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MAINTENANCE MANAGEMENT OF EDUCATIOANAL INFRASTRUCTURE IN GHANA: DEVELOPMENT OF A FRAMEWORK FOR SENIOR HIGH SCHOOLS

By

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BSc., PG.Dipl. Architecture,

MASTER OF PHILOSOPHY in Building Technology

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DECLARATION

I hereby declare that this submission is my own work towards the Mphil 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

Maintenance management in the built environment in Ghana faces numerous challenges in the areas of inadequate research, inadequate resource allocation and inadequate knowledge among users and occupants of facilities and buildings. The education sector in Ghana plays one of the major developmental roles in training the human resource needs of the country. The sector covers elementary, second cycle and tertiary institutions engaged in the training processes. The second cycle stage which provides secondary education for students entering the tertiary stage operates in organized campuses. Unfortunately, the maintenance practices in these schools are faced with the common challenges of maintenance management (MM) in most academic institutions, resulting in inefficiencies that affect performance of the built infrastructure. The main aim of this research was to develop a MM framework to enhance the MM practices of SHSs in Ghana. Four objectives were developed to assist in the realization of the main aim. These objectives included: 1) To map the evolution, emerging trends and best practices MM within the construction industry from existing literature; 2) To develop a snap shot of existing MM practices prevalent in Ghanaian SHSs; 3) To determine the underlying inefficiencies inherent in the current MM practices in SHSs in Ghana; 4) To design a procedural framework to assist Ghanaian SHSs enhance their maintenance management practices. Following literature review on maintenance management, concepts and best practice benchmarks were established. A mixed-method and cross-sectional research approaches were employed. The field survey employed structured and semi-structured questionnaire, interviews and observations. Quantitative data collected was analysed using one sample t-test and

factor analysis. Descriptive statistics was used in analyzing qualitative data. The results were presented in tables, graphs and figures. The results revealed that SHSs practiced mainly unplanned corrective maintenance. As a result of the analysis, the main performance activities established covered; policy and standards criteria, planning criteria, technical management criteria, resource management criteria and finally, communication criteria. Twenty best practice factors also emerged as critical to a successful MM framework in SHSs. The analysis also revealed that, maintenance units in SHSs are poorly resourced and the existing MM process does not gain priority from top management. The research ended with the development of a conceptual maintenance management framework, proposed to guide the maintenance management process in SHSs in Ghana. The framework integrated existing MM practices and best practices to develop the conceptual framework. The framework was however validated by experts to enhance it for improvement and onward recommendation to top management of SHSs. The study has contributed to the body of knowledge on MM especially in the education sector, through the identification of pointers that can improve MM process in the second cycle institutions in Ghana and beyond.

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DEDICATION

To:

My husband: Tony. This thesis would have remained an unfulfilled dream but for your unconditional love, support, encouragement and prayers.

And the loving memory of our late son: Jesse.

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND TO THE RESEARCH

Maintenance is a phenomenon that transcends disciplines the world over and its importance cannot be overemphasized. Higgins (2002) stated that maintenance is a science, an art, a philosophy and must above all be fitted carefully to the organization it serves, and that its effectiveness is influenced by the executors of the maintenance operation. Maintenance today, has become very critical in organizational success such that its intervention or omission is indispensable (Pintelon and Parodi-Herz, 2008). Hence, a thorough insight of maintenance is relevant to the execution of maintenance activities.

Scrhrag et al. (2007) and Arazi et al. (2009) emphasized that newly completed infrastructure particularly buildings are often beautiful, energy efficient and functional for the users. They further added that these state-of-the-art buildings bring happiness to stakeholders, however behind the scenes are maintenance requirements. To this end, Allen (1995; 2005 cited in Arazi et al., 2009) posited that birth, growth, maturity, decline, death, and rebirth are fundamental stages in all natural cycles. However, in the case of infrastructure and buildings in particular, nature begins a systematic destruction through gravity, seismic movement, ultraviolet light, and decomposition of organic components in advance to the completion of the project.

This buttresses the observation made by Adenuga, et al. (2007) that, it is impossible for industry to produce buildings and other products which are maintenance free.

Historical evidence shows that, prior to the industrial revolution of the 1750s, the practice of maintenance consisted of individual craftsmen such as carpenters, smiths, wheelwrights, masons, etc. who repaired buildings, primitive machines and vehicles of the day (Sherwin, 2000). Over the decades maintenance practitioners have improved upon their practices and have sought other strategies for carrying out maintenance works. Further information by Sherwin (2000) indicated that the growing availability of maintenance solutions gave an opportunity for maintenance practitioners to solve seemingly non-solvable maintenance problems.

In earlier literature, Coetzee (1999) observed that, maintenance theory was not in existence until fairly recently while technology was developing at a pace which made the maintenance practices of the time obsolete. Pintelon and Parodi-Herz (2008) however traced the evolution of maintenance from the 1940s, 1960s and through to the 1970s, when maintenance metamorphosed into a technical matter and gradually transformed over the decades to become a cooperate partner in organizations. In a similar vein, Gomez Fernandez and Crespo Marquez (2012) also observed that, maintenance has been experiencing a slow but constant evolution across the years and is now considered an integral function of productivity in organizations.

The general improvements in technology across disciplines have brought along tremendous improvements and solutions to various industries and organizations with regards to maintenance. There is a consensus among authors (including Pintelon and Gelders, 1992; Crespo Marquez et al., 2009; Gomez Fernandez and Crespo Marquez, 2012) that approximately three decades ago, companies, organizations and institutions realized the need to manage maintenance adequately by including it in the general scheme of the organization, and managing it interactively with other functions of the organization. In order to enhance maintenance effectiveness, the concept of management has to be deeply rooted in the day-to-day maintenance activities of the organization.

The European standards (2001, cited in Crespo Marquez and Gupta, 2006) defined maintenance management (MM) as all activities of management that determine the maintenance objectives, priorities, strategies and responsibilities. These activities are implemented by means such as; maintenance planning, maintenance control and supervision and economics. Adul Lateef et al. (2010) and Farinloye et al. (2011) expanded on the essence of MM to include planning, controlling, coordinating and organizing maintenance activities with focus on efficient allocation and utilization of resources in order to improve the value of the item or asset being maintained. The benefits of having MM integrated in the organization include; protection of capital investment, promotion of health and safety of users, improvement in production efficiency, improvement in maintenance leadership and support, and sustainability of organization's performance (Vanneste and Wassenhove, 1995; Akasah, 2009; Gomez Fernandez and Crespo Marquez, 2012).

Globally, the growth and recognition of MM has developed greatly as a result of governments' investment in maintenance of public infrastructure (Idrus et al., 2009). Al-Arjani (2002) and Lam et al (2010) further emphasized that governments all over the world have considerable expenditure on maintenance and operation projects. According to Egbu et al. (2002) and Lam et al. (2009; 2010), there has been a significant increase in refurbishment works both in the UK and in the Italian construction industries in the last 30 years. For instance in Britain, maintenance activities have reached a level of 50% of all annual construction activities (Kherun et al., 2002 and Shohet, 2002). Lam et al. (2010) further added that, statistics portray the percentage of the gross value of repair and maintenance works has increased steadily from 20% in 2000 to 28% in 2004 in Hong Kong. The data further showed that between 1997 and 2007, the value of maintenance works and repair increased from 22.5% to 51.6% in the 10year period.

According to the International Bank for Reconstruction and Development and the World Bank report (2010) on Africa's infrastructure investment, the cost of addressing Africa's infrastructure needs is around $93 billion a year. The report stated that about one-third of this amount, approximately $31 billion, is required for operation and maintenance of the infrastructure. However, the report further stated that, in Sub-Saharan Africa, infrastructure financing needs are estimated to be $39 billion per year, of which $17 billion is required for operation and maintenance annually. Ghana, a Sub-Saharan African country is equally saddled with huge expenditures for infrastructure development and operation, and maintenance. For instance in 2010, the Government of Ghana (GoG) through the Ghana Education Trust Fund (GETFund) expended GHC296.42 million on

educational infrastructure (Monetary Policy Report of Bank of Ghana, 2011). This figure covers only construction and consultancy costs.

The situation of maintenance challenge to the growth and development of Ghana permeates all facets of the fabric of the nation, including both private and public sectors. The maintenance situation of public infrastructure in Ghana as observed by researchers such as, Afrane and Osei-Tutu, (1999); Affare, (2003); Obimpe, (2003); Barimah, (2005); Kyerematen, (2008); Osei-Tutu and Morgan (2008); Cobbinah, (2010); Nartey, (2011) remains a big challenge. General observations include poor and inadequate budgetary allocations, general state of disrepair of buildings, poorly trained and incompetent maintenance staff etc. and thus, the infrastructure need more care and attention. In the Educational sector of Ghana for instance, the basic, second cycle and tertiary sub-divisions also face their share of MM problems.

This research focuses on the educational sector of the country with particular attention to Senior High Schools (SHSs). Most SHSs operate within the campus-type environment, which consists of various physical facilities that accommodate academic, recreational, religious, social activities as well as other infrastructure to support day-to-day activities with its attendant MM challenges.

1.2 STATEMENT OF THE PROBLEM

Maintenance remains a key issue and has been identified as one of the areas in which the construction industry must achieve significant improvement (De Silva et al., 2004). Neglect of maintenance in industries like aviation and manufacturing affects day-to-day operations tremendously, resulting in idle times and huge losses. The building industry however has a peculiarity to maintenance. Building projects in general have commencement and completion periods after which they are handed over to the users who are responsible for the upkeep of the facility. Iyagba (2005) observed that, many people do not understand maintenance and this is evident in how they practice it. He further added that, a number of people also see maintenance as an avoidable task, fragmented and uncoordinated which contributes little to the working environment. (Adenuga et al., 2007; Idrus et al., 2009; Lateef et al, 2010; Lam et al., 2010).

Coll & McCarthy (1998) emphasized that maintenance of school buildings is sometimes regarded as unproductive and is thus neglected. Maintenance expenditure is sometimes kept to a minimum with no recourse to the long-term effects, due to ignorance and lack of understanding. More than a decade has elapsed since this observation was made however; the neglect of maintenance still persists. Wood (2005) also opined that maintenance still remains under-researched. This has been attributed to the unique and diversified nature of maintenance, where new challenges emerge as solutions are being sought for existing problems. A number of factors have been identified by various research work on maintenance within the built environment as responsible for maintenance challenges, especially in industries and the public sector (El-Haram and Horner, 2002; Adenuga et

al., 2007; Ali et al., 2010; Assaf et al., 2011; Farinloye et al., 2011; Zulkarnain et al., 2011; etc). Afrane and Osei-Tutu (1999); Chew and De Silva (2003); Barimah, (2005); and Lam (2010); have identified limited expertise and equipment; lack of a systematic maintenance recording system; long response system; and limited budgets as leading factors responsible for the inefficiencies directly affecting MM programmes. Other factors include improper planning, socio-cultural reasons, improper management and insufficient MM related training (Afrane and Osei-Tutu, 1999; Osei-Tutu and Morgan, 2008; Idrus et al., 2009; Chandler and Lewis, 2011). These factors adversely affect maintenance managers and organizations in meeting the expected performance level.

Maintenance strategies, models and frameworks have been developed by researchers and practitioners to curb maintenance related challenges. However, these interventions are predominated by those developed for manufacturing, production and aviation industries. Wang (2008) stressed that most models and policies are more theoretical than practical and were developed in response to domain-specific applications. This research however, seeks to develop a maintenance management framework (MMF) for Ghanaian public SHSs to serve as guide for executing maintenance activities. Public SHSs like other public institutions face challenges regarding maintenance. The peculiarity of the proposed MMF relates to considerations of procedure and practicality in the development process. Even though the framework is earmarked specifically for SHSs in Ghana, it can be adopted for use by other organized public institutions in Ghana and West Africa for executing MM activities.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of the research is to develop a MMF to enhance maintenance practices of SHSs in Ghana. The objectives guiding this research include:

1.3.2.1 To map the evolution, emerging trends and best practices of maintenance management within the construction industry from existing literature;

1.3.2.2 To develop a snap shot of existing maintenance management practices prevalent in Ghanaian SHSs;

1.3.2.3 To determine the underlying inefficiencies inherent in the current maintenance management practices in SHSs in Ghana; and

1.3.2.4 To design a procedural framework to assist Ghanaian SHSs enhance their maintenance management practices.

1.4 RESEARCH METHODOLOGY

This research intends to develop a MM framework for SHSs in Ghana to enhance their maintenance practices. To achieve this aim, the process commenced with a comprehensive review of relevant literature from sources such as books, journals, reports, conference proceedings and other publications regarding maintenance and MM. The aim of the literature review was to establish best practices and benchmarks on MM. Preliminary consultations with maintenance experts were sought to enhance the benchmarks established from the literature review. The established benchmarks served as a basis for subsequent stages of the research.

The research then adopted the most suitable epistemological, ontological and axiological approach based on the set aim and specific objectives. This process aided the research design and outlined the processes and techniques to utilize. To this end, positivism was adopted primarily as the underpinning paradigm with a slight leaning towards realism and employed a deductive methodology. The study then employed the mixed method strategy and combined elements of both quantitative and qualitative methods, particularly the concurrent nested mixed method variation as outlined in Creswell (2008). Here, the quantitative methods were the predominant approach and the qualitative methods, nested. Accordingly, employing mixed methods in research will assist in making better interpretations since informants will be providing information that is both measurable and analyzed through rich description (Creswell, 2003; 2008). The study then proceeded with the formulation of the research design which encompassed the design of the instruments, sample selection, data collection, data analysis and interpretation of findings.

Combinations of desk study, observations, survey and interviews were utilized to elicit the relevant data from management and maintenance staff of selected SHSs. Structured and semi-structured questionnaires and pre-determined interview questions was thereafter formulated. The questionnaires comprised sections that included respondent's profile and general questions on maintenance practices. There was also a major section on the assessment of MM practices in SHSs based on best practice criteria adopted from literature as well as expert views. The respondents were then asked to rank and rate benchmarking and performance respectively on a five-point Likert scale, where benchmark, 5 represented most important and 1, least important. On performance, 5

represented highly satisfactory and 1, not satisfactory. The questionnaires went through a piloting phase and were amended prior to the actual survey.

Respondents were drawn from SHSs in the Kumasi metropolis of the Ashanti region and Cape Coast metropolis in Central region of Ghana. The sample comprised all heads and maintenance officers or their representatives in the nineteen (19) and eleven (11) public SHSs in Kumasi and Cape Coast respectively. The study subsequently proceeded to the field to collect data. Self administration of the questionnaires and face-to-face interviews were employed in addition to desk study of related literature, observations of facilities, existing maintenance policies and plans, maintenance history and documentation among others. The data collected was then analyzed using the Statistical Package for Social Sciences (SPSS) data analysis tool (version 16) and utilized descriptive statistics, one sample t-tests, and factor analysis techniques.

In order to establish the inefficiencies inherent in the current maintenance practices, further interpretations of the findings were carried out using the MM benchmarks. This outcome in addition to findings on improved methods of carrying out MM from reviewed literature was synthesized into the design and formulation of the MM framework. The framework was validated to enhance it. The iterative validation process established by Presley and Waltman-William (1993) was utilized. Here, experts' consensus on the conceptual framework was sought during the process. The research methodology is discussed in detail in Chapter 3 of this report.

1.5 SCOPE OF THE RESEARCH

The research was undertaken in the Republic of Ghana, which is situated along the centre of the West African coast and lies between longitude 4°W and 2°E and latitude 4°N and 12°N. Ghana shares land borders with Burkina Faso to the north, Cote d'Ivoire to the west and Togo to the east. It is also bounded to the south by the Gulf of Guinea and the Atlantic Ocean (Berry, 1994; Bunnett and Okunrotifa, 1999). The local government system of Ghana consists of a Regional Coordinating Council, a four-tier Metropolitan and a three-tier Municipal/District Assembly Structure (Ghana Districts, 2006; ed. Friedrich-Ebert-Stiftung, 2010).

Ghana is made up of various sectors including the education sector. The education sector consists of various levels from pre- school, basic, junior and senior high to tertiary. The schools in Ghana's educational sector are either privately or publicly owned. The research focuses on public SHSs in Ghana. However, SHSs within Kumasi, capital of the Ashanti region and Cape Coast, capital of the Central region were surveyed. Kumasi is Ghana's second largest city and has the largest number of public SHSs in its Metropolis. Cape Coast on the other hand, located in southern Ghana is well-noted for the concentration of a number of the finest SHSs which include some of the oldest in the country (Korboe and Tipple, 1995; Sinai, 1998; Ghana Districts, 2006).

In terms of content, the study is limited to MM of educational infrastructure in general, particularly buildings. The emphasis of the research is on the management aspect of maintenance and alludes to the stance by Arazi et al. (2009) that, the MM process has no

beginning or end but in practice, when to commence maintenance requires a complex thought process. This decision as opined by Swanson (2001); Pinjala et al. (2006); Arazi et al. (2009); and Muchiri et al. (2011) involves the asset; the maintenance (strategy, approach and process) and the corporate objectives (goals and aspirations as well as policy) of the organization/ institution in question concurrently. To this end, this study dwells on the MM process and activities of management including planning, controlling, coordinating and the organization of maintenance works. It also traces the evolution of MM and best practices. A conceptual procedural framework was eventually formulated based on the current practices and established MM best practices to enhance MM in Ghanaian SHSs.

1.6 JUSTIFICATION FOR THE RESEARCH

As more infrastructural needs are met with the passage of time, the need for maintenance has also increased and hence, the improvement of MM to meet new maintenance challenges is imperative. Lam et al, (2010) observed that the increasing number of maintenance projects worldwide presents the need to urgently identify major problems for establishing better management strategies. Earlier, Wood (2005) suggested the need for greater sharing of good and innovative maintenance practices due to the diversity of maintenance.

The development and expansion of infrastructure is important to every nation since it provides among others, physical structures to support day-to-day activities. Roads, water supply systems, power grids, telecommunication systems, buildings etc. are needed to

provide the commodities and services essential to enable, sustain and enhance societal living (Fulmer, 2009). Hence, the incessant quest by nations to invest huge sums in providing buildings and other infrastructure for various sectors of economies. In Ghana for instance, the government expends a lot of funds with respect to infrastructure to support the various sectors of the economy. In the education sector in particular, GoG and other stakeholders have over the years, been making huge investments in infrastructure. Considering the quantum of investment made towards the provision of infrastructure, care, attention and most importantly maintenance is necessary.

Some research findings by Afrane and Osei-Tutu (1999); Kyeremanteng (2008); and Nartey (2011) on the observation of MM practices in some schools in Ghana show that mainly unplanned maintenance interventions which are basically corrective and reactive in nature are employed in maintaining buildings and other infrastructure. Maintenance problems and repairs of defects are tackled mostly as and when they occur or deferred to a later date due to lack of finance and inadequate expertise. The absence of MM plans and policies coupled with inadequate documentation and the fact that the maintenance units are not fully equipped, also compound the maintenance challenges that these institutions face. Other observations include the prevalence of unwritten maintenance policies in schools in the Kumasi Metropolis. In Cape Coast, most schools have developed maintenance plans. However, about 2/3rds of these schools, do not follow the plans (Kyeremanteng, 2008; Nartey, 2011).

This study set out to develop a MMF to consolidate arrangements, plans and policies regarding the management of maintenance in public SHSs. The MMF produced from the research will guide both management and maintenance personnel in carrying out maintenance activities more efficiently. This will ultimately contribute to prolonging the life spans of buildings, furniture and equipment. Hence, resources can be channeled to other areas of need to augment the day-to-day operations of SHSs. Since a greater number of SHSs have similar facilities, a standard document will serve as a valuable resource for maintenance work. This standard document will eventually coordinate and improve MM practices. Data collected from the field survey can be used for future research to overcome new maintenance challenges that may emerge.

1.7 ORGANIZATION OF THE RESEARCH

The thesis is presented in five chapters. These are organized as outlined in the following:

The first chapter, the introduction to the research captures the background to the study, statement of the problem, research aim and objectives. It also presents the research methodology, scope as well as justification for the research.

Chapter two reviews literature on maintenance management of educational infrastructure in Ghana. It sets off by documenting information on Educational Infrastructure and then delves into their state of maintenance. It then proceeds with the evolution and an overview of maintenance and MM. It also reviews existing MM policies and MM models, highlighting components, processes/methodologies, tools and techniques and finally documents innovations in MM and case studies of MM models.

The third chapter discusses the research methodology. It describes the philosophy and strategy the research employed. The data collection process including the design of the instruments is also discussed. Finally, the chapter summarizes the modelling process adopted for the MM framework.

The fourth chapter provides information on the existing maintenance practices in Ghanaian public SHSs based on the analysis of the data collected from the schools surveyed. Also, the challenges and inefficiencies inherent in the current MM practices are documented. The design and development of the MM framework is also discussed.

Finally, chapter five presents a summary of the main findings, achievements and limitation of the research in relation to the aim and objectives as well as the conclusion and recommendations. It further highlights the contributions of the research to knowledge and industry. Areas for further research are also outlined.

1.8 SUMMARY

This chapter documented the background to the study, statement of the problem, aim and objectives, scope and a summary of the research methodology adopted. The justification of the research which highlights the benefits of the research and significance of the findings has also been presented. Finally, the organization of the research concludes the chapter.

The next chapter, (i.e. chapter two) presents a review of MM in general with emphasis on MM relating to the built environment.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter reviews existing literature on the area of study, Maintenance Management (MM) of Educational Infrastructure in Ghana. It sets off by documenting information on Educational Infrastructure and then delves into types of infrastructure in SHSs. It then proceeds with an overview of maintenance and MM, thereby putting the research in context. It also looks at MM policies and MM models and finally documents case studies of MM models. These include models developed by Crespo Marquez (2007), Akasah and Amirudin (2010). This chapter however gives a deeper understanding of the subject area of maintenance management.

2.1 EDUCATIONAL INFRASTRUCTURE (EI) IN GHANA

Ghana has since independence made significant strides in its education system. The educational landscape in Ghana today is the result of major policy initiatives in education adopted by past governments as well as the present one (Ghana's Education System report, 2011). Some of the laws, policy documents and reports, which have helped in meeting the educational needs and aspirations of the people include; The Education Act of 1961, The Education Commission Report on Basic and Secondary Education 1987/88, The Free Compulsory Universal Basic Education Programme, 1996 and the Ghana Education Trust Fund - GET Fund Act 2000, (Act 581). These initiatives have not only helped in structurally transforming the education system but also improved considerably

access, quality teaching and learning, infrastructure delivery as well as management efficiency.

Infrastructure to support, enhance and promote teaching and learning as well as management is essential at the various stages of education from pre-school, through primary, junior and senior high (or technical) to the tertiary level. Teaching and learning areas (classrooms, lecture halls/ theatres, workshops, laboratories, and libraries), administration, accommodation facilities (for both students and staff), recreation and sports infrastructure, parks and gardens and other ancillary facilities are generally found in educational institutions in Ghana.

2.1.1 Infrastructure in Senior High Schools

Infrastructure makes available the physical structures such as roads, railways, ports and harbours, water supply systems, sewers, electrical grids, telecommunication systems and buildings needed to provide the commodities and services essential to enable, sustain and enhance societal living (Fulmer, 2009; Agyefi-Mensah et al., 2012). In the case of SHSs however, mention can be made of roads, water supply systems, sewers, electrical grids, telecommunication systems, sports infrastructure and buildings.

Buildings constitute a greater percentage of the infrastructure in most SHSs especially in the boarding schools. Dormitories, classrooms, laboratories, assembly hall(s), administration block, dining hall(s), kitchen complex, libraries, staff accommodation, and chapel. However, road network, telecommunication systems, power supply systems (both

grid and generator), water supply system and sewerage system form part of the physical infrastructure that enhances the smooth operation of SHSs.

Over the years, Ghana Government through the GETFund has been making huge investments on infrastructure in the education sector. For instance in 2010, GETFund expended GHC296.42 million on education infrastructure (Monetary Policy Report of Bank of Ghana, 2011). This figure, according to the report does not include maintenance costs but simply covered construction and consultancy costs. Agyefi-Mensah et al. (2012) however observed that, infrastructure projects in general are built with the intention to operate for a very long time. They further added that the consequent impact of infrastructure on capital investment, resource utilization, the quality of the environment and overall quality of human life can be very significant. It is therefore important that, infrastructure meet performance requirements in economic, ecological and social sustainability terms.

2.1.2 State of Maintenance of Educational Infrastructure (EI)

A general shortage of space currently exists in all the sub-sectors of the educational system. The expansion of the education system, mainly through the introduction of universal primary education, has put pressure on education facilities that did not expand at the same rate as the school population (Moja, 2000). The existing buildings are in a state of decay due to lack of maintenance and repair. The present conditions of buildings impact negatively on the quality of education offered (Moja, 2000; Akasah et al 2010). Such conditions have encouraged a brain drain of teaching and administrative personnel

out of education to other sectors of the economy or out of the country. Dilapidated school environments contribute to the high dropout of learners from school. The amount of funding needed for new buildings is high and the estimated cost of the rehabilitation of the existing infrastructure is even higher. The need for provision of adequate education facilities at all levels of education is paramount.

The *maintenance situation* as observed by many Ghanaian researchers (Afrane and Osei –Tutu, 1999; Affare, 2003; Obimpe, 2003; Barimah, 2005; Kyerematеng, 2008; Osei-Tutu and Morgan 2008; Cobbinah, 2010; Nartey, 2011) in all sectors predominantly the public sector in general and the education sector in particular posses a big challenge to development. It can be inferred from the findings of these authors that those at the helm of affairs and other stakeholders who play diverse roles seem to have a fair idea of what ought to be done with some incubating ambitious and over ambitious dreams. They however grapple with several degrees of difficulties and other hitches which include socio-cultural, economic, technical, managerial, and environmental. In simple terms these challenges range from attitudinal behaviour of users, absence or inadequate financial allocations for maintenance, design and construction specifications and workmanship, delays in taking maintenance decisions and actions, weathering, corrosion and dirt accumulation on buildings.

Afrane and Osei-Tutu (1999) painted a picture of the maintenance situation in schools by the following observations: no maintenance staff in the schools covered; low budgetary allocations for maintenance; and the absence of plans and arrangements for maintenance.

Kyerematenng (2008) observed that Schools in the Kumasi Metropolis did not have documents containing maintenance policy rather schools had an unwritten policy which sought to ensure that school properties were maintained as and when needed. However, recent research in some schools in Cape Coast has shown that most schools have developed maintenance plans but 2/3rds according to the research do not follow the plans (Nartey, 2011). This implies that, there seem to be some gradual acceptance of the relevance of maintenance in prolonging the life spans of school infrastructure.

2.2 OVERVIEW OF MAINTENANCE

2.2.1 Definition of maintenance

Maintenance, an age-old discipline has over the years been viewed from various perspectives and had varying definitions by several authors. According to Higgins (2002), maintenance is a science since its execution relies on almost all the sciences, an art because problems that seem identical regularly demand and receive varying approaches and actions, and because some managers and craftsmen display greater aptitude for it than others show or even attain. Higgins further added that, it is above all a philosophy because it is a discipline that can be applied intensively, modestly or not at all, depending upon a wide range of variables that frequently transcend more immediate and obvious solutions.

Abdul Lateef et al., (2010); Farinloye et al., (2011); Zulkarnain et al., (2011) observed that even though maintenance has had varied definitions and redefinitions, all definitions revolve around care. The British Standards Institution (BSI) gives a widely adopted

definition of maintenance. It defines maintenance as "*work undertaken in order to keep or restore every facility and contents, to an acceptable standard and to sustain the utility and value of the facility*" (BSI, 1984). Other schools of thought share similar views with little or no variations. These include, Seeley (1976); Horner *et al*, (1997) and Njuangang and Liyanage (2012).

Smith (2003) and Iyagba (2005) stand on the notion that, "*Maintenance means to keep in its existing state, preserve, continue in good operating condition, and protect*". From these authors' perspective, efforts should be geared towards keeping the facility in its existing state. However, this will require a lot more since ageing, weathering, and wear and tear are natural phenomena. This brings to fore efforts including technical and administrative. The BSI further added an administrative element in the decision-making process in conducting maintenance work as observed by Njuangang and Liyanage, (2012) and hence the definition, "*The combination of all technical and administrative actions, including supervision actions, intended to keep an item in, or restore it to, a state in which it can perform a required function*" (BSI, 1991).

According to Allen (1993), the above definition introduces the resource actions and processes and limits the corrective action to retaining or restoring it so that, it can perform to a predetermined standard. Nonetheless, Wood (2005) has criticized it, stating that "every term is contestable: citing the example, "intent" – questioning who decides the "required function" and whether or not the item can, or does perform adequately. He reiterates that the definition in question does not explicitly mention who decides on the

'required function' and the adequate performance of the item. Even though, the definition in question appears to be the most preferred of the Yeovil NHS Foundation Trust (2009), it nonetheless has added the clause "*... given due consideration to viability and economic financial responsibilities*" (Njuangang and Liyanage, 2012).

Most of the latter definitions of maintenance focused on the theme of retaining or restoring an item into its original state, viewing the discipline from different viewpoints. For example, Reason (2000 cited in Sharma et al., 2011 and Dhillon and Liu, 2006) defined maintenance as "*those activities required to keep a facility in 'as built' condition and therefore continuing to have its original productive capacity*". Viewing Maintenance from another perspective, it may accordingly be defined most effectively by what it does, namely; the preservation or restoration of the desired function of a given process, at the lowest total cost (Narayan, 1998); and the process of maintaining an item in an operational state, by either preventing a transition to a failed state, or by restoring it to an operational state following failure" (BS 4778-3.1: 1991; Yiu, 2008).

Farinloye et al. (2011) opined that, "*Maintenance is the action of performing activities to keep the system operational*". The "system", used in this context can pass for a business, an organization, a production plant or an institution. Similarly, Njuangang and Liyanage, (2012) explained that, "*Maintenance is the act or work of keeping the state of an asset in a proper condition needed to sustain business operations*". According to Sharma et al. (2011), it is "*an activity, in which repairing is carried out at certain intervals, to extend useful life of the machine*" By ensuring the continuous functional suitability of an asset,

maintenance contributes towards the profit of an organization. However, the Maintenance Engineering Society of Australia (MESA) has adopted a sector-focused approach by defining maintenance as "*The engineering decisions and associated actions necessary and sufficient for the optimization of specified capability*" (Tsang, 1998). The characteristic of capability includes function, capacity, rate, quality, responsiveness and degradation (Njuangang and Liyanage, 2012).

The manner in which maintenance is undertaken, could also give an impression of people's understanding of the discipline. Iyagba, (2005) maintains that "*there are a substantial number of people who do not know the meaning of maintenance, and that the way they practice it indicates this*". In practice, prevalent interpretation of maintenance is to *"fix" it when "it breaks*". This however, he points out is a good definition for repair, but not true maintenance. This style of maintenance according to Iyagba is reactive. He however referred to the RICS/ISVA Working Committee adopted definition, "*work undertaken in order to keep, restore or improve every facility, to an acceptable standard and to sustain the utility and value of the facility"* as proactive maintenance.

In the nature of things, nothing man-made is indestructible, but performing repairs at intervals by an activity known as maintenance according to Dhillon and Liu, (2006) can extend useful life.

2.2.2 Objectives of maintenance

The function of maintenance is to maximize the aesthetic and economic values of buildings and other infrastructure, as well as increase the health and safety of the occupants. Some of the specific maintenance objectives are summed up in the following by Magee, (1988, cited in Aris, 2006) include, to: perform daily housekeeping and cleaning; develop and execute a system of regularly scheduled maintenance actions; undertake major repairs based on lowest life-cycle cost; complete improvement projects; provide for easy and complete reporting of maintenance work; monitor the progress of maintenance works; estimate and track costs accurately; schedule all planned work in advance; allocate and anticipate staff; and continually seek workable solutions to maintenance problems.

These objectives however, encapsulate maintenance in its totality, combining technical and administrative actions. This brings to bare, the management aspect of maintenance.

2.2.3 Significance of Maintenance

There is a growing awareness worldwide on the importance of the maintenance of constructed facilities (Aris, 2006). Regular maintenance retains the value of investment and assists in retaining the economic life of buildings. According to Afranie and Osei-Tutu (1999); Dave (2002); and Cobbinah (2010), maintaining economic assets such as infrastructure ensures that they appreciate in value and result in a return, either socially or economically.

Ikhwan (1996) and Al- khatam (2003) also observed that, maintenance is a productive activity at both private and national levels. They further explained that, at the private

level, proper maintenance leads to lower depreciation costs and consequently, higher profitability. While at the national level, proper maintenance leads to lower expenditures on replacement. Thus, allowing more expenditure on expansion into new productive investment.

Frequent maintenance of the built environment brings such benefits as comfort and satisfaction to its inhabitants. Maintaining the physical structures of a property ensure that investments made do not only yield the highest possible returns over the life of the property but also fulfills the ultimate responsibility of providing the needed human satisfaction and comfort. Akasah et al. (2010, citing Hamid, 1997); O'Neill, (2000); Wei, (2003); and Lair, (2003) emphasized that, maintaining school buildings in good condition is important as their conditions can have an impact on students' well being and achievements. This goes to explain further the importance maintenance of buildings and other facilities play in the learning and social life among users.

Finally, the built environment in general expresses physically, the complex social and economic factors which give structure and life to the community (Cobbinah, 2010). Conditions and quality of buildings and other infrastructure are a measure of public pride, prosperity, priorities, social values and virtues. These combine with other variables to give image and meaning to the country's unique characteristics. However, Njuangang and Liyanage (2012) shared the view that, despite the significance of maintenance, it appears maintenance often takes low priority in the overall operating strategy of a facility

or an organization. This is because maintenance has no real product, and is often seen as a drain on a company or an establishment's finances.

2.2.4 Classification of maintenance works

BS 3811 categorizes building maintenance as follows;

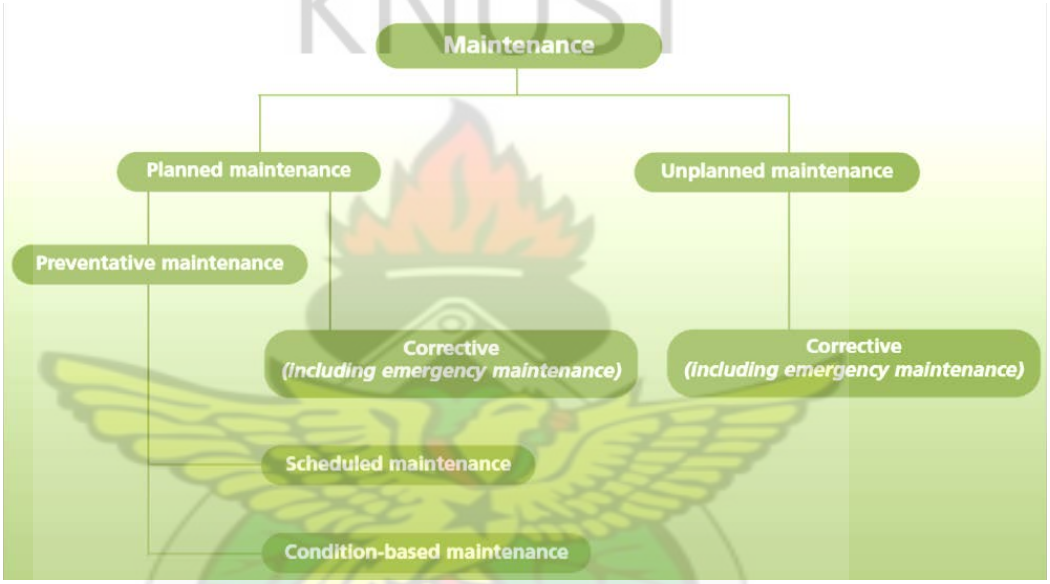


Figure: 2.1: Types of maintenance

i. *Planned maintenance*: The maintenance organized and carried out with forethought, control and the use of records to a predetermined plan. Planned maintenance is based primarily on a preventative approach, where maintenance is planned and carried out to avoid damage or deterioration.

ii. *Unplanned maintenance*: The maintenance carried out to no predetermined plan. It refers to work necessitated by unforeseen breakdown or damages.

iii. *Preventive maintenance*: Maintenance carried out at predetermined intervals or corresponding to prescribed criteria and intended to reduce the probability of failure.

iv. *Corrective maintenance*: The maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function.

v. *Emergency maintenance*: The maintenance which it is necessary to be undertaken immediately to avoid serious consequences.

vi. *Condition-based maintenance*: The preventive maintenance initiated as a result of knowledge of the condition of an item from routine or continuous monitoring.

vii. *Scheduled maintenance*: The preventive maintenance carried out to a predetermined interval of time, number of operations, mileage, etc.

viii. *Running maintenance*: Maintenance which can be carried out whilst an item is in service.

Another approach to the classification of maintenance adopted by Speight (1982) as cited in Seeley (1987), subdivided maintenance into three broad categories:

i. *Major repair or restoration*: such as re-roofing or rebuilding defective walls and often incorporating an element of improvement.

ii. *Periodic maintenance*: a typical example being annual contracts for decorations and the like.

iii. *Routine or day-to-day maintenance*: This is largely preventive in nature, such as checking rainwater gutters and servicing mechanical and clerical installations.

Other authors such as Coll and McCarthy, (1998), categorize these subdivisions under planned maintenance.

Das (1999) also argued that there are two types of maintenance work: *Preventive maintenance*, which if not done will cost more at a later stage; and *Essential maintenance*, which is required to keep a structure or an asset safe. However, Van Noortwijk and Frangopol (2004) opined that, whilst it is easy to defend essential maintenance work on safety grounds since failure consequences are in general extremely large, preventive treatments are more difficult to justify.

Another school of thought, according to Dhillon, (2002) and Dhillon and Liu (2006), categorizes maintenance into the following:

i. *Preventive maintenance*: all actions carried out on a planned, periodic, and specific schedule to keep an asset in working condition through the process of checking and reconditioning;
ii. *Corrective maintenance*: unscheduled maintenance or repair to retain assets in a defined state; and
iii. *Predictive maintenance*: the use of modern measurement and signal-processing methods to accurately diagnose assets' condition during operation.

Maintenance therefore involves extensive work as demonstrated by Harper (1968) and Seeley (1976) in categorizing maintenance into three (3) main components namely; Servicing, Rectification, and Replacement.

Servicing covers cleaning operations carried out at regular intervals with varying frequencies and is sometimes termed day-to-day maintenance. Afrane and Osei-Tutu (1999) explained this component to mean "daily sweeping of floors, monthly washing and cleaning of windows and regular painting of surfaces. They explained further that, servicing becomes necessary as a result of factors such as, constant use of facilities, the effect of the weather and atmospheric conditions on the components of the building.

According to Stapleton (1994, cited in Afrane and Osei-Tutu, 1999), rectification is the response to inherent defects in design, construction or installation stages of the building process. Rectification work usually occurs fairly early in the life of a building, but it can also occur sometimes within the life span of the building. It arises because of factors such as shortcomings in design, inherent faults in or unsuitability of components, damage of goods in transit or installation and incorrect assembly.

Again, Afrane and Osei-Tutu (1999) explained that, replacement occurs at all costs in building since the extent of exposure of materials to the vagaries of the weather varies as well as the capacity of elements of buildings to withstand changes and different intensities of the weather. Seeley (1976) further explained that, replacement works stem not so much from physical breakdown of materials or elements as from deterioration of appearance.

Maintenance is usually classified or categorized differently by various authors. This can be summed up thus; how, why and when maintenance is carried out, viewed from the author's standpoint.

2.2.5 Concept of Building Maintenance

As the name implies, building maintenance is a branch of maintenance which deals with buildings, their surroundings and contents. There are a number of definitions to this end, which include definitions by White, (1969); Seeley, (1976); Crips, (1984); Burra Charter, (2004); BS3811; and Zulkarnain et al, (2011). These stem from maintenance in general but focus on buildings in scope. Rakhra, (1983) and Olanrewaju, (2009) summarized building maintenance as processes, services, preservation, repair and care for buildings, after commissioning, renovation, refurbishment, and conversion to improve the life-span without drastically upsetting its basic features and use. These processes and services according to Lam et al. (2010) may be organized and carried out with forethought, control and records or carried out on an emergency basis when the need arises. Kherun et al. (2002, cited in Lam et al, 2010) perceive building maintenance projects as improvement, refurbishment, maintenance and repair works which have a number of unique features distinctive from new construction. Some of these features have been summed up by Olsson and Espling, (2004) in the table 2.1.

Table 2.1: Features maintenance versus new construction

Construction	Maintenance
Time perspective	
Construction work can be described as a project, with a start and an ending	An ongoing process Short contract periods of one to three years Long contract periods of five to seven years
Specifications	
Detailed standards and specifications	Difficult to exactly assess asset condition before, during and after a contract period
Dependence	
Contracts are designed to minimize dependence between client and contractor.	Major dependence between client/contractor. Contractor's engagement, knowledge and flexibility are essential and critical.
Competence	
Work is carried out by employees with all levels of education and skill.	Low education levels. Competence developed on the job. Successful outcome is dependent undocumented or recognized skills
Knowledge	
Extensive documented knowledge required (handbooks, research reports, papers). Traditional university programs, courses, apprenticeship programs. Frequent meetings and conferences	Maintenance is a new formal discipline. Methods and tools are sometimes unknown to maintenance management and personnel. Formal training not widely available. Few meetings and conferences for learning
Finance	
Clear budget boundaries. Change in costs must be negotiated. Budget fluctuations are common	Maintenance activities are postponed or cancelled when funds are unavailable
Working conditions	
Construction is normally a sole activity in the area of operations	Work performed on existing structures while they are being used Work performed within planned time frames Time allocated for maintenance work is limited Demands for rapid response in event of failure Must plan for preventive and predictive maintenance

Source: Olsson and Espling, (2004)

The primary aim of maintaining a building as opined by Afranie and Osei-Tutu (1999) and Cobbinah (2010) is to ensure that the building continues to serve the purpose for which it was put up. The purposes for which maintenance is undertaken include among others: to maintain the value of a building; to ensure optimum use of buildings; to create or maintain suitable appearance; to maximize the life of main components and materials; and to ensure that buildings do not detract from surroundings and also maintain a suitable appearance.

It is however not uncommon to have varied views and standpoints when dealing with issues on maintenance. The objectives of building maintenance according to Alner and Fellows, (1990, cited in Al- khatam, 2003) on the other hand include the following: to ensure that buildings and their associated services are safe condition; to ensure that buildings are fit for use; to ensure that the condition of the building meets all statutory requirements; to carry out the maintenance work necessary to maintain the value of the physical assets of the building stock; and to carry out the work necessary to maintain the quality of the building.

Okechukwu (1988, cited in Mac-Barango & Kakulu, 2011), observed that, the use to which the facilities are put also determine the frequency and extent of maintenance required. Mosaku and Kuroshi (2002) also observed that, the scale of maintenance is influenced by factors such as, climatic conditions, design considerations, social and ergonomic implications, availability of funds and staff resources dictate the volume of maintenance and repair work that could be undertaken at any given time.

Finally, Adenuga, et al., (2007) iterated that, it is impossible to produce buildings which are maintenance free, but maintenance work can be minimized by good design and proper workmanship carried out by skilled experts or competent craftsmen using suitable codes of installation, requisite building materials and methods. Although building maintenance has been termed by some authors as the "Cinderella" of the construction industry, it has nonetheless grown into an important function supporting core business operations (Dekker, 1996; Njuangang and Liyanage, 2012).

2.3 MAINTENANCE MANAGEMENT (MM)

2.3.1 Historical Overview of MM

MM has over the years, developed to some extent on the basis of the current requirement. Sherwin (2000) stated that, prior to the Industrial Revolution, generally believed to have begun in England in about 1750, maintenance consisted of individual craftsmen such as carpenters, smiths, coopers, wheelwrights, masons, etc. repairing the buildings, primitive machines and vehicles of the day. As there was no concept of dimensional control or spare parts, failures were mostly repaired by making a new part to fit or repairing the old one. Moreover, repair rather than discard of assemblies was the order of the day, and the basic structures were either themselves repairable, or highly durable or both. Accordingly, it is also likely, in the absence of methods for calculating stresses, etc., that design evolution and repairs were closely integrated. The craftsman would naturally fit a stronger part to replace one that had clearly failed from being too weak, and would incorporate the design change in the next new machine.

As time went on, Diagnosis and repair became an integral part of MM. The maintainer's job gradually came to require less craft skill and more diagnostic ability. Maintenance, however, continued to be performed by craftsmen, who originally learned as apprentices by watching and imitating their masters. As the actual job became more diagnostic, apprentice training was progressively centralized into craft schools, the "watch and learn" method having become inadequate for skill development in a reasonable time. As a result, poor quality maintenance, particularly where craft skill is still required, became and remains a problem (Sherwin and Lees, 1980).

Operational research (OR) then took centre stage. OR was defined by its originators as, "the application of scientific method to operational problems" where using scientific method, that is, inductive reasoning and calculations based upon real-life data, they worked out which maintenance activity should be dropped and which routines could be done at what increased intervals. This was first applied to maintenance in the Second World War and eventually, resulted in the genesis of models. According to Ascher and Feingold, (1984); Sherwin, (1997), true OR analyses the problem first and bases the model upon the realities found. However, the prevalence of these models, some of them unusable then, arguably prejudiced the maintenance engineering profession against optimization in general, and pushed it towards softer and less sound methods such as reliability centered maintenance (RCM) (Sherwin, 2000).

Then the issue of striking the balance between Supervision and computers became a herculean task. It is that issue which recorded unfortunately, the first period (1960-1975)

of rapidly-expanding interest from non-engineers and engineers with statistical knowledge, coincided with the need for more supervision, and that this also happened when the supervisors were driven indoors by increasing paperwork demands stemming from the need to feed data into the computers. Sherwin (2000) further added that, manuals and (re-)training became essential from that period onwards. This was because the rate of advance of technology eventually became too rapid for a skilled technician to complete a working life of around 40 years without training and retraining. It soon became necessary to bridge the dichotomy between scheduling, planning and computers. Other concepts and adaptations also became necessary. For instance reliability engineering dominated by reliability rather than maintainability and availability. Also, maintenance and safety where periodic maintenance was first prescribed to improve safety rather than to increase availability or reduce costs also emerged.

It has lately become fashionable again to measure the performance of maintenance departments by means of dimensionless ratios such as, cost over sales, or profit. This actually has quite a long history (Priel, 1974). Some writers, notably Dwight (1998), have tried to take this delayed impact effect into account, but most do not even acknowledge that it exists. The author's view is that, such overall comparisons can too easily be doctored by ambitious managers, and in any case distract attention from the need to gather data at the component level, analyze it and optimize the schedules.

An alternative view of recent maintenance history and a more thorough review of maintenance management literature were compiled by Kelly (1989). Pintelon et al.

(1997) view the history as a progression from a production task and a “necessary evil” in 1940-1950, to special maintenance departments, “technical specialization” in 1960-1970, to efforts at integration, “profit contributor” (1980-1990), with external and internal partnerships' “positive co-operation” as the latest trend.

Until fairly recently maintenance theory was non-existent and in the meantime, technology was developing at a pace which made present maintenance practices obsolete. As possible maintenance “solutions” thus became available, they were seized by hungry maintenance practitioners to solve their seemingly non-solvable situation (Coetzee, 1999). Pintelon and Gelders, (1992); Crespo Ma´rquez et al,(2009) reported that since approximately three decades, companies (organizations and institutions) realized that if they wanted to manage maintenance adequately it would be necessary to include it in the general scheme of the organization and to manage it in interaction with other functions.

2.3.2 Maintenance Management Defined

Management, according to the Webster’s Dictionary, is described as the process of leading and directing all or part of an organization, often a business one through the deployment and manipulation of resources (human, financial, material, intellectual or intangible). Crespo Marquez (2007) also suggested that management functionally is the action of measuring a quantity on a regular basis and adjusting an initial plan and the actions taken to reach one’s intended goal. Other authors also describe management of any process to entail assessing performance and maintenance management is no exception (Turrell, 1997; Adenuga et al, 2007).

Wireman (1998, cited in Bivona and Montemaggiore, 2005) defined Maintenance management as, the management of all assets owned by a company, based on maximizing the return on investment. To this end, Allen (1993) and Zulkarnain et al. (2011) opined that, maintenance management encompasses many operations and functions and can be described as "the effective and efficient utilization of resources to ensure that the process and its facilities are kept operable to a standard required by the users". Maintenance management is a medium provider and operator that oversee the components related to building condition and services installation so as to ensure it can perform at the optimum level (Zulkarnain et al, 2011).

The acceptable definition adopted for maintenance management as stated by Crespo Marquez (2007) is, all the activities of management that determine the maintenance objectives or priorities (defined as targets assigned and accepted by management and maintenance department), strategies (defined as a management method in order to achieve maintenance objectives), and responsibilities and implement them by means such as maintenance planning, maintenance control and supervision, and several improving methods including aspects in the organization. Maintenance management therefore involves decision making by organizations (management, maintenance manager) under multiple objectives and uncertainty, in addition to budgetary constraints (Lounis & Vanier, 2000; Farinloye et al, 2011) so that, buildings, equipment, and installations can be maintained in a more cost effective manner and perform efficiently.

2.3.3 Factors Affecting Maintenance Management

The requirements for good practice in maintenance management of building stock have been established over a considerable period and the achievement of good practice is by no means universal (Turrell, 1997). In order for any maintenance manager to measure performance and set priorities, the organizational needs have to be considered that is, the function and performance of buildings and their appropriate standards will be independent on the user's perception and their primary needs (Chanter and Swallow, 1996). This underscores the importance of sequencing in maintenance management.

The quality and efficiency of MM operations of buildings, assets and other infrastructure depend to some extent, on the condition information of the buildings or what is to be maintained, the expectation from the sector or organization and the works carried out for each maintenance activity (Zulkarnain et al, 2011). A number of studies have identified a gap between organizational strategy and maintenance strategy, which may hinder organizational efficiency. This has often been blamed on maintenance staffs for relying too much on their technical experience and behaviour and, for not connecting with core business objectives (Lee and Scott, 2008). It could also be attributed to confusing and unrelated core business objectives that give little scope to building maintenance.

According to Hicks (2004), some companies (organizations and institutions) have not even realized the benefits of having written missions, visions, goals, objectives for their maintenance division. In cases where they have done so, they have focused mainly on cost (Lee and Scott, 2008). Such a culture can create a dysfunctional maintenance

division that has no business orientation. Conversely, where an organization has too many procedures, this may in turn, hinder the worker's sense of originality, innovation and initiative (Njuangang and Liyanage, 2012).

The selection of a maintenance system to be operated in the building should take into consideration the life cycle of the building materials, services, installation provided, space function or activities to be carried out in that particular building. In some cases, when the material has reached the 'wear and tear' condition, the maintenance work is then required to rectify those defects (Zulkarnain et al, 2011). From literature, maintenance management is affected by factors such as organizational needs and strategies, building or infrastructure status information relevant for maintenance planning, poor or no linkage between organizational strategies and the organization's maintenance strategy. Other factors identified from the literature are absence or poor vision on maintenance for organizations, and the choice of maintenance strategies without adequate recourse to life cycle considerations for materials, services and even the accommodation spaces.

2.4 MAINTENANCE MANAGEMENT POLICIES

2.4.1 Definition of Maintenance Management Policy

BS3811 defines maintenance policy as a strategy within which decisions on maintenance are taken. It can be defined as the ground rules for the allocation of resources between the alternative types of maintenance actions that are available to management. MM policies entail decisions made on the allocation of human, material and monetary resources

(Reginald Lee, 1983; Aris, 2006). Thus, a maintenance management policy is a wider perspective of maintenance strategies that require management decisions on the policy's implementation.

2.4.2 Maintenance Management Policies

The types of maintenance management policies are directly linked to the maintenance strategy employed by management to execute maintenance activities. BS3811 described maintenance policy as being a strategy within which maintenance decisions are taken. Coetzee (1999) opined that, a maintenance policy determines the detailed design of the maintenance process for the specific organization.

According to Pintelon et al (2006) maintenance management policies can categorized into corrective maintenance (CM), preventive maintenance (PM) and predictive maintenance (PDM). They further explained that these policies sometimes include other maintenance concepts like total productive maintenance (TPM) and reliability centered maintenance (RCM). Swanson (2001) identified three types of maintenance strategies namely; Reactive strategy, Proactive strategy, and Aggressive strategy.

Pintelon et al. (2006) described these strategies of Swanson as follows; reactive strategy as corrective maintenance (CM); proactive strategy as preventive maintenance (PM) & predictive maintenance (PDM); while the aggressive strategy they described as total productive maintenance (TPM). Pintelon et al. (2006) further cited Tsang (2002), Bevilacqua and Braglia (2000) and Kevin and Penlesky (1988) as having divergent views on how maintenance policies should be handled. For instance Kevin and Penlesky (1988)

see maintenance strategy as a mix of elements, Tsang (2002) suggests that four dimensions make up the strategy: 1) Service-delivery options; 2) Organization and work structuring; 3) Maintenance methodology; and 4) Support systems. However Bevilacqua and Braglia (2000) as cited in Pintelon et al. (2006) consider maintenance policy as a separate strategy. Literature however acknowledged the different approaches applicable to maintenance management.

2.5 MAINTENANCE MANAGEMENT PROCESS/METHODOLOGY

2.5.1 The MM Process

Every maintenance organization engages in some processes or approaches to carry out maintenance work. These processes are based on concepts such as, reliability centered maintenance (RCM), condition based maintenance (CBM), and computerized maintenance management system (CMMS). Soderholm et al. (2007) explained maintenance process to contain four main activities; *maintenance planning, maintenance execution; functional testing; and feedback*. Geraerds (1990) however noted that the haphazard manner in which they are introduced is a certain formula for sub-optimality. Coetzee (1999) also identified that there is an increasing inefficiency with the implementation of these processes.

A number of other literature have cited the lack of understanding of the maintenance management process among school administrators as the bane for designing and developing good maintenance programmes for their schools (Aller, 2002; Agron, 2006;

Akasah et al 2010). Hence, two MM processes have been considered in this research and discussed under the following sub-headings;

- Maintenance management process as described by Coetzee (1999)
- Maintenance management process as described by Crespo Marquez (2007)

2.5.2 Maintenance Management Process by Coetzee

Coetzee (1999) described the MM process to contain two main processes, namely; a strategic process and an operational process. The strategic process according to the Figure 2.2 consists of managerial planning and measurement processes. The management planning process is made up of maintenance policy, procedures, objectives and business planning. According to Coetzee (1999) the implementation of the policy and procedures takes place through a regular setting of objectives and business planning process. The objectives are aimed at bridging the gap between the policy (and procedures) and the actual operating practices, while business planning ensures that the organizational design, facilities, resource planning and the budget are in step with the results envisaged through the policy, procedures and objectives.

The second main process according to the model is the operational process which contains the maintenance plan, maintenance operations, maintenance information as well as maintenance history. Coetzee explains that these sub-processes are utilized in maintenance operations such as preventive and corrective maintenances, and also for improving the maintenance plan on regular basis. He also acknowledged that both

strategic and operational processes are not limited to a certain level of management but each managerial level contributes to both processes.

Coetzee's views on the maintenance management process emphasized that MM is a process that is systematic with different sub-processes that must work together for efficiency.

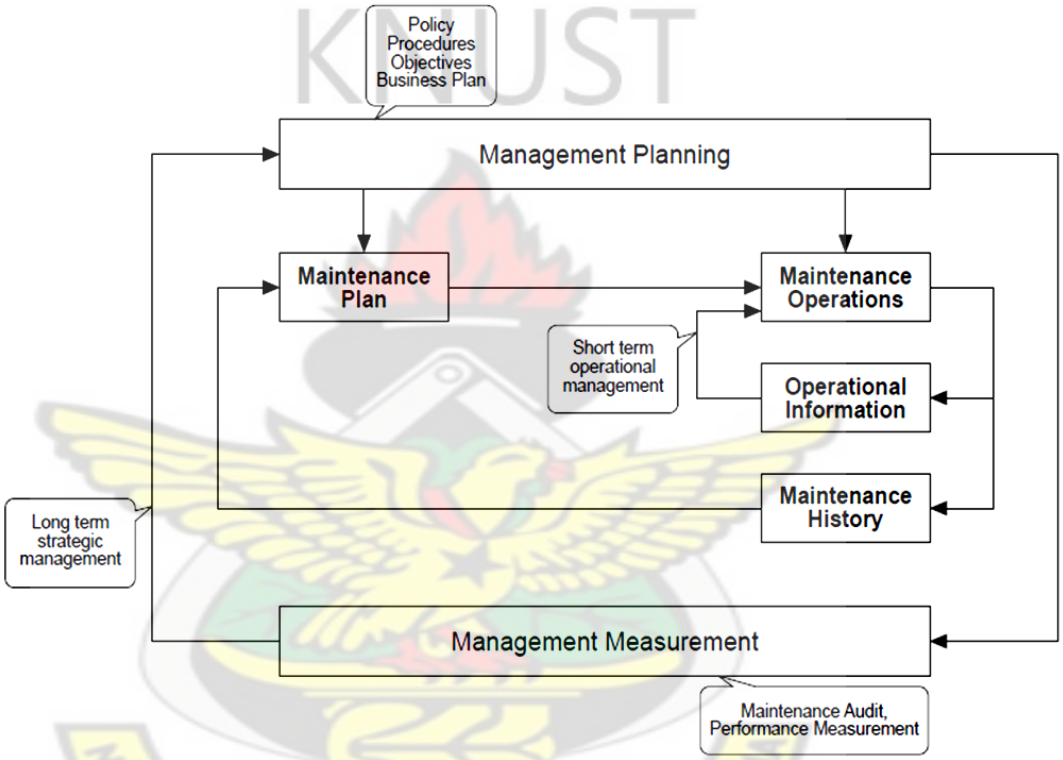


Figure 2.2: The maintenance cycle

Source: Coetzee (1999)

2.5.3 Maintenance Management Process by Crespo Marquez

Crespo Marquez (2007) referred to maintenance management process as the course of action and the series of stages or steps to follow in order to manage maintenance properly. He went on to describe maintenance management process generically as consisting of sequential management steps outlined below;

i. *Asset management planning;* this involves

- Identify the asset
- Prioritize the asset according to maintenance strategy
- Identify its performance requirements according strategy
- Evaluate the asset's current performance
- Plan for its maintenance

ii. *Schedule maintenance operations;*

- Schedule maintenance operations
- Manage maintenance actions execution (including data gathering and processing)
- Assess maintenance
- Ensure continuous improvement
- Consider the possibility of equipment and facility re-design or refurbishment.

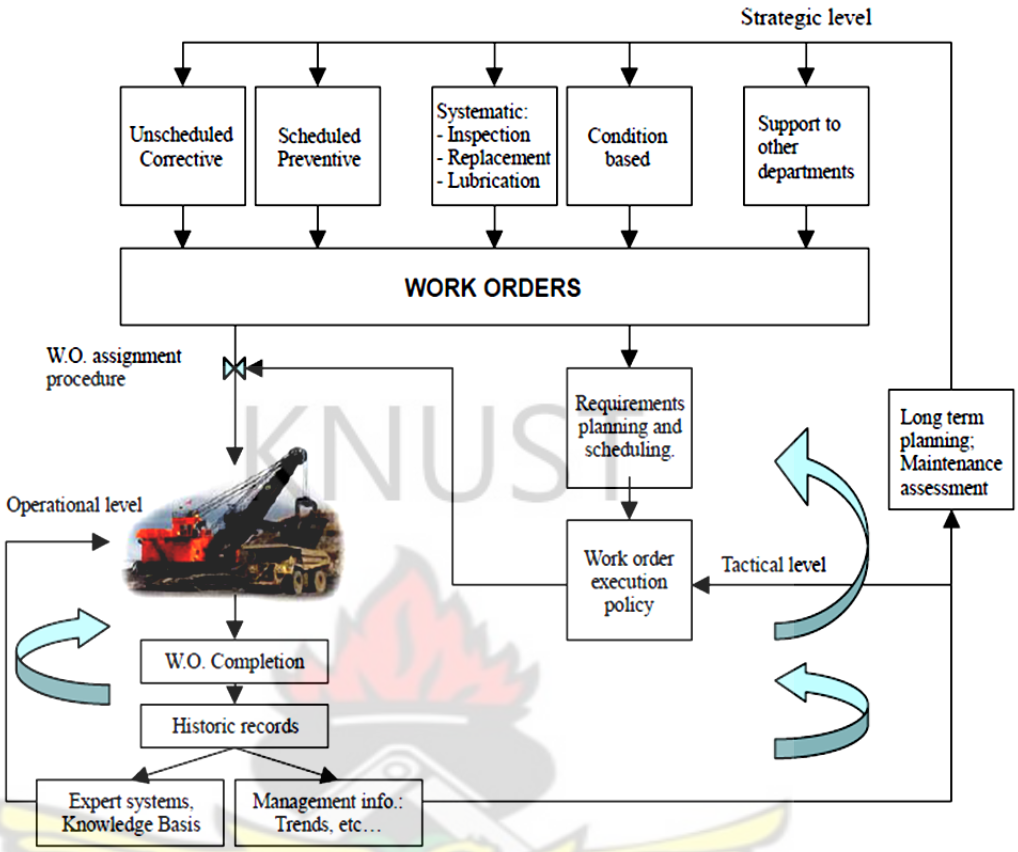


Figure 2.3: Maintenance management process

Source: Crespo and Gupta (2006)

2.6 MAINTENANCE PLANNING

One major element of the maintenance process is maintenance planning. Crespo Marquez (2007) explained that, maintenance planning is an activity employed to prepare the maintenance plan. According to the European Committee for Standardization, EN 13306:2001; the maintenance plan is made up of structured sets of tasks that include activities, procedures, resources and the time scale required to carry out maintenance. The development of the maintenance plan cannot be said to be without challenges. Jones and Sharp (2007) observed that, maintenance planning process is driven by

organizational policies which too often have unclear objectives and without direct links between the organization's strategic objectives and their built asset maintenance programmes.

Wordsworth (2001) developed a linkage between policy, modeling, planning, and action on the maintenance process. Wordsworth (2001) proposed that, the maintenance planning stage should prioritize options on maintenance activities and develop specific strategies, whilst making room for contingency. He proposed that maintenance planning requires technical information such as survey data on the condition of stock (facilities), budgetary data and other technical specifications relevant for modeling and onward strategizing should result in an effective maintenance management process. Figure 2.4 outlines the maintenance process by Wordsworth.

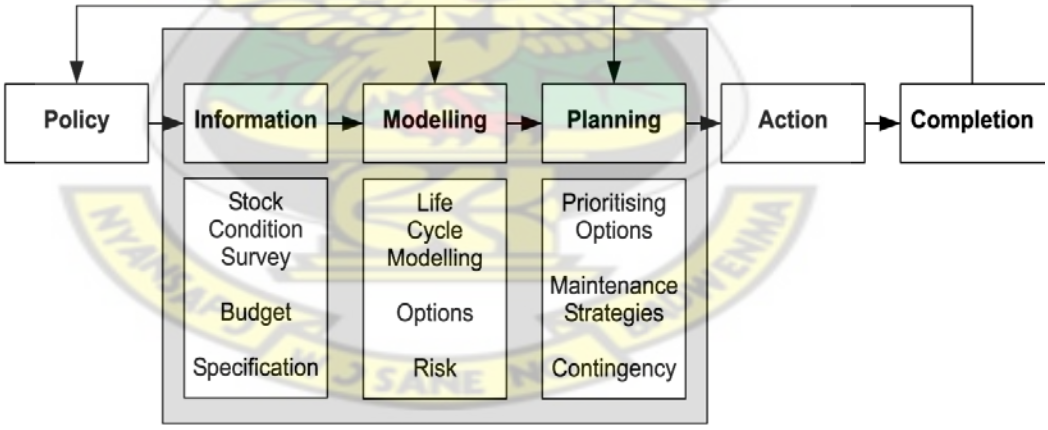


Figure 2.4: Maintenance process model
Source: Wordsworth (2001)

2.7 MAINTENANCE MANAGEMENT (MM) MODELS

2.7.1 Maintenance management model defined

Many authors (Pintelon and Gelders, 1992; Vanneste and Van Wassenhove, 1995; Wireman, 1998; Hassanain et al., 2001; Crespo Marquez et al., 2009) have proposed various descriptions to maintenance management model based on different variables and processes centered on a common goal of achieving efficiency. Efficiency is acting or producing with minimum waste, expense or unnecessary effort (Crespo Marquez et al., 2009).

A maintenance management model or framework is described as, the essential supporting structure and the basic system required for managing maintenance. The *supporting structure* in the model is also referred to as the distinct technological support to the maintenance process, consisting of a set of various tasks that must be accomplished on a day-to-day basis to manage maintenance (Crespo Marquez and Gupta, 2003; 2004). Lateef et al. (2010) also defined MM model as a decision-making framework for the maintenance of buildings and facilities. MM model therefore serves as a guide to management strategies, actions and plans in order to manage maintenance in the organization.

2.7.2 Components of a Maintenance Management Model

As identified earlier, literature revealed that there are various components or building blocks that make up a MM model. However, for the discussion here the model proposed

by Hassanain et al. (2001) will be used. The components of their model include five sequential management steps:

i. Identify the asset
ii. Identify its performance requirements
iii. Assess the asset's current performance,
iv. Plan for its maintenance, and
v. Manage the maintenance operations.

These five management steps are common to other models that have been integrated to produce generic MM models for the improvement of maintenance management.

2.8 CASE STUDIES ON SELECTED MAINTENANCE MANAGEMENT MODELS

2.8.1 Maintenance Management Model (Crespo Marquez et al.)

This maintenance management model proposed by Crespo Marquez et al. (2009) consists of eight sequential management building blocks, appropriate for built and in-use assets. The building blocks are categorized as phases grouped under effectiveness, efficiency, assessment and improvement.

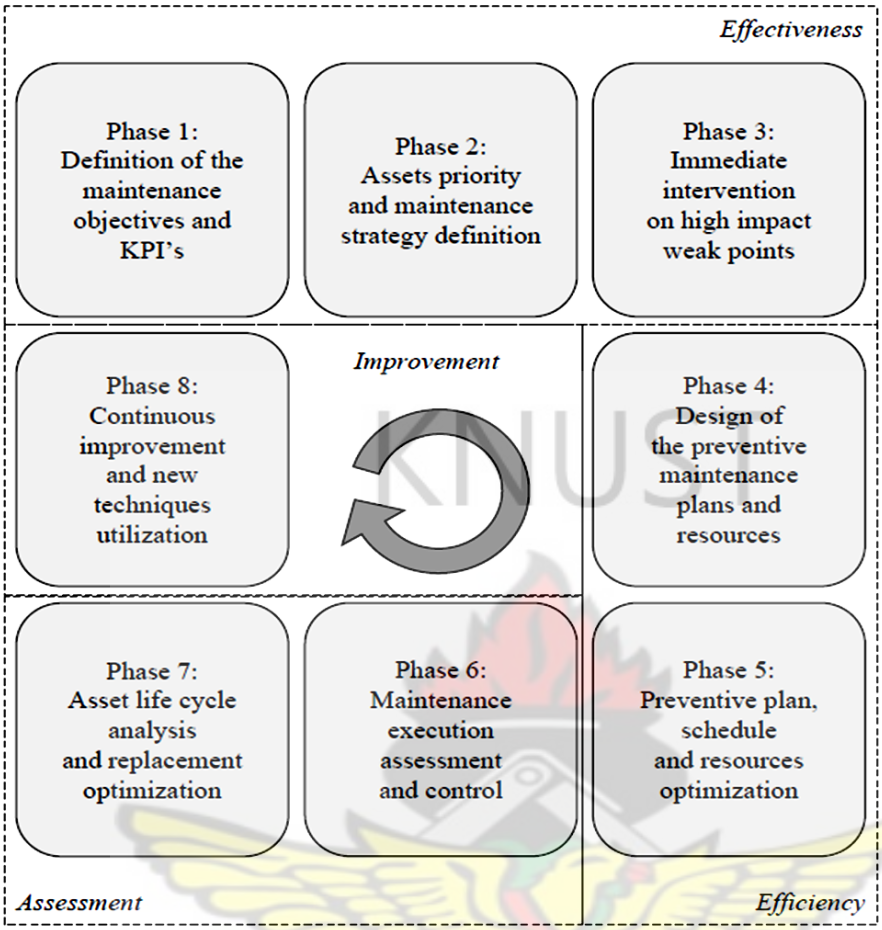


Figure 2.5: Maintenance Management Model

Source: Crespo Marquez et al. (2009)

As shown in Figure 2.5, in order for the MM model to achieve effectiveness in maintenance, the maintenance objectives and key performance indicators (KPIs) should be identified and defined, assets prioritized, maintenance strategy defined, as well as undertaking immediate intervention on high impact weak points. Phases 4 and 5 of the model are responsible for efficiency if utilized well. They include design of preventive maintenance plans, schedules, resource planning and optimization. The authors devoted phases 6 and 7 to life cycle cost assessment of the asset(s) and maintenance execution.

They acknowledged that, the number of assets potentially at risk out-weighs the resources available to manage them and hence the need for critical asset assessment to establish priorities and resource allocation for effectiveness in maintenance operations (Crespo Marquez et al, 2009). Phase 8 of the model is tailored to bring improvement to the model and the MM practices in general. This is achieved by the continuous review of the various components of the model regarding new technologies and technique utilization for maintenance and maintenance management.

This model is suitable for preventive maintenance management; however it makes provision for other forms of maintenance management. The model is also designed with a participatory process to involve all stakeholders both internal and external, senior management, key personnel of the maintenance unit/department, and the users. Tsang (1999) emphasized that this approach results in high performance outcomes for the maintenance operation. It is worth noting that Soderholm et al (2007) opined that stakeholder requirements are expressed in terms of the needs, wants, desires, expectations and perceived constraints of identified stakeholders. These requirements however, are subject to change (Juran, 1992; Kotonya and Sommerville, 1998; Herzwurm and Schockert, 2003) and they should be catered for in the model which Crespo Marquez et al have successfully done.

2.8.2 Maintenance Management Model for Schools (Akasah and Amirudin)

The maintenance management model developed for school buildings consists of six main components or steps namely;

- A1: Determine building status
- A2: Evaluate and Estimate defects
- A3: Perform Maintenance Assessment
- A4: Plan maintenance activities
- A5: Implement the maintenance plan
- A6: Evaluate and report on maintenance.

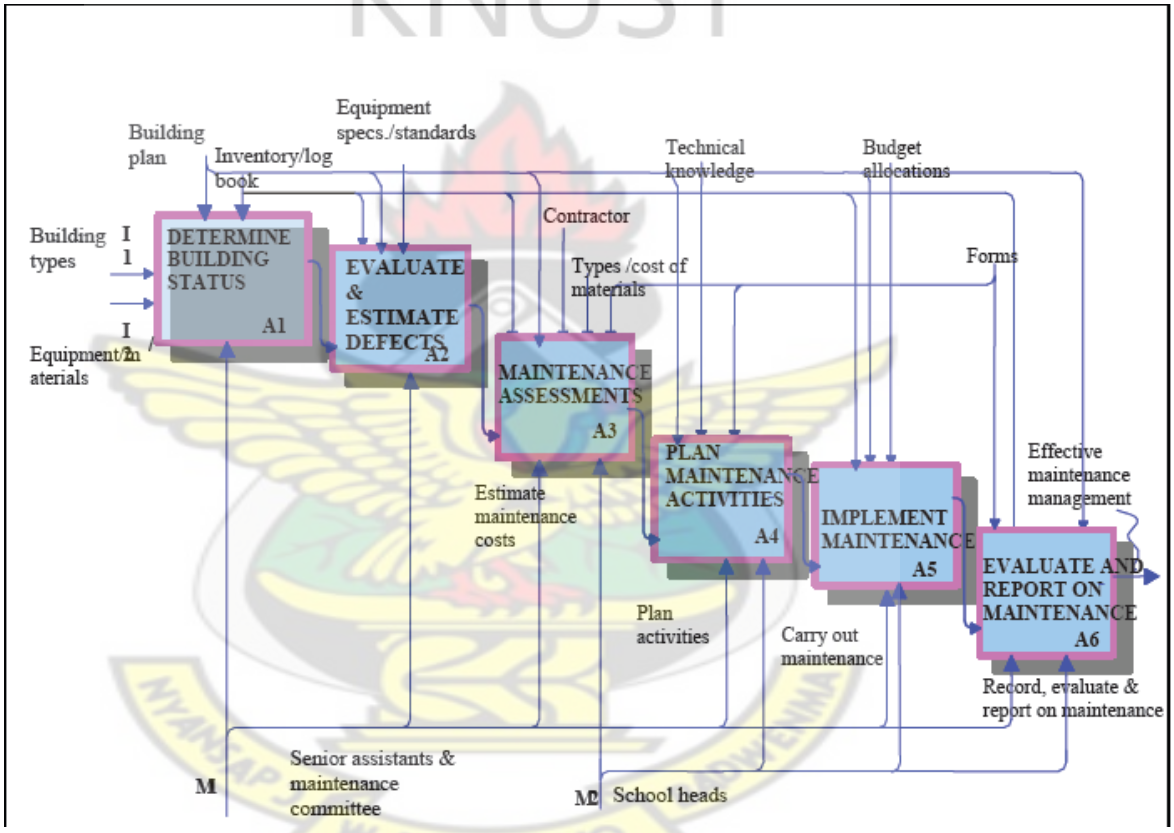


Figure 2.6: Maintenance Management Model for Schools

Source: Akasah and Amirudin (2010)

The steps in the model are explained below;

- *Step A1* involves determination of the maintenance status of the building. The model suggests an inventory of the building status to be carried out, using relevant

tools and equipment, building drawings, and the log book from the maintenance unit/department. The maintenance unit/department is responsible for meeting the requirements of Step A1.

- *Step A2* is the second step which involves evaluation of the data collected in order to establish and estimate the defects that require maintenance. The senior assistants/deputy heads and the maintenance committees undertake the evaluation.
- *Step A3* is the third stage of this model, where management performs maintenance assessment to establish the type and cost of materials required for the maintenance. Management also considers contracting options depending on the scale and cost involved. Cost and material assessment is carried out by the maintenance unit and reported to the school head(s) for the necessary action.
- *Step A4* marks the planning stage for maintenance activities. A high level of technical knowledge is required at this stage to prepare implementable maintenance plans. This is carried out by the maintenance unit/department and reported to the school head(s).
- *Step A5* is the implementation stage where the maintenance plans are implemented. Akasah & Amirudin emphasized that, this is a critical stage since it involves budgetary allocation and financial appropriateness by school heads. The success of this implementation or otherwise is also hinged on availability of funds.
- *Step A6* is a measure of the effectiveness of the maintenance management procedures/process. Here, the process is evaluated and presented in a report form to management regarding the maintenance.

The MM model by Akasah et al. has activities decentralized to involve various management levels in the school, which is good for efficiency. However, the level of involvement of users and other stakeholders like Parent-Teacher Associations (P.T.A) and students have not been clearly defined in the model. Another highlight is the performance assessment carried out on the entire maintenance process at the end of the implementation. Since this model is mainly designed for condition based maintenance, Finch (1998) argued that it will at best allow the building capacity to return to its original condition. Finch further stated that increased functional and technology demands on the building will result in an obsolescence gap, which when unchecked periodically will ultimately lead the building to its demise. This model however, lacks clear cut interventions on proactive/preventive maintenance policy to guide the maintenance management process in order to address the obsolescence gap.

2.9 INNOVATIONS IN MAINTENANCE MANAGEMENT

MM practitioners and stakeholders worldwide (in various fields including academics and industry) have over the years, sought improved and innovative ways of carrying out maintenance. Wood (2005), citing earlier researches outlined the following innovative maintenance practices identified.

- Just-in-time maintenance (Smyth and Wood, 1995);
- Intelligent building maintenance (Wood, 1999a);
- Call centered maintenance (Wood, 1999b); and
- Sustainable building maintenance (Wood, 1999c).

- *Just in time maintenance* is defined as "getting the maximum life from each building component or piece of equipment and leaving repair or replacement until the component is broken or fails to function. Action is however taken prior to it having a serious effect upon the performance of the organization".
- *Intelligent building maintenance* as stipulated by Wood (2005), relates to the use of intelligence in MM. Wood explained further that, while technology enables building services to be monitored and controlled by sensors, the application of intelligence implies a more thoughtful response. This involves the identification of information from data, relating it to the creation of comfortable environmental conditions for building occupants.
- *Call centered maintenance* identified the key role of a call centre in providing a responsive maintenance regime. The process requires the call receiver to identify from the caller, using a script and "repair finder" software, the precise nature of the problem and to call up an appropriate response. An appointment is made and the operative booked online.
- *Sustainable building maintenance* applies to maintenance operations considerations of both the sustainability of the building and sustainability of the operations. Wood (1999c) further stated that, the costs of maintenance and operation of a building are several times greater than the initial construction cost and it therefore makes sense to consider investing in more expensive materials and components if they are more durable.

The dynamism with which maintenance innovation is evolving as shown in the above concepts is an indication of the need for maintenance to be given more priority.

2.10 SUMMARY

This chapter presented a review of literature relating to maintenance management, infrastructure in SHSs, an overview of maintenance and MM, policies and MM models, among others. It also documented case studies of MM models. These include models developed by Akasah and Amirudin (2010), Reliability Centered Maintenance (RCM) model by Crespo Marquez (2007) among others.

The next chapter, 3 deals with the research methodology employed in the entire research process.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 INTRODUCTION

This research seeks to develop a maintenance management framework (MMF) to enhance the maintenance practices of Senior High Schools (SHSs) in Ghana. Four objectives were tailored to assist in the realization of the main aim. These objectives are inter-related and are outlined in the following:

- To map the evolution, emerging trends and best practices of MM within the construction industry;
- To develop a snap shot of existing MM practices prevalent in Ghanaian SHSs;
- To determine the underlying inefficiencies inherent in the current MM practices in SHSs in Ghana; and
- To design a procedural framework to assist Ghanaian SHSs enhance their MM practices.

This chapter presents the methodology employed for the study, geared towards achieving the main objective of the research. The methodology basically outlines the overall approach to the research linked to the paradigm or theoretical framework, including the methods. Methods in this context refer to systematic modes, procedures or tools used for collection and analysis of data in any research endeavour (Mackenzie and Knipe, 2006).

Fellows and Liu (2008) further described research methodology as the principles and procedures of logical thought processes which are applied to a scientific investigation.

This section sets off with a discussion on the design of the study which encompasses the philosophical considerations and research paradigms and then proceeds with the research approach adopted for the research. The chapter also outlines the choice of research strategy and process. Details of the processes and techniques which were utilized in the data collection, including the design of the instruments, sample frame and selection of the sample size is presented. Finally, data analysis, interpretation of the findings, as well as the procedure for the design of the MM framework is also discussed.

3.1 DESIGN OF THE STUDY

Research design refers to the general structure which serves as a guide in the collection and analyses of data, and the techniques involved and employed in the research. The design of the research is not merely a work plan that details what has to be done to complete a project but the work plan will flow from the project's research design (De Vaus, 2001; Yin, 2003). A research design deals with a logical problem following a logical structure of inquiry and ensures that the evidence obtained enables one to answer the initial research question as unambiguously as possible and also attain the main objective of the research (De Vaus, 2001; Yin, 2003).

Design of the research encompasses decisions from broad assumptions to detailed methods of data collection. The research work plan flows from this and design matters

must be outlined right from the beginning of the process (Bryman, 2008). These decisions on the plan and procedure for the research must be designed by the researcher based on the nature of the research problem and the researchers' personal experiences. Bryman, (2008) further explained that the research design in essence answers three key questions: *What* the underlying assumptions are; *how* the research will be conducted; and *why* the selected design is the best option for the study.

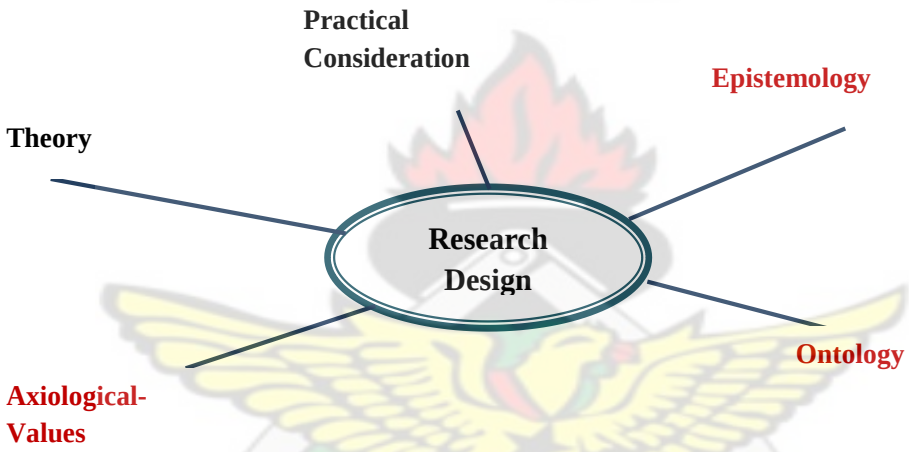


Figure 3.1: Influences on Research Design

Source: Bryman (2008)

Figure 3.1 demonstrates the major influences on research design. These influences include practical consideration, theory and research philosophies. For instance, practical considerations such as the research topic, the people being investigated and the availability of data are essential and have an impact on the research design. Creswell (2008) described the framework for design of research to comprise philosophical worldviews, selected research strategies and research techniques and procedures, where the research philosophy guides the research.

The ensuing discussion will outline the components of the research design which include philosophical considerations, research paradigms and the philosophical position of the research.

3.1.1 Philosophical Considerations

The philosophical stance of any research work has a major impact on how the research is conducted. To this end, Easterby-Smith et al (2002; 2008) argued that the absence of an underlying research philosophy will negatively affect the quality of the output of the research in question. According to Flowers (2009), the consideration of philosophical issues especially relating to ontology and epistemology as well as research paradigms are of paramount importance to any research since these parameters describe perceptions, beliefs, assumptions, and the nature of reality and truth (i.e. knowledge of that reality). These parameters however can influence the research process and choices from inception through to conclusion of the research.

Research philosophy relates to a set of beliefs that guides and dictates how research should be carried out and how the results should be interpreted. Research philosophy entails important underlying assumptions about the general orientation of the worldview the researcher holds (Creswell, 2008). These underlying assumptions, epistemological, ontological and axiological considerations, often lead researchers to adopt a particular philosophy.

The term epistemology is associated with an aspect of philosophy that deals with how knowledge is obtained. An epistemological issue is one concerned with what is (or should be) regarded as acceptable knowledge (Collis and Hussey, 2003; Bryman, 2008) and in addition, epistemology explains theories on how to obtain knowledge about the world (Ryen, 2008). There are two major distinct viewpoints of the epistemological stance. These are positivism and interpretivism (Bryman, 2004). Proponents of positivism hold the view that, scientific processes and techniques can be applied to the study of society and that only phenomenon which can be observed and measured can be regarded as valid knowledge. Interpretivists on the other hand, believe that social phenomenon does not necessarily follow the natural science model and that knowledge is based on the perception of individuals.

The root definition of ontology as described by Blaikie (1993) is 'the science of being'. Ontology is a theory regarding social phenomenon which deals with the nature of reality and the assumptions researchers have concerning the way the world operates and the commitment held to a particular view. It considers issues such as what reality is, what it is made up of, how it is perceived and what there is to know about reality (Ryen, 2008; Saunders, Lewis and Thornhill, 2009). The nature of reality however, could be perceived as an objective reality that actually exists or subjective reality, created in one's mind. This brings to bare the two main categories of ontology which are objectivism and subjectivism (also referred to as constructivism) with realism and idealism being the two extremes (Hatch and Cunliffe, 2006; Flowers, 2009; Saunders et al., 2009). Objectivism is that aspect of the body of knowledge regarding reality which is skewed towards a

description, external to social actors. That is, phenomenon and their meanings exist beyond the influence of social actors. Subjectivism on the other hand asserts that phenomenon and their meanings are a construction by social actors and that the social world is an integral part of what exists in an individual's mind. Reality here is a production through social interaction and is constantly being reviewed (Bryman. 2008; Saunders et al., 2009).

The other consideration which aids in the adoption of a particular philosophy relates to axiology. Axiological assumptions deal with judgments concerning human values. The role that a researcher's values play during the research process is important since it influences the credibility of the research in question (Saunders et al., 2009). Human values guide all human action and researchers portray their value judgments by their ability to integrate these values in their research (Heron, 1996 cited in Saunders et al., 2009). The axiological assumption could be value free, where the researcher is detached from the research process or have values embedded in the research process such that, the researcher is involved. Saunders et al. (2009) further explained that clarity about a value position helps in the decision regarding what is ethically appropriate.

These philosophical assumptions are related such that one's view of ontology affects the epistemological persuasion which in turn affects the axiological stance (Holden and Lynch, 2004). The guiding philosophical assumption will ultimately determine the research paradigm and subsequently the methods and methodology to be adopted for the research.

3.1.2 Research Paradigms

According to Fellows and Liu, (2008) a paradigm is a framework which serves as a lens through which people view events and happenings. Paradigms operate to determine the views that are adopted as well as the approach to questioning and discovery. They further observed that, verification and explanation of expected and unexpected results is necessary to accord with the adopted paradigm(s). Saunders et al. (2009) also posited that, the term paradigm has several meanings and as a result can lead to confusion. This study therefore adopted the definition that; *"A research paradigm is a way of examining social phenomena from which particular understandings of these phenomena can be gained and explanations attempted"* (Saunders et al. 2009, p.118).

Researchers such as Easterby-Smith et al. (2002; 2008) and Fellows and Liu (2008), identified two main paradigms frequently used in social science research. These are positivism and interpretivism. Interpretivism is also referred to as constructivism. Flowers (2009) however included realism as part of the paradigms with the argument that there are three key paradigms prevalent in management research. These include the positivist, interpretivist and realist paradigms which form the basis from which other paradigms are derived. Saunders et al (2009) on the other hand, outlined four main research paradigms commonly used in management research, with an addition of pragmatism as the fourth paradigm to the three mentioned earlier.

Positivism has its root from natural science and asserts that observable facts can be observed and measured by an observer without being influenced by the observation or

measurement. Interpretivism, sometimes referred to as anti-positivist, contends that there is a dichotomy between the social world and natural science and that individuals and groups shape their world and derive meanings based on their experiences and construct meanings which result in differing interpretations (Hatch and Cunliffe, 2006; Fellows and Liu, 2008; Flowers, 2009). Hence the observer and the observed cannot be isolated. The realism paradigm relates to the natural science system of enquiry based on the view that real structures exist without any influence from human consciousness but what the senses portray as reality is the truth.Pragmatists however advocate that, the research question(s) that the research seeks to answer is the key determinant of the research philosophy to adopt.

Table, 3.1 outlines a comparison of the four major research paradigms in management research by Saunders et al. (2009). This comparison summarizes the distinction between the four main paradigms based on the various philosophies; namely ontology, epistemology and axiology with additions on corresponding data collection techniques suitable for the paradigm. Knowledge of these paradigms goes a long way to shape the entire research process. The four major paradigms outlined in table 3.1 have distinct philosophical assumptions guiding the various stages of research. Data collection methods and techniques, analysis of findings and interpretation of results hereafter are guided, primarily on the research paradigm adopted for any given study.

Table 3.1: Research Philosophies and Paradigms

	Positivism	Realism	Interpretivism	Pragmatism
Ontology: the researcher's view of the nature of reality or being	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence, but is interpreted through social conditioning	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: the researcher's view regarding what constitutes acceptable knowledge	Only observable phenomenon can provide credible data, facts. Focus on causality and law like generalizations, reducing phenomenon to simplest elements	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations. Alternatively, phenomena create sensations which are open to misinterpretation. Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: the researcher's view of the role of values in research	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by worldviews, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Source: Adopted from Saunders et al. (2009)

3.1.3 Research Paradigm Adopted

In determining the research paradigm to adopt for this study, the philosophical assumptions relating to ontology, epistemology and axiology were considered. As mentioned earlier in section 3.1.1, the philosophical stance of any research impacts greatly on how the research is carried out and also guides the entire process. The philosophical inclination will subsequently dictate which paradigm to adopt. Pathirage et al. (2008) citing Easterby-Smith et al. (2003) posited that, issues regarding philosophy are fundamental and actually constitute the core of research design. Therefore, failure to carefully consider these issues can affect the quality of a research. Table 3.1 in section 3.1.2, summarizes four main paradigmatic distinctions between the aforementioned philosophical schools which were considered.

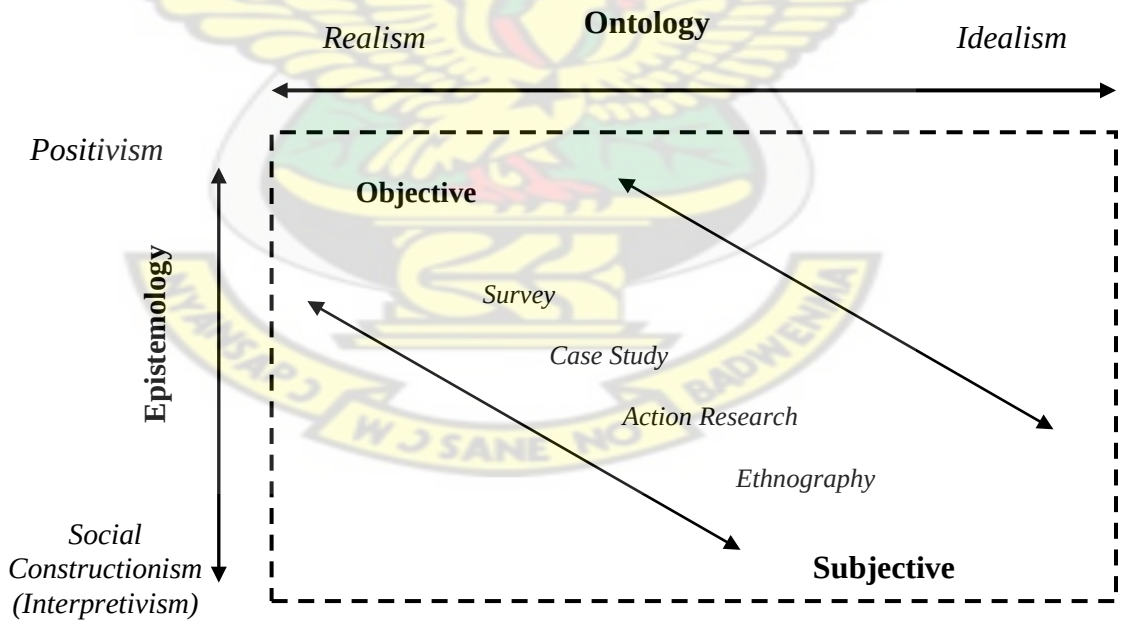


Figure 3.2: Dimensions of research philosophy

Source: Sexton, (2004 in Pathirage, 2008)

Also, Figure 3.2 above depicts the various dimensions of research philosophy identified by Sexton, (2004, cited in Pathirage, 2008). Here, the philosophical assumptions, paradigms, and the accompanying methods that were taken into consideration are outlined.

As noted in section 3.1, the aim of any particular research endeavour plays a major role in the choices regarding philosophies, methodologies and methods. It influences to a large extent, the philosophical and the inherent paradigm the research has to be inclined in order to attain optimal results and most importantly, achieve the aim and objectives. In this vein, this study seeks primarily to develop a maintenance management framework (MMF) for educational institutions in Ghana; particularly SHSs. Hence, the aspect of the formulation of a framework which is for purposes of adoption and replication was looked at and the most suitable philosophical paradigm, methodology and methods taken into consideration.

Researchers like Blaikie, (2004); Pathirage et al., (2008); Flowers, (2009) opined that the interpretivist-idealist tradition is appropriate for research in social science, management and some aspects of the built environment. Another school of thought also posited that, scientific methods can be appropriate depending on the key research question, aim and objectives the research sets out to accomplish. For instance, Ahadzie (2007) observed that even though there are criticisms regarding the use of the positivist tradition in social research, there is a consensus among some authors that the approach and methods remain reasonably valid and reliable.

The main aim of this research is to develop a MMF which requires an objective and value-free position of the researcher (see Saunders et al., 2009). After considering the philosophical assumptions and dimensions relating to ontology, epistemology and axiology together with the key features of the major paradigms, an inclination to the positivist tradition emerged the most appropriate for this research. To this end, this study adopted a positivist epistemological position and leaned slightly towards a realist ontological position. The realism tradition which was adopted in this case, agrees with the view of Saunders et al. (2009) that though objective in nature, reality is interpreted through social conditioning. Hence, qualitative approaches can also be employed during the data collection process. With regards to axiology, the research was undertaken in a value-free way; where the researcher was independent of the data and maintained an objective stance. This was necessary for eliciting objective primary data on the subject being studied from the respondents.

The succeeding section summarizes the research approaches for the philosophical stances.

3.2 RESEARCH APPROACH

A research approach can be defined as the way in which the research objectives can be questioned (Naoum, 2007). However, the type of approach to follow depends on the purpose of the study and the type and availability of the information required (Biggam, 2008). The research approach adopted for the study is outlined in this sub- section 3.2. It discusses the two broad conventional approaches, quantitative (also referred to as the deductive approach) and qualitative research (inductive approach) and then summarizes

the differences between the two. Mixed methods, an approach that combines the strengths of the two approaches is also discussed.

3.2.1 Quantitative Research

This refers to research that is concerned with quantities and measurements and tends to relate to positivism. It seeks to gather factual data, study relationships between facts and how such facts and relationships accord with theories and findings of any research executed previously. The data is therefore not abstract, they are hard and reliable; they are measurements of tangible, countable, sensate features of the world (Bouma and Atkinson, 1995; Naoum, 2007; Biggam, 2008; Fellows and Liu, 2008; Vanderstoep and Johnston, 2009). Analysis of the data yields quantified results and conclusions are derived from evaluation of the results in the light of theory and literature (Fellows and Liu, 2008).

In quantitative research, one uses theory deductively and places it towards the beginning of the plan for the study as depicted in Figure 3.3. The objective therefore is to test and/or verify a theory rather than develop it. One thus begins the study advancing a theory, collects data to test it, and reflects on whether the theory was confirmed or unconfirmed by the results of the study (Naoum, 2007; Creswell, 2008).

Quantitative research methodologies have come under a lot of criticisms. A summary of some of the arguments against quantitative strategies by Bryman (2004) are as follows:

- It does not distinguish people and social institutions from 'the world of nature';

- The measurement process is artificial and possesses an unreal sense of precision and accuracy;
- Processes rely greatly on instruments and procedures hence no relationship between research and everyday life; and
- Analysis of relationships between variables creates the impression that social life is independent of people's lives.

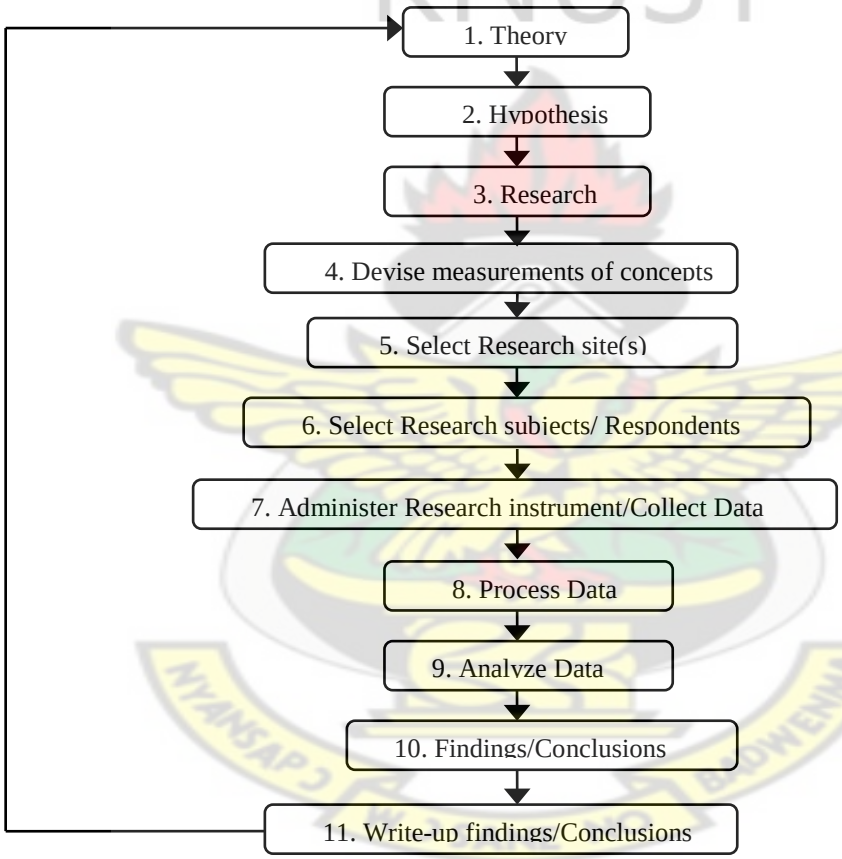


Fig. 3.3: Quantitative research process

Source: Bryman (2004)

3.2.2 Qualitative Research

This type of research is subjective in nature and involves studying 'things' in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings

people bring to them. The approaches employed seek to gain insights and also understand people's perception of 'the world'- whether as individuals or as groups (Denzin and Lincoln, 1994; Biggam, 2008). In qualitative research, the researcher gradually makes sense of a social phenomenon by contrasting, comparing, replicating, cataloguing and classifying the object of study. This entails immersion in the everyday life of the setting chosen for the study (Miles & Huberman, 1984; Marshall and Rossman, 1989; Creswell, 2008). Figure 3.4 outlines a typical qualitative research process adopted from Bryman (2004).

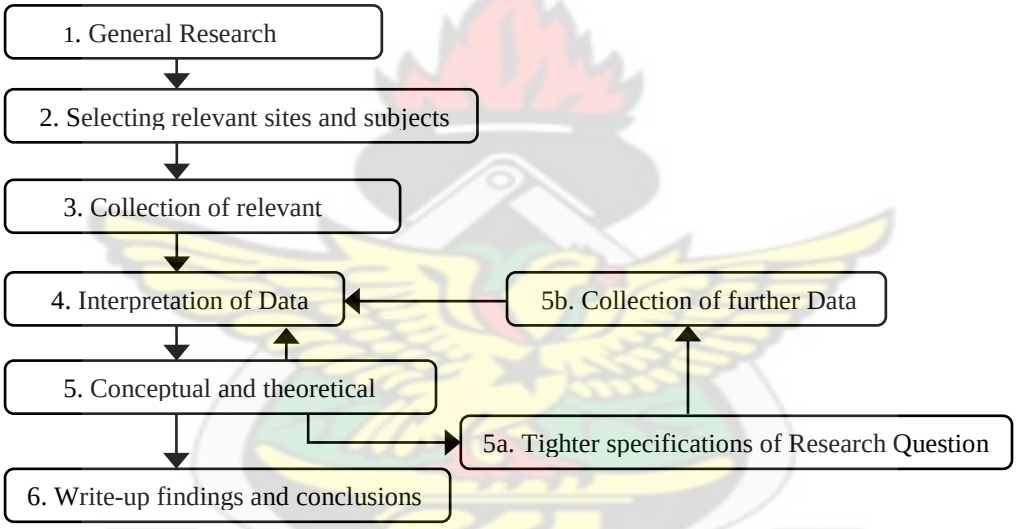


Fig. 3.4: Qualitative research process

Source: Bryman (2004)

Qualitative research has over the years been criticized by authors. For instance, Bryman (2004) listed the following as some major arguments regarding this strategy:

- It is very impressionist and subjective in nature and findings are based on systematic views on what is deemed important and significant;

- Not easy to replicate since it relies mostly on unstructured data and also because there is hardly any standardized procedure, quality is based on the ingenuity of the researcher;
- It is often restricted in scope and has problems with generalization as a result; and
- The absence of transparency due to difficulties arising from the establishment of what the researcher actually did and how they arrived at the research conclusions.

3.2.3 Comparison between Qualitative and Quantitative Research

Distinctions between qualitative and quantitative research design and the development of the enquiry process are usually highlighted by authors (Hammersley & Atkinson, 1995; Maxwell, 1996; Becker, 1996; Lloyd-Jones, 2003). According to these authors, quantitative research honours the logic of experimental or correlational method in adhering to agreed rules and predetermined sequences irrespective of emerging data and analysis. By contrast, qualitative design displays an interactive, dynamic, and emergent character in which the aims, strategies, data, analysis and validity are woven together in the process of the study.

A number of authors including Bryman (1998; 2004); Naoum (2007); Vanderstoep and Johnston (2009) have documented the differences between qualitative and quantitative research. These differences are summarized and presented in Table 3.2 below.

Table 3.2: Differences between Qualitative and Quantitative research

	Qualitative	Quantitative
Purpose	Description	Prediction
Focus	Generalize to large population	Give voice to silenced people and groups
Methods	Inductive analysis of "texts"	Deductive analysis of units (individual, corporations, etc.)
Criteria for Truth	Adequate and realistic	Statistics, replication, and cumulative findings
Role	Attitude measurement based on opinions, views and perceptions measurement	Fact finding based on evidence or records
Relationship between researcher and subject	Close	Distant
Scope of findings	Idiographic	Nomothetic
Relationship between theory/ concepts and research	Emergent/ development	Testing/ confirmation
Nature of data	Rich and deep	Hard and reliable
Epistemological Orientation	Interpretivism	Natural science model, in particular, positivism
Ontological Orientation	Constructionism	Objectivism
Primary disadvantage	Small sample, not generalizable to the population at large	Superficial understanding of participants' thoughts and feelings

Source: Bryman (1998; 2004; 2012); Naoum (2007); Vanderstoep and Johnston (2009)

Biggam (2008) argued that a research approach cannot be in itself, qualitative or quantitative. However, the combination of the research strategy, research objectives and data collection techniques help determine the quantitative or qualitative nature of a research.

3.2.4 Mixed Methods Research

Generally, quantitative research answers '*how*' questions whereas the '*why*' questions are answered through qualitative research. The reality, according to Myers (1997, cited in Lloyd-Jones, 2003), is that it is rare to stick to only collecting and analyzing either quantitative or qualitative data without a combination of the two. The term mixed method approach is usually used to imply the combination of qualitative and quantitative research approaches in research. However, Fellows and Liu, (2003); Ritchie and Lewis, (2003) opined that the use of more than one qualitative method in undertaking a research could also be referred to as mixed methods.

Johnson et al. (2007) defined mixed methods research as the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (for instance, the use of qualitative and quantitative viewpoints, data collection, analysis and inferences) for the purposes of breadth and depth understanding and corroboration (Creswell, 2010; Tashakkori & Teddlie, 2010).

A key feature of mixed methods research is its methodological pluralism or eclecticism, which frequently results in superior research compared to research which employs mono methods (Johnson and Onwuegbuzie, 2004). Being a relatively new approach which has been questioned by some researchers, mixed methods can be employed in different ways and several fields (Tashakkori & Teddlie, 2010). Table 3.3 summarizes some of the varied areas where the mixