionnaires are designed to primarily collect information that can be used as data for analysis. It consists of series of questions asking respondents to directly provide information requested in line with the objectives of the study (Denscombe, 2010; Kothari, 2004). The use of a structured questionnaire reduces misinterpretations in the nature of data expected and responses received from those surveyed (Walker, 2007).

Questionnaires may comprise of either open-ended questions (where respondents formulate their own responses) or closed-ended questions (where limited number of options are provided for respondents to choose from) or a mixture of both types (Jackson, 2010). The questionnaire for this study was developed using insights obtained from the review of literature on the subject. It comprised of a series of close- ended questions to allow respondents to either select from a list of options or provide ratings on questions based on defined scales (using Likert rating scale). To assist in effectively assessing the first objective

of the research, one open-ended question was included to allow for respondents to express their understanding of the LCC tool by defining the term in their own words.

3.5.2 DISTRIBUTION OF QUESTIONNAIRES

Questionnaires were both self-administered and through volunteered correspondents in the various campuses. Some questionnaires were delivered and collected in person and assistance provided for respondents in answering them whilst others were sent by delivery to correspondents to administer to sampled practitioners.

3.6 INTERVIEWS

The use of interviews involve oral/verbal stimuli questions aimed at gathering data from oral/verbal responses. Interviews are very flexible and can be structured, semi-structured or unstructured. Interviews are administered either one-on-one or in a group, preferably, not exceeding 6 participants and the process is recorded by writing down major points, video-taping or audio-recording the entire session (Denscombe, 2010; Fellows & Liu, 2008; Creswell, 2003).

For the study, since in-depth information and clarification was being sought on pre-determined responses from the questionnaire survey, the follow-up interviews were restricted to five senior technical staff from the three main categories of Consultants (Development Office), Procurement Officer and Estate Officer. They comprised of one Senior Estate Officer, one Procurement Officer and three senior officers from the Development Office- one Engineer, one Quantity Surveyor and one Architect.

One-on-one personal interviews were conducted, adopting the unstructured approach, where few broad questions were asked concerning the existing practices and barriers encountered.

Issues relating to how best practices can be implemented were also discussed and matters arising from the interactions were written down for further assessment and discussion in chapter four of the study.

3.7 DATA ANALYSIS AND RESULTS PRESENTATION

Analysis of quantitative data involves a combination of related operations such as categorization of findings, coding of data, tabulation and drawing of statistical inferences (Kothari, 2004). Quantitative data gathered from the questionnaires were statistically analysed using mean scores after the Statistical Package for Social Science (SPSS) had grouped them in proportions and frequencies. Ordinal data collated were ranked using relative importance index (RII) for discussion whilst nominal data were grouped in frequencies and percentages and presented in charts, graphs and tables for discussion.

Qualitative data obtained from the open-ended question was analysed by deductive thematic analysis and coding of responses to be able to statistically populate the frequencies of common themes which were then presented in tables and graphs for discussion of the findings.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents a discussion of responses received from questionnaires distributed to sampled respondents. Mean score averages and thematic analysis were used to analyse the results, presented and discussed in frequencies, percentages, charts, graphs and relative importance index (RII). A total of 60 questionnaires were distributed and 42 of them were received representing a response rate of 81%. After going through the returned questionnaires, two (2) were rejected due to incompleteness and inconsistencies in the responses provided, thus deemed as non-responsive for further analysis and discussion. A total of 40 responses were therefore considered for further analysis. It is based on this number that all discussions for the study have been made in this chapter.

4.2 PRESENTATION OF DATA

The questionnaire was organised into five (5) sections. The first section sought to gather demographic data from the respondents by finding out their respective professions, years of experience, association with professional institutions and years played in their chosen roles with the specified client organisation. Based on the first objective of the study, the second section focused on assessing the level of knowledge of the LCC tool by sampling the extent of their knowledge of the tool and how they came across it, awareness of standard documents and their opinion on the initiating department for LCC.

In meeting the second objective of the study, the third section of the questionnaire was on documenting existing LCC practices used on projects in the UEW. After practices had been

documented from reviewed literature, this section aimed at identifying which of the standard practices are applied on projects in UEW. The fourth section of the questionnaire, meeting the third objective, was targeted at identifying factors that inhibit the application of LCC on capital projects in the UEW. Respondents were to indicate on a likert scale, the extent of the challenge each factor posed to the implementation and use of LCC. The final section of the questionnaire sought to gather views from respondents as to feasible approaches to ensure the effective implementation of the LCC tool in Ghanaian Public Universities.

4.3 DEMOGRAPHIC DATA OF RESPONDENTS

4.3.1 PROFESSION OF RESPONDENTS

Table 4.1 Profession of Respondents

Profession	Frequency	Percent
Architect	2	5.00
Engineer	12	30.00
Quantity Surveyor	5	12.50
Project Manager	3	7.50
Estate Officer	5	12.50
Procurement Officer	13	32.50
Total	**40**	**100.00**

Source: Field Survey, 2016

From the demographics of the respondents for the study, the majority of them comprised of Procurement Officers and Engineers, representing 32.5% and 30% respectively of the total respondents for the data analysis. 5 of the respondents representing 12.5% were Quantity Surveyors and Estate Officers respectively with 3 Project Managers and 2 Architects also participating in the study.

4.3.2 YEARS OF EXPERIENCE

Figure 4.1 below illustrates the years of experience that the respondents possess in their specified professions. The graph shows that majority of the respondents (42.5%) have less than 5 years of experience in their fields with 5% of them having more than 20 years of experience in their field. The second most populated experience group was between 6 and 10 years (27.5%) and the third being between 11 and 15 years (17.5%).

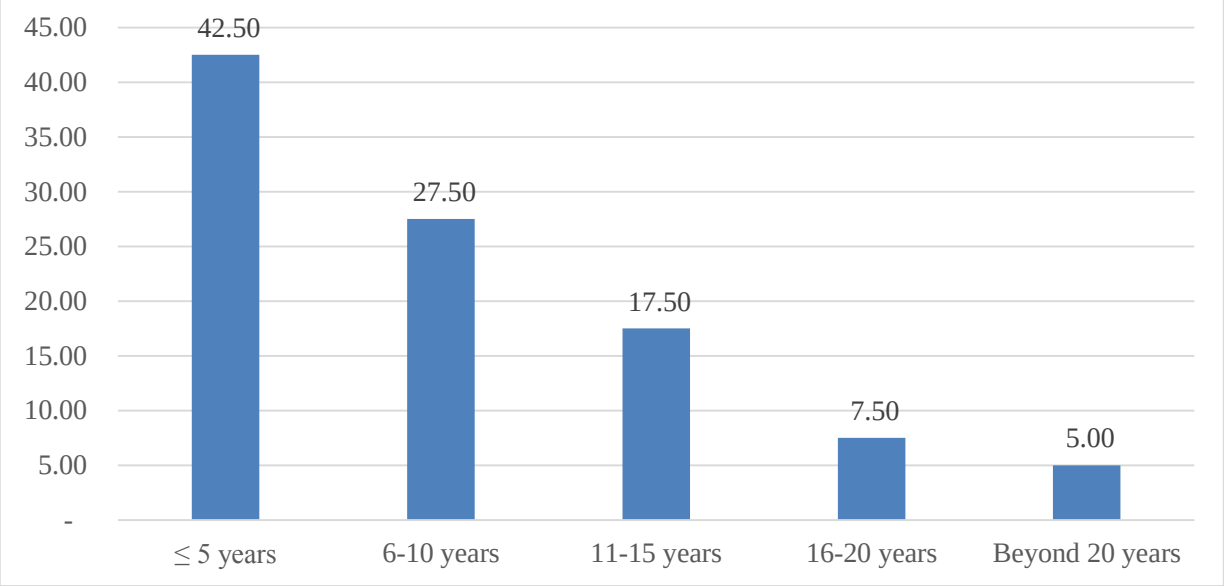

Fig. 4.1 Years of Experience in the Profession *(Source: Field Survey, 2016)*

4.3.3 ASSOCIATION WITH PROFESSIONAL BODY

The study further sought to find out how many of the respondents belonged to a recognised professional body in their area of practice. From Table 4.2 below, 19 out of the 40 respondents belonged to professional bodies with 21of them not belonging to professional bodies.

Table 4.2 Association with Professional body

Profession	Frequency	Percent
Yes	19	47.50
No	21	52.50
Total	**40**	**100.00**

Source: Field Survey, 2016

Out of the 19 respondents that belonged to professional bodies, four (4) each, representing 21.05% belonged to the Ghana Institution of Surveyors (GhIS) and Institute of Engineering and Technology (IET) as shown in Figure 4.2 below. The rest were distributed across the Ghana Institution of Architects (GIA), Ghana Institution of Engineers (GhIE), Chartered Institute of Purchasing and Supply (CIPS), Ghana Institute of Construction (GIOC) and the Association of Chartered Accountants (ACA).

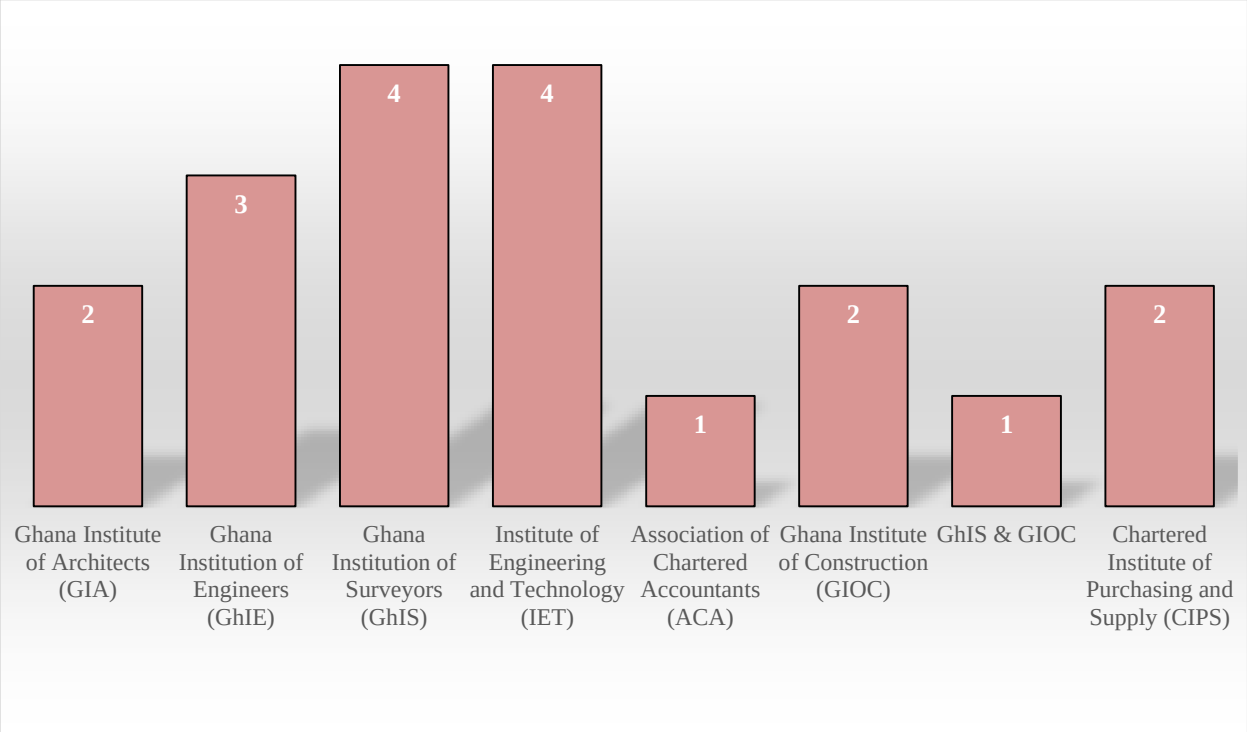

Fig. 4.2 Association with Professional body *(Source: Field Survey, 2016)*

4.3.4 ROLE PLAYED IN THE BUILT ENVIRONMENT

From Fig. 4.3 below, the bulk of the respondents, being 21 out of the 40 respondents (i.e. 52.5%) were from the consultants' category (both in-house and outsourced consultants). 32.5% of the respondents were from the Procurement section whilst 15% were in the Estate/Facilities Management category of the built environment.

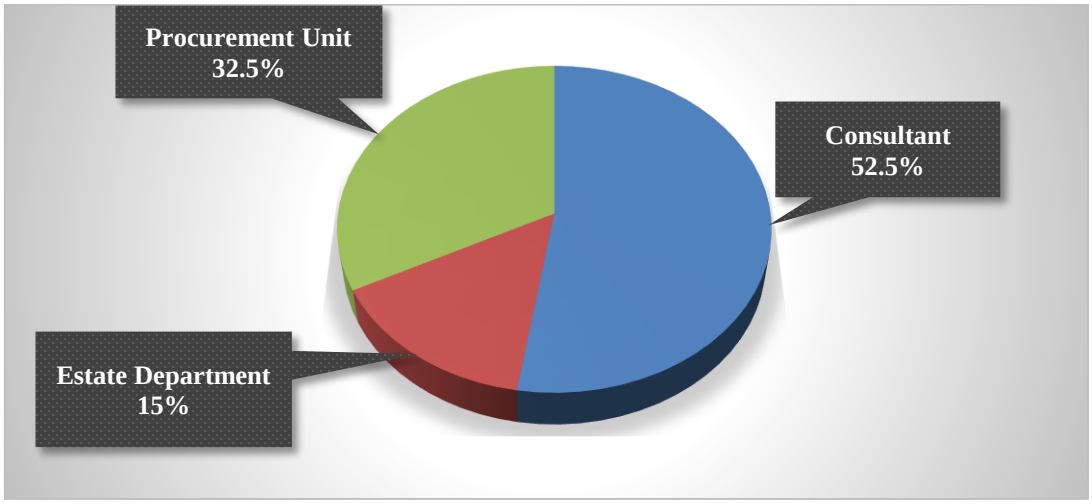

Fig. 4.3 Role played in Built Environment *(Source: Field Survey, 2016)*

Out of these sampled respondents, majority of them (i.e. 50%) had worked less than 5 years with the University of Education, Winneba (UEW) in the specified categories of the built environment above. This is followed distantly by 27.5% and 17.5% respectively for 6-10 years and 11-15 years. This is illustrated in Fig. 4.4 below.

Compared to Fig. 4.1 above, the pattern of experience shows that though the proportions of those with experience between 6 and 15 years remained constant, years worked with UEW under 5 years had increased at the expense of experiences 16 years and above. Thus, though 12.5% of the respondents had experience of 16 years and above, only 2.5% had spent similar years of experience working with the UEW.

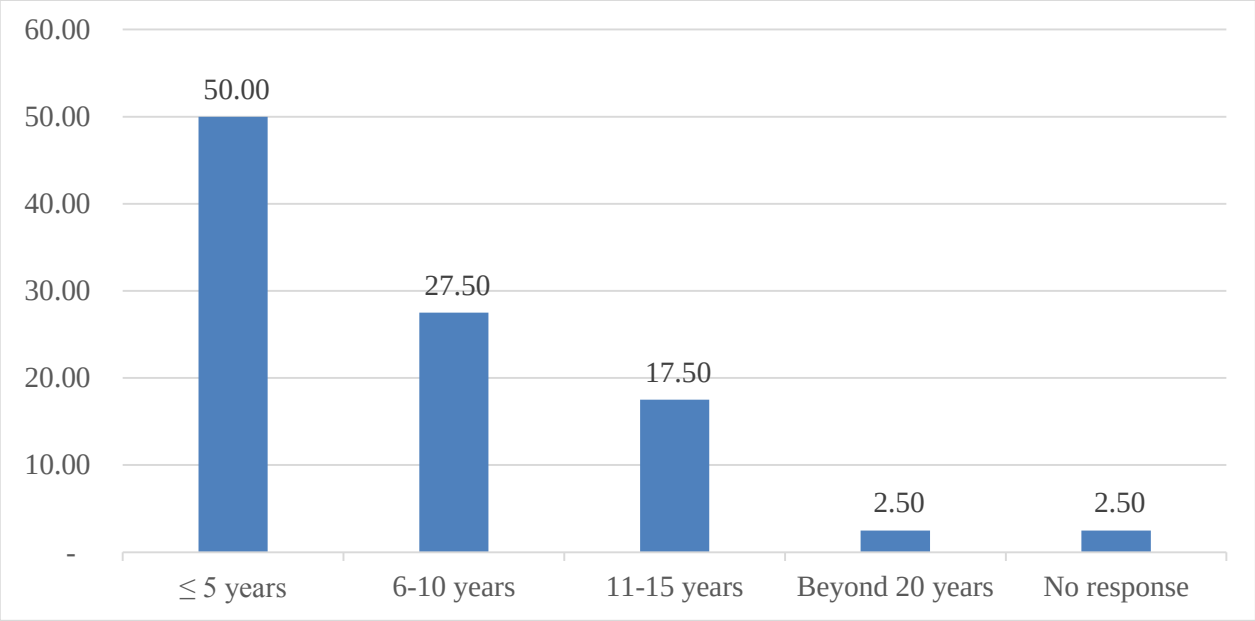

Fig. 4.4 Years worked with the UEW *(Source: Field Survey, 2016)*

4.4 LEVEL OF UNDERSTANDING OF THE LCC TOOL

The first objective of the study was to identify the level of understanding of respondents of the LCC tool. To achieve this, respondents answered by indicating their level of awareness of the tool including how they came across the term and to define it in their own words. Their knowledge of the LCC standard developed by ISO was also inquired, including how often they practiced it and their opinions of who was to initiate the use of LCC.

4.4.1 LEVEL OF AWARENESS OF LCC

As the first step to determining respondents' level of understanding of the tool, majority of them, representing 52.5% had heard briefly about the terminology. 37.5% of the respondents indicated that they were substantially knowledgeable about the term whilst 10% (being 4 out of the 40 respondents) stated that they were not familiar with the term. None of the respondents were experienced in the application of the term.

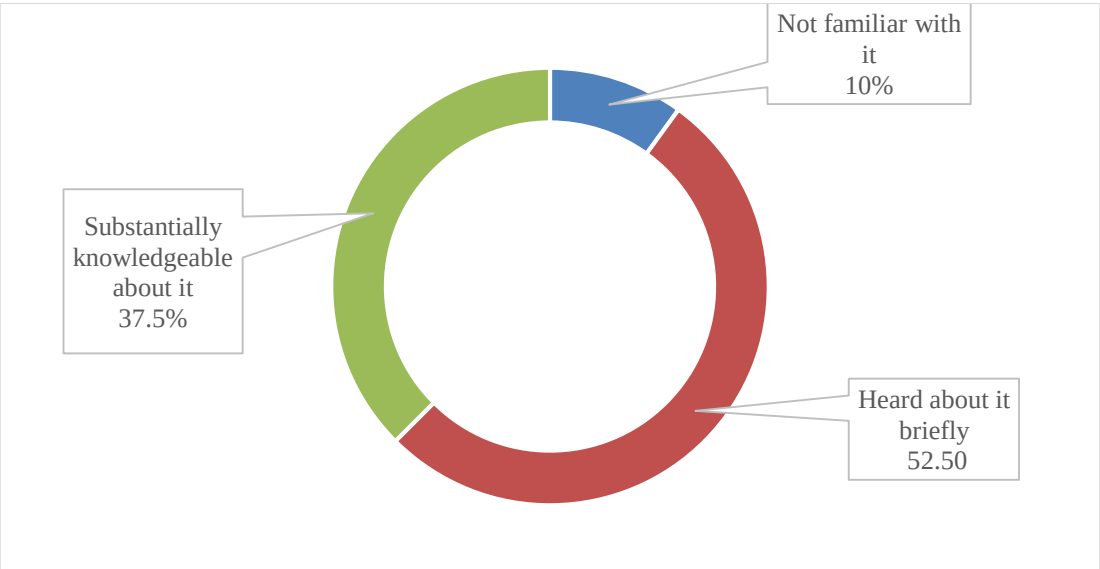

Fig. 4.5 Level of Awareness of LCC *(Source: Field Survey, 2016)*

Since only 36 out of the 40 respondents had indicated being familiar with the term, further analysis on how they came across the term involved a sample frequency of 36 for the analysis and discussion. The responses are illustrated in Table 4.3 below.

Table 4.3 How Respondents came across the LCC term

Medium	Frequency	Percent
In school (academic programme)	14	38.9%
At a CPD (seminars, conferences, training, etc.	5	13.9%
Read about it in a journal/magazine	3	8.3%
Learnt about it at work (practice, on-the-job training, etc.)	8	22.2%
CPD and at work	2	5.6%
School and CPD	2	5.6%
School and at work	2	5.6%
Total	**36**	**100.0%**

Source: Field Survey, 2016

From the table, 14 of the 36 respondents under consideration, being 38.9%, indicated having encountered the LCC term in an academic programme. 8 more of the respondents (i.e. 22.2%)

came across the term at work by practice, on-the-job training, industrial attachment, etc. Meanwhile, 13.9% and 8.3% came across it at a Continuous Professional Development program and by reading a technical/academic journal/magazine respectively.

4.4.2 DEFINITION OF LCC

Respondents were asked to define life cycle costing in their own words. Out of the 40 valid respondents received, 29 (72.5%) of them attempted a definition whilst 11 (27.5%) respondents gave no answer to it as shown in Table 4.4 below. From the 29 attempts, however, 2 were rejected due to remoteness of the definitions given as compared to findings obtained from literature reviewed (2.5.2 of this study).

Table 4.4 Definition of LCC

Status	Frequency	Percent	Cumulative Percent
Accepted Definition	27	67.50%	67.50%
Rejected Definition	2	5.00%	72.50%
No Response	11	27.50%	100.00%
Total	**40**	**100.00%**	

Source: Field Survey, 2016

The remaining 27 answers (67.5%) were analysed qualitatively by summarizing themes from the responses obtained. Using Microsoft Excel (2013), information from definitions were entered into the spreadsheet. In the first stage of the analysis the key words of each respondent's definition were entered separately on each row adjoining the respondent's identification number.

After entering the data, the next stage comprised of summarizing the various key words into major themes. Five major themes were deduced from the responses. They included all costs

incurred over the lifespan of a project; acquisition costs (made up of planning, design and procurement costs); construction cost; operational and maintenance costs; and disposal costs. The themes were then assigned distinct codes, which were matched with the survey responses entered.

The third stage of the analysis involved the statistical frequency count of how often respondents had mentioned any of the coded themes, using the COUNTIF function. Proportions of these frequencies were formulated and represented graphically as shown in Fig. 4.6 below.

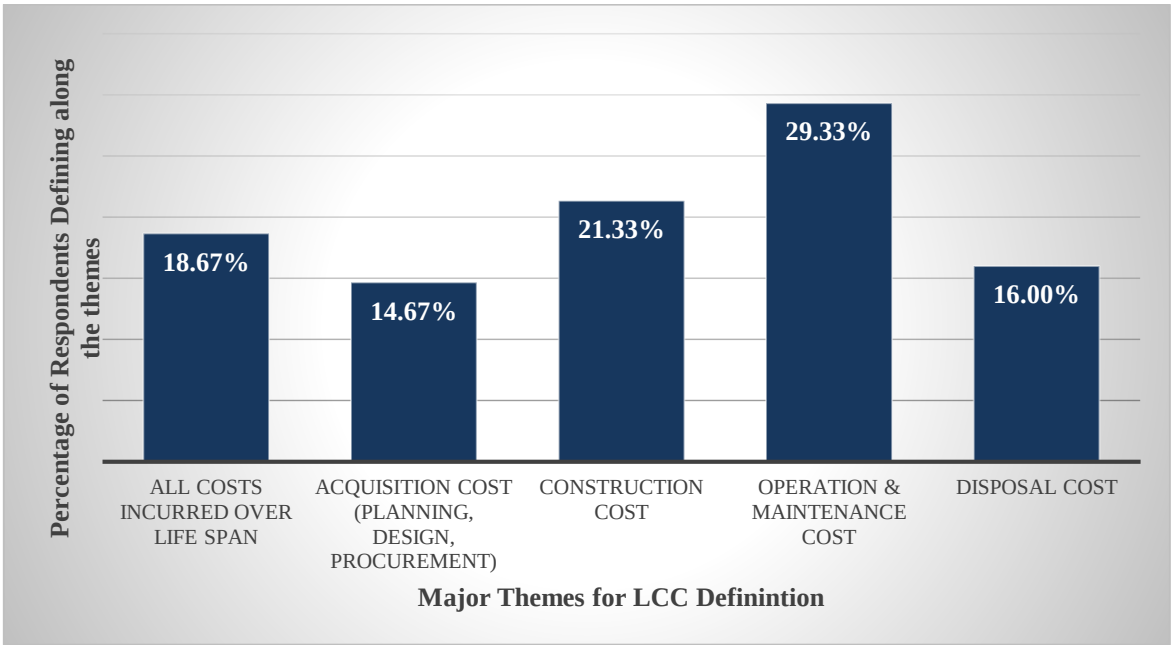

Fig. 4.6 Definition of LCC *(Source: Field Survey, 2016)*

The figure above shows that majority of the respondents, being 29.33%, defined LCC along the lines of operation and maintenance cost. Some respondents went further to express these costs in terms of annually recurring and non-recurring costs, confirming their appreciation of operational costs as a vital component of any LCC analysis. The next major theme was that of construction cost, obtaining 21.33%, followed by overall lifespan costs (18.67%). Disposal

costs appeared in 16% of respondents' definitions with Acquisition costs being the least mentioned in the analysed definitions.

It is worth noting that none of the respondents mentioned the consideration of energy costs in their definitions. Although most sources of literature reviewed considered energy costs under running/operating costs, it is noteworthy to state here that the American Society for Testing Materials (ASTM)'s mathematical LCC model separated energy costs from both recurring and non-recurring costs (Rum & Akasah, 2012).

4.4.3 AWARENESS OF BS ISO 15686-5:2008

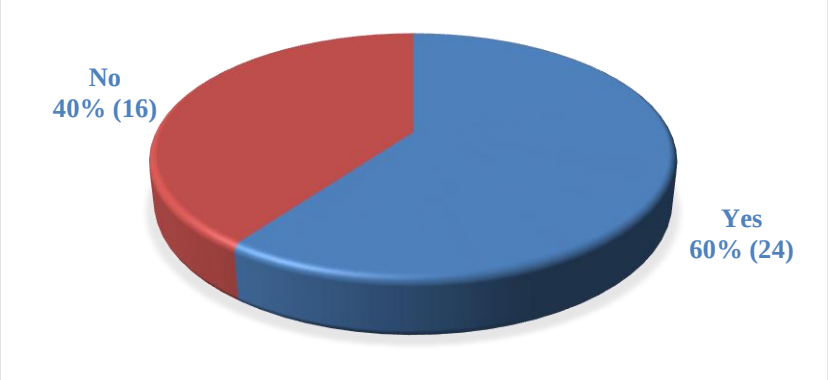

Fig. 4.7 Awareness of BS ISO 15686-5:2008 *(Source: Field Survey, 2016)*

In assessing the knowledge of respondents of the tool, the study sought to find out how many of the respondents were aware of the existence of the ISO (International Organisation for Standards) standard framework for LCC. From Fig. 4.7 above, 24 out of the 40 respondents (i.e. 60%) indicated that they were aware of the standard with the corresponding 40% having no knowledge of the standard. In spite of the majority of the respondents having knowledge of the standard, 10 out of the 24, representing a majority of 41.7% do not apply the standard at all in their practice as shown in Fig.4.8 below. 29.3% rarely applied it whilst 16.7% and 12.5% applied it sometimes and often respectively.

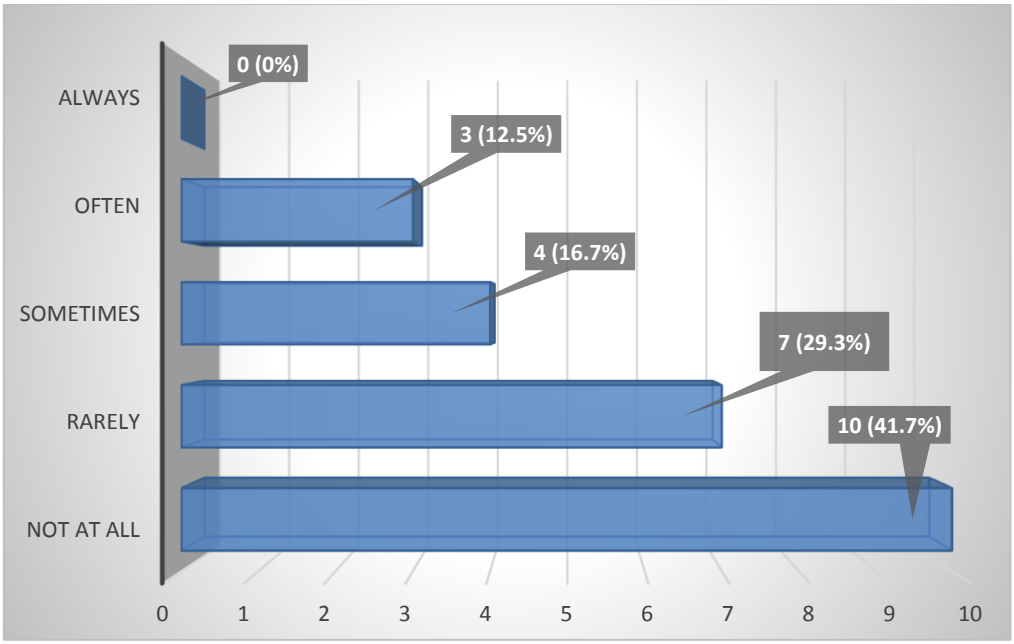

Fig. 4.8 Application of BS ISO 15686-5:2008 *(Source: Field Survey, 2016)*

4.4.4 RESPONSIBILITY FOR INITIATING LCC

Respondents were asked to choose which stakeholder in the built environment should be responsible for initiating the use of LCC in Ghanaian Public Universities (GPUs). In the view of respondents, the Contractor is not expected to bear this responsibility as illustrated below Fig.4.9).

From the responses illustrated, 47.5% clearly feel that the Development Office bears the utmost responsibility to initiate the use of LCC for projects in GPUs. This was followed by 30% choosing the Client as responsible for initiating the practice. In similar studies conducted in the UK construction industry, however, respondents felt this responsibility was the preserve of the Client followed by the cost advisors (Higham et al., 2015). This difference is however accommodated, bearing the fact that the Development Office in the study scope is technically part of the client organisation.

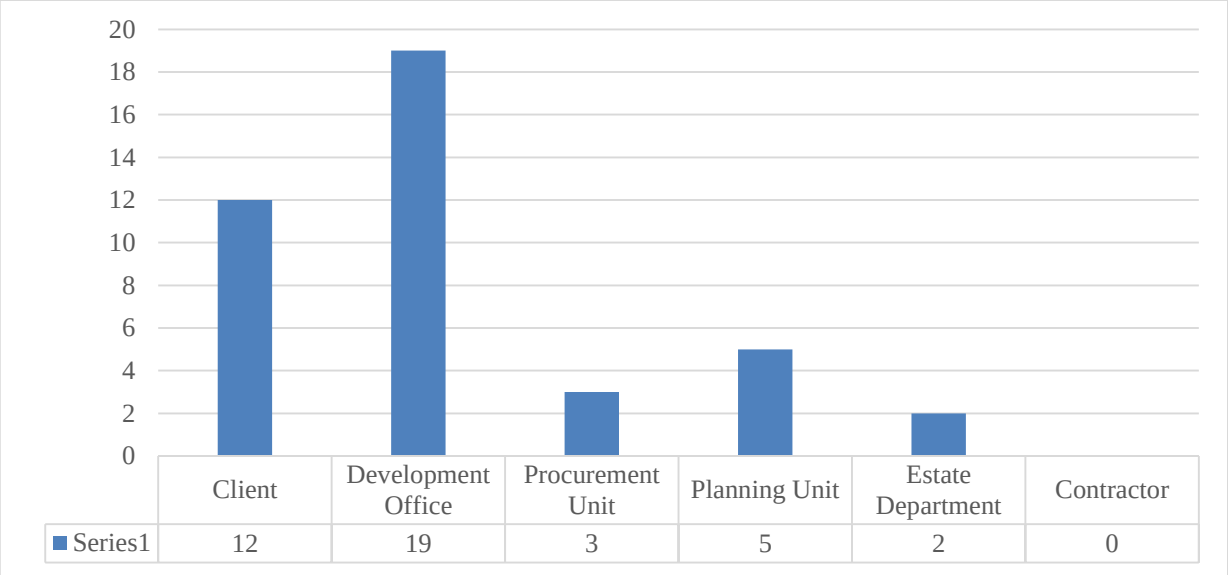

Fig. 4.9 Responsibility for initiating LCC *(Source: Field Survey, 2016)*

4.5 DOCUMENTING EXISTING LCC PRACTICES EMPLOYED

Survey respondents were again asked to select practices that are applied on projects executed at the UEW. A likert scale was used to allow respondents to rank how often they applied the identified practices. After data for this question was summarized with descriptive statistics produced by a SPSS (Statistical Package for Social Sciences) output, the relative importance index was used to rank the frequently applied practices of LCC. The responses were ranked on a scale of 1 being not at all and 5 being always used. The formula for the computation is defined as;

Relative importance Index (RII) = $\sum W/AN$

where, A= the highest rank (i.e. 5 for this study)

N= the total number of the sample

W= weightings for each response

The analysis is summarized and presented in Table 4.5 below.

Table 4.5 Existing LCC Practices Used

PARAMETERS LCC PRACTICES EMPLOYED	TOTAL NUMBER OF SAMPLE	∑ W	MEAN	RELATIVE IMPORTANCE INDEX (RII)	RII (%)	RANK
Involvement of Maintenance personnel at early stage of projects	40	125	3.13	0.63	62.50	1st
Conducting Sensitivity and Risk analysis for projects	40	114	2.85	0.57	57.00	2nd
Availability and use of institutional design standards	40	104	2.60	0.52	52.00	3rd
Availability and use of institutional operations and maintenance manual	40	97	2.43	0.49	48.50	4th
Periodic reviews of standards and manuals	40	89	2.23	0.45	44.50	5th
Budgeting for operational and maintenance costs	40	75	1.88	0.38	37.50	6th
Use of discounting methods for cost forecast decisions	40	70	1.75	0.35	35.00	7th

Source: Field Survey, 2016

The analysis in the table above show that among the practices documented, the most practiced is the involvement of Estate/Maintenance personnel at the design stage. However, with the highest mean score of 3.13, it suggests that it is only practiced sometimes. The study also ranked conducting Sensitivity/Risk analyses for projects as the second practice employed. This was followed by the three related practices with relative importance indices of 52 %, 48.5% and 44.5%, occupying the 3rd, 4th and 5th ranks respectively. These are the availability and use of institutional design standards, maintenance manuals and periodic reviews of these standards and manuals respectively. The two least practiced involved budgeting for operational costs of

projects and use of discounted methods for cost forecasts at the 6th and 7th positions with mean scores of less than 2.00 suggesting them to be rarely practiced.

Given the survey results illustrated and discussed above, it was resolved to conduct a follow-up interview to gain some in-depth information on the responses gathered about LCC practices employed. To ensure effective probing, five senior technical staff from the three main categories of Consultants, Procurement Officers and Estate Officers were interviewed. This methodology has effectively been used by Higham et al. (2015) in their study on evaluating the use of LCC in UK to derive in-depth knowledge of practices. The interviewees comprised of one Senior Estate Officer (Int.1), one Procurement Coordinator (Int.2) and three senior staff- one Engineer (Int.3), one Quantity Surveyor (Int.4), and one Architect (Int.5) each- from the Development Office. They were each asked concerning the practices identified and indicated by the respondents and their views have been discussed along the lines of the rankings from the mean scores computed.

For the first ranked practice, all five interviewees confirmed that a representative from the Estate/Maintenance Department is usually involved in deliberations before designs are finalized. Some of the vital imports received from them for the design process relate to location of the development, environmental effects of decisions, future layout and developments plans for the university, maintenance concerns on various building materials, designs and specifications. Int.1, however expressed concerns with the level of involvement as being insufficient which is confirmed from the importance index of 62.5%, though being the highest rank.

On the practice of sensitivity and risk analyses, Int.3, 4 and 5 indicated that they were somewhat done qualitatively. They explained that the analyses were mostly done using team brainstorming methods for assessing the risks associated with particular designs, specifications, contractual clauses, etc. Sensitivity of these decisions are also assessed considering probable stakeholder responses to proposed soft and hard components of the project. Thus the use of quantitative methods for these analyses are rarely done on projects, yet required results could be derived for decision making. The interviewees admitted that use of mathematical methods will improve the accuracy of decisions made from this practice.

The next three practices for design standards, maintenance manuals and their periodic reviews were interrogated. For the design standards, Int.3 and 5 explained that there were no documented design standards, however, designs approved have always been subject to previously agreed trends, sizes, specifications, etc. for both new construction works and renovations. Though no current initiative has been made to officially document these agreed standards for future use, all the interviewees agreed to the need to get this document for the institution to avoid double standards and the difficulty in satisfying contradictory institutional stakeholders' needs. Comments from Int.1, 3 and 5 indicated that there were also no formally documented maintenance manual though certain practices had become accepted over time and used as the rule of thumb, deemed as standards adhered to for maintenance works. Information however was obtained on the initiative already taken to document these standards and practices into a manual for similar reasons explained earlier.

With budgeting for operational and maintenance (O&M) costs, interviewees indicated that this was rarely done at all for projects in their actual meanings. This is confirmed from the survey response of 77.5% of the respondents who indicated the practice as not being done at all or

rarely applied. The opinion shared by Int.2 concerning the other 22.5% who responded to the practice being done sometimes was that, their actual intended meaning could be for the annual budgeting and procurement plans drawn annually which covered costs of new construction, maintenance/renovation costs and particular services/goods to supplement operational activities. To this, Int.4 reiterated that the client shows very little interest in any of such projections and any such projections have been made only for the consumption of consultants' future analysis.

Finally, interviewees shared their views on the use of discounting methods for cost forecast decisions. Similar proportions (to budgeting for O&M costs) responded to this with a majority of 47.5% indicating the practice as not used at all. Interviewees 3, 4 & 5 indicated that though future costs were often anticipated and planned for, discounting methods were rarely used for the analysis of these forecasts. Same response was confirmed from Int.2 for goods and services procured.

4.6 BARRIERS TO THE APPLICATION OF LCC

To satisfy the fourth objective of the study which was to identify barriers to the use of LCC practices, respondents were asked to assess, on a likert scale, inhibiting factors sampled from reviewed literature. Responses obtained were collated and mean score averages were computed to assist in ranking them in order of severity of the challenge. Using a likert scale of 1 to 5 with 1 being not challenging and 5 representing very challenging, Table 4.6 below illustrates the results analysed.

Table 4.6 Barriers to the application of LCC

PARAMETERS BARRIERS TO THE USE OF LCC	TOTAL NUMBER OF SAMPLE	∑ W	MEAN	RELATIVE IMPORTANCE INDEX (RII)	RII (%)	RANK
Bureaucratic structures in administrative procedures	40	167	4.18	0.84	83.50	1st
Poor maintenance culture	40	160	4.00	0.80	80.00	2nd
Unreliable data (overreliance on assumptions)	40	156	3.90	0.78	78.00	3rd
Unavailability of standardized approach/LCC policy	40	154	3.85	0.77	77.00	4th
Insufficient expertise of professionals on LCC	40	149	3.73	0.75	74.50	5th
Restrictions to use of more sustainable options	40	149	3.73	0.75	74.50	5th
Challenge with satisfying multiple stakeholder needs	40	148	3.70	0.74	74.00	7th
Effects of inflation on forecasted figures	40	147	3.68	0.74	73.50	8th
Low Interest of Client	40	141	3.53	0.71	70.50	9th
Reluctance to commit to change in management policy and strategy	40	139	3.48	0.70	69.50	10th
Restrictions from the PPA	40	138	3.45	0.69	69.00	11th
Short-term budgeting of Client	40	135	3.38	0.68	67.50	12th
Insufficient demonstration of interest by project team	40	123	3.08	0.62	61.50	13th
Insufficient awareness of the benefits of its use	40	123	3.08	0.62	61.50	13th
Ineffective comm. among project team members	40	126	3.07	0.61	61.46	15th
Fragmented Nature of the project team	40	119	2.98	0.60	59.50	16th
Cost of exercise	40	115	2.88	0.58	57.50	17th
Length of required payback period for commercial facilities	40	105	2.63	0.53	52.50	18th

Source: Field Survey, 2016

From the table above, the bureaucratic structures of the client are seen as the most inhibiting factor to the implementation and use of LCC practices, having a mean score of 4.18. With this factor, Int.4 and 5 had this to say; that certain long-route procedural approval lines make certain decisions not reap their timely purpose. This concern was reiterated by Int.1, adding that this procedural approval routes become even more 'congested' when the request has to deal with making certain long-term decisions that deviate from the status quo which hitherto had not been perceived to be cost ineffective.

The second most challenging factor was the poor maintenance culture that entangles the Ghanaian maintenance system. Int.1 tied this factor to the unavailability of documented maintenance manuals that sets defined timelines and triggers for maintenance works to be undertaken for projects. This view was shared by Int.3 and 5, and added that the vagueness of maintenance plans poses enormous restrictions on how best to design facilities with the glaring restrictions to use of more expensive but sustainable options (which came as the 5th rank).

Furthermore, access to reliable data for cost forecasts was ranked as the 3rd most challenging factor with an importance index of 78%. This confirms findings in literature as being one of the major limiting factors globally to the use of LCC (Higham et al, 2015; Rum & Akasah, 2012; Cole & Sterner, 2010; Olubodun et al., 2010). The 4th most challenging factor (with RII of 77%) was the unavailability of an abridged LCC policy or standard for the local market to assist practitioners. A solution to this factor is also the 4th most possible implementation measure recommended by respondents as shown in Table 4.7 below. This initiative has been taken by the UK construction industry with the 1st and 2nd supplements to the ISO standard. The ASTM has also produced a similar document for the American industry and same could be done in the sub region.

The study also confirmed previous studies concerning the insufficient expertise of practitioners of the LCC tool (reviewed in 2.5.8.2) as already established in section 4.4 of this chapter. This factor was ranked the 5th most challenging barrier to using LCC with a mean score of 3.73. The need for training of professionals through continuous professional development courses is emphasised in section 4.7 of this chapter. The challenge posed by the difficulty in satisfying the needs multiple institutional stakeholders makes the life cycle management of projects a mountain to climb. This worry was deeply shared by interviewees as differing needs of stakeholders become difficult to balance with the most effective life cycle cost in focus.

It is worth mentioning that certain perceived restrictions to the use of LCC were not shared by the sampled respondents. The study discovered that the restrictions from the use of the Public Procurement Act (PPA) was not enough to strongly limit the application of LCC (ranked 11th with mean score of 3.45). Similarly, its use is limited not mainly because of the insufficient awareness of the benefits of its use (ranked 13th most challenging factor), as opposed to similar studies where about 42.86% of respondents ranked this as the second most limiting factor to the use of the tool (Higham et al., 2015). Respondents also believed that the cost of implementing LCC is not enough a barrier to its implementation and use, scoring a mean of only 2.88 at the 17th rank.

4.7 MEASURES TO IMPLEMENT LCC IN GHANAIAN PUBLIC UNIVERSITIES

Finally, the study sought to sample recommendations for the effective implementation and use of LCC in Ghanaian Public Universities (GPUs). Various implementation measures were provided for respondents to choose from using a likert scale of 1-5 with 1 representing not possible measures and 5 for very possible measures. Mean scores were computed for each of

the factors and relative importance indices extracted from their averages to rank them in the order of most possible measures for implementing LCC in GPUs as illustrated in Table 4.7 below.

From the table, developing an institutional design standard in a manual was deemed the first and most possible measure to implementing LCC for GPUs. This result is affirmed by interviewees' comments (discussed in 4.5 of this chapter) on the need to properly document the agreed design standards already being practiced whilst unifying them with various design and construction codes widely accepted by industry to avoid the attempt to 're-invent the wheel'. With majority of practitioners (62.5%) with only brief or no knowledge of the tool at all (refer Fig. 4.5), the secondly ranked most probable measure was for built environment professionals to attend Continuous Professional Development (CPD) programmes to enrich their knowledge and use of this early stage evaluation tool.

Respondents also believed that GPUs should conduct value-for-money assessments for projects before their commissioning, having scored a mean of 4.15. The study also recommends for public university clients to embrace more innovative procurement methods. This is closely linked to the reason why most respondents (52.5%) believed the Public Procurement Act was an inhibiting factor to the use of the tool, though being the 11^{th} ranked inhibiting factor. Int.2 however pointed out that since it is a statutory requirement of public sector organizations to use the Public Procurement Act, this should be done subject to approval from relevant authorities.

With most respondents agreeing that the unavailability of a localised LCC standard is one of the most challenging reasons why it is not widely applied in practice, it has also been recommended as the fourth most probable approach to implementing LCC in GPUs. Joint

efforts by built environment professional institutions can work towards producing an abridged LCC standard or policy for use by practitioners in Ghana. As efforts have already began on developing an institutional maintenance manual for use in UEW, respondents also recommended the need for its documentation across GPUs.

Table 4.7 Measures to Implement LCC in GPUs

PARAMETERS MEASURES FOR IMPLEMENTING LCC	TOTAL NUMBER OF SAMPLE	∑ W	MEAN	RELATIVE IMPORTANCE INDEX (RII)	RII (%)	RANK
Develop an institutional design Standard manual	40	170	4.25	0.85	85.00	1st
Professionals should attend CPDs	40	169	4.23	0.85	84.50	2nd
Value for money assessments	40	166	4.15	0.83	83.00	3rd
Professional Institutions to develop LCC standards	40	165	4.13	0.83	82.50	4th
Embrace innovative procurement methods	40	164	4.10	0.82	82.00	5th
Develop institutional maintenance manuals	40	164	4.10	0.82	82.00	5th
Incorporation of LCC analysis in consultancy requirements	40	163	4.08	0.82	81.50	7th
Mounting of facilities management programs	40	158	3.95	0.79	79.00	8th
Periodic reviews of design & maintenance manuals	40	156	3.90	0.78	78.00	9th
Clients must enforce on LCC implementation	40	156	3.90	0.78	78.00	9th
Hire personnel with expertise in LCC	40	152	3.80	0.76	76.00	11th
Use Professional LCC software for analysis	40	149	3.73	0.75	74.50	12th
Stretch budgets to cover LCC	40	139	3.48	0.70	69.50	13th

Source: Field Survey, 2016

With an importance index of 81.5% (7th rank), the study recommends the incorporation of LCC analysis by Clients as part of requirements for selection of Consultants in submission of tenders. In supplementing the recommendation of practitioners attending CPDs on the subject area, the study recommends that academic modules on life cycle costing and facilities management should be mounted for the various built environment related programmes in tertiary institutions across board. With this well instituted, the analysis of data obtained does not place premium on the need to hire a personnel with expertise in the use of LCC mainly for capital projects. This is demonstrated by its rank of 11th out of the 13 measures analysed. This recommendation was strengthened by the views of Int.1 and 4 that support and training of staff was enough given the level awareness of practitioners, making it cost ineffective to employ an individual as against training majority of professionals to ensure widespread benefits of their application of the knowledge gained.

4.8 CONCLUSION

The chapter has meticulously analysed and discussed all data gathered from the survey and presented in simple and reader-friendly formats for appreciation of the findings of this study. The discussion of the results also touched on all the areas of the research objectives to ensure that the aim of this study is addressed adequately.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This research study was conducted to explore practices of life cycle costing (LCC) practices in Ghanaian Public Universities (GPUs) by documenting pre-requisites for LCC, level of knowledge of the tool and existing practices in GPUs as well as identifying factors that inhibit the practice of the tool. The study also sought to recommend measures for the successful implementation of the tool in GPUs. Various literature materials sourced from journals, books, conference proceedings, reports and technical papers were reviewed to throw more light on the study subject and to aid in documenting the pre-requisites for effective practice of the tool. The review of literature also covered related areas such as university education in Ghana, capital projects in the built environment, the concept of sustainability and sustainable development.

Structured questionnaires were sent to practitioners in the built environment who handle projects related to the study scope of the University of Education, Winneba (UEW). Sampled respondents were made up technical staff from the Procurement Unit, Estate Department and Development Office as well as from outsourced agency consultants. The questionnaires were structured into five major sections with respondents requested to choose from options provided, their demographic data and general knowledge on the subject of LCC. Respondents were required to rank on a likert scale, questions from the other sections to enable documenting existing practices employed, barriers to the application of the LCC tool and measures to ensure the effective implementation of the tool in GPUs. 41 responses were analysed and statistically analysed for discussions which

have been detailed in Chapter Four (4) of this study. One-on-one follow up interviews were also conducted to seek in-depth information on responses gathered from the survey.

5.2 CONCLUSIONS TO THE RESEARCH

5.2.1 RESEARCH OBJECTIVE ONE

The first objective of the study was *to document the level of knowledge of the LCC tool by practitioners*. Information on this objective was gathered by testing the knowledge of respondents on the tool. They were in the first instance asked to indicate their level of knowledge of the tool and how they came across it. They were then to define the term in their own words and then to state their awareness of the International Organization of Standardization (ISO)'s document on LCC and how often they applied it. They were finally to indicate in their respective views, whose responsibility it was to initiate the use of LCC in GPUs.

The research found out that majority of practitioners have brief knowledge of the tool. Only few of the respondents were not familiar with the term at all and none of the respondents were experienced in the use of the evaluation tool. With the fraction of the respondents who had heard about the tool, majority of them had learnt it in an academic programme or encountered it in the course of their work, through training and/or practice.

From the bulk of those who knew of the tool, they were asked to define the term in their own words. 65.85% of respondents submitted acceptable definitions which were analysed by drawing themes out of them. Analysis showed that most of them understood the importance of Operation and Maintenance (O&M) costs in addition to construction costs to

life cycle analysis. The concept of 'all costs accrued over a project's lifespan' was also understood yet with few touching on the inclusion of disposal costs.

The survey also indicated that majority of practitioners were aware of the ISO standard on life cycle costing (BS ISO 15686-5:2008) though an exceptional majority of them had rarely or not applied it at all in their practice. In recommending an initiating department in GPUs for the implementation of the tool, the study recommended the Development Office to take the initiative of pushing for the use of the tool. This could begin with inclusion of the practice in their design and management of projects as well as requesting the analysis to be conducted by outsourced Consultants whenever their services are procured.

5.2.2 RESEARCH OBJECTIVE TWO

The second objective of the study was *to document existing LCC practices employed in GPUs*. Review of literature exposed some of these practices which were presented for respondents to rank them in order of the frequency of their use. This was followed by in-depth interview of five senior professionals in the areas of Procurement, Maintenance, Engineering, Architecture and Quantity Surveying to substantiate the actual details of the practices adopted and their mode of application of each at the UEW.

The study identified that the most practiced among the list was the involvement of maintenance personnel at the early stage of projects, followed by conducting sensitivity and risk analyses for projects. The sensitivity analyses, though not often conducted, was found to be done more of the qualitative way than the more recommended and accurate mathematical methods. Next to this, it was discovered that design and maintenance were done in accordance on already agreed standards, principles and ideologies, though not

documented. The follow up interviews revealed that plans are underway to document an institutional maintenance manual, though same cannot be said of design manuals. Budgeting for O&M costs as well as use of discounting methods for cost forecasts were found to be rarely practiced. However, interviewees indicated that forecasts were often done though not discounted. O&M costs were only included in budget plans when drawing annual budgets and procurement plans and not the conventional requirement of budgeting as part of the original development costs.

5.2.4 RESEARCH OBJECTIVE THREE

The third study objective was *to identify barriers to the application of LCC practices*. A list of identified barriers were sampled from reviewed and a few others from the researcher's intuition were added. Respondents who participated in the study were to choose and rank on a likert scale, indicating the level of severity of the identified challenge. Mean scores were computed for each of the factors and ranked by relatively ascribing importance indices to them.

Major among the barriers was the bureaucratic administrative procedures encountered in seeking approval for various decisions and recommendations that have a bearing on life cycle planning. Poor maintenance culture was also identified as a very challenging inhibiting factor which affects fluidity of decisions of a life cycle nature when there is the need to fulfil a maintenance requirement in order to validate an earlier decision taken.

The difficulty in assessing reliable data for forecasting decisions has over the years led to overreliance on assumptions which makes life cycle decisions short of accurate. The study confirmed this as being a very challenging factor to the practice of LCC in GPUs. The

unavailability of an abridged standardized approach for LCC in the built environment, coupled with the insufficient expertise of professionals on the tool also substantially limits the ability to effectively implement and adopt LCC practices.

Other notable barriers identified included the restrictions to using more sustainable options, created by tight budgets allocated by Clients; the challenge with satisfying multiple institutional stakeholders' needs, holding them in a balance whilst achieving the best value for money; the effects of inflation on forecasted figures among others. The survey also identified that though implementing an effective LCC system may require some capital, the cost of the exercise was not a major limiting factor to the employment of LCC.

5.2.3 RESEARCH OBJECTIVE FOUR

The fourth and final objective of the study was *to determine the pre-requisites for effective LCC practices*. This was to be obtained from literature reviewed and supplemented with recommended measures from responses gathered.

From the review of literature, it was discovered that an effective LCC system must be institution-focused and not customer-based by adhering to certain established standards. The BSRIA (Building Services Research and Information Association) has presented a summarized 5-step approach to managing an effective LCC process. The steps as given in the BG67/2016 (Fig.2.4) involve defining the problem, developing the LCC models, collecting data and subsequent calculations, conducting sensitivity/risk analyses and interpreting results obtained.

The review also identified the need for documented LCC standards. The ISO standard, BS ISO 15686-5:2008 on Life-cycle costing documents reliable follow-through approaches for practicing LCC. With the UK construction industry having the first and second abridged supplements to the code, and the BSRIA 67/2016, it pre-supposes that professionals in a particular industry can develop an abridged version of the ISO standard to reflect the needs of the country.

Another pre-requisite discovered was the need to collect, store and analyse reliable data using the appropriate discounting methods to enable equity in investment comparisons for decision making. Various mathematical equations have been developed for calculating the life cycle cost of a project among which the ASTM's method has been accepted as very comprehensive for LCC analysis (Rum & Akasah, 2012). The final pre-requisite discovered was with the availability of competent professionals with adequate expertise in the application of LCC principles and practices.

In addition to these pre-requisites identified, survey respondents were given the opportunity to recommend best measures for the successful implementation of the tool in GPUs. Major among the recommendations made were the development of an institutional design standard manual; undertaking value for money assessments for proposed project functions (H.M. Treasury, 2003); the need for professionals in the built environment to attend relevant CPDs; Clients' readiness to embrace more innovative and cost-maximising procurement methods and processes; professional bodies in the built environment coming together to develop an abridged LCC standard for the local market; the development and periodic reviews of institutional maintenance manuals among other recommendations.

5.3 LIMITATIONS TO THE RESEARCH

This research had a couple of limitations in its execution. Among these was the rather limited scope to a single university among the numerous public universities in Ghana. There was also difficulty in getting sampled respondents to take time off their busy schedules to respond to the questionnaires as well as participate in the limited follow-up interviews conducted.

5.4 RECOMMENDATIONS

From the findings of the research, it is highly recommended that for a start, GPUs should have well documented design and maintenance standard manuals each with predetermined review periods. Institutions should also be ready to support staff from the built environment to equip themselves in the knowledge, practice and effective implementation of LCC. As part of the identified pre-requisites, Professional Institutions like the Ghana Institution of Architects (GIA), Ghana Institution of Engineers (GhIE), Ghana Institution of Surveyors (GhIS), Institute of Engineering and Technology (IET), Ghana Institute of Construction (GIOC) and all other recognised built environment related institutions in Ghana should team up with the Ghana Standards Board to develop a localised abridged supplement to the ISO standard for LCC.

Reviews must be conducted by the developers of educational curricula for built environment courses in the various tertiary institutions to include modules that expose students to the tool and its practice. In addition to all these measures, however, it is imperative that built environment professionals make efforts to open up to more sustainable practices available by subjecting themselves to wilful training, and exploring the global reservoir of knowledge on best practices.

With life cycle costing becoming a more recognised practice due to the global promotion of sustainability in all aspects, there are a lot of prospects for researchers to explore. It is foremost recommended that the study is conducted considering a wider scope of all public universities in Ghana on one hand and all Ghanaian universities on the other hand. 'The perception of Life Cycle Costing practices in the Ghanaian Construction Industry' can be researched on as well as a study on 'The Perception of Built Environment Professionals on the use of Life Cycle Costing' within the Ghanaian Construction Industry.

5.5 IMPACT OF THE STUDY

The information gathered, reviewed and analysed by the study will serve as a reference material to propagate the need for the commencement of conscious practices of life cycle costing in Ghanaian Public Universities. It will also serve as a starting point for other researchers to conduct further studies on the subject area in Ghana.

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APPENDIX

(SURVEY QUESTIONNAIRES)

SECTION A: DEMOGRAPHIC DATA

1. What is your profession?

   [ ] Architect [ ] Project Manager
   [ ] Engineer [ ] Estate Officer
   [ ] Quantity Surveyor [ ] Procurement Officer
   [ ] Other (please specify) ……

2. How many years' experience do you have in this area?

   [ ] ≤ 5 years [ ] 16 – 20 years
   [ ] 6 – 10 years [ ] Beyond 20 years
   [ ] 11 – 15 years

3. Do you belong to any professional body in your area of competence?
   [ ] Yes [ ] No

4. Indicate which professional institution(s) you belong to.
   [ ] Ghana Institute of Architects (GIA)
   [ ] Ghana Institution of Engineers (GhIE)
   [ ] Ghana Institution of Surveyor (GhIS)
   [ ] Institute of Engineering and Technology (IET)
   [ ] Association of Chartered Accountants (ACA)
   [ ] Project Management Institute (PMI)
   [ ] Ghana Institute of Construction (GIOC)
   [ ] Chartered Institute of Purchasing and Supply (CIPS)
   [ ] Other (please specify) ……

5. What role in the built environment do you play?
   [ ] Consultant [ ] Procurement Unit
   [ ] Estate Department

6. How many years have you worked with the University of Education, Winneba (UEW) in the above role?

   [ ] ≤ 5 years [ ] 16 – 20 years
   [ ] 6 – 10 years [ ] Beyond 20 years
   [ ] 11 – 15 years

SECTION B: GENERAL KNOWLEDGE ON LIFE CYCLE COSTING (LCC)

7. Indicate your level of awareness of the LCC tool

   [ ] Not familiar with it
   [ ] Heard about it briefly
   [ ] Substantially knowledgeable about it
   [ ] Experienced in its application

8. If you are familiar with the term, indicate how you came across it

   [ ] in school (academic programme)
   [ ] at a Continuous Professional Development (seminars, conferences, training, etc.)
   [ ] read about it in a journal/magazine
   [ ] learnt about it at work (practice, on-the-job training, etc.)
   [ ] Other (please specify) ……..

9. In your own words how will you define Life Cycle Costing?

   ……

   ……

   ……

   ……

10. Are you aware of the British Standard BS-ISO 15686-5:2008 on Life Cycle Planning?

    [ ] Yes [ ] No

11. If YES, how often do you apply the Standard in your practice?

    [ ] Not at all [ ] Rarely [ ] Sometimes [ ] Often [ ] Always

12. In your view, whose responsibility is it to initiate the use of LCC analysis as an early stage project evaluation tool? (choose only one)

    [ ] Client [ ] Planning Unit
    [ ] Development Office [ ] Estate Department
    [ ] Procurement Unit [ ] Contractor
    [ ] Other (please specify) ……

SECTION C: DOCUMENTING EXISTING LCC PRACTICES EMPLOYED

13. Select practices of the LCC evaluation tool that have been applied on projects at the UEW. Please rank using the scale of

    1= Not at all 2= Rarely 3= Sometimes 4= Often 5= Always

CODE	LCC PRACTICES IN USE	SCORE				
		1	2	3	4	5
1	Availability of use of an existing institutional design standard					
2	Availability and use of an operations and maintenance manual					
3	Periodic reviews of standards and manuals					
4	Budgeting for operational and maintenance costs of projects					

5	Use of discounting methods for cost forecast decisions					
6	Involvement of Maintenance personnel at early stage of project					
7	Conducting sensitivity and risk analyses for projects					
	Other (s), please specify and rank					
8						
9						
10						

SECTION D: BARRIERS TO THE USE OF LIFE CYCLE COSTING PRACTICES

14. Select the factors with the potential to inhibit more frequent and effective use of LCC practices on projects in UEW. Please Use the scale of 1=not challenging 2=less challenging 3=quite challenging 4=challenging 5=very challenging

CODE	INHIBITING FACTOR	SCORE				
		1	2	3	4	5
1	Cost of undertaking the exercise					
2	Insufficient expertise of professionals on using LCC					
3	Insufficient awareness of the benefits of its use					
4	Poor maintenance culture					
5	Unavailability of standardized approach/ LCC policy					
6	Unreliable data (overreliance on assumptions)					
7	Low interest of Client					
8	Insufficient demonstration of interest by project team					
9	Fragmented nature of the project team					
10	Bureaucratic structures in administrative procedures					
11	Effects of inflation on forecasted figures					
12	Ineffective communication among project team members					
13	Restrictions to the use of more sustainable options (designs and specifications) due to tight budgets					
14	Challenge with satisfying multiple institutional stakeholders with competing needs					
15	Short-term budgeting of Client (no provision for operation and maintenance costs for projects)					
16	Reluctance to commit to change in management policy and strategy					
17	Restrictions from the Public Procurement Act					
18	Length of required payback period (return on investment) for commercial facilities					
	Other (s), please specify and rank					
19						
20						

SECTION E: MEASURES TO IMPLEMENT LCC

15. What do you suggest can be done to help implement LCC practices in Ghanaian Public Universities (GPUs)? Use the scale below to score the possibilities of these interventions. (Please score for all)

    1= not possible 2=less possible 3=quite possible 4=possible 5=very possible

CODE	POSSIBLE MEASURES FOR IMPLEMENTATION OF LCC	SCORE				
		1	2	3	4	5
1	Professionals should attend CPDs on the use of the tool					
2	Conducting value for money assessments must be done for projects					
3	Hire personnel with expertise in LCC					
4	Mounting of facilities management programs in tertiary institutions for training on LCC					
5	Develop an institutional Design Standards Manual					
6	Develop an institutional Maintenance Manual					
7	Periodic reviews of design and maintenance manuals					
8	Joint effort by professional institutions to develop an abridged LCC standard or policy for practice in Ghana					
9	Use of a professional LCC software for analysis					
10	Clients must enforce/insist on LCC implementation					
11	Incorporation of LCC analysis as part of consultancy requirements					
12	Clients must stretch budgets of capital projects for its life cycle (provisions for running costs)					
13	Embrace other innovative procurement methods					
	Other (s), please specify and rank					
14						
15						

END OF QUESTIONNAIRE

You **may** provide your email address if you are interested in receiving findings gathered from this study _____

THANK YOU FOR YOUR TIME.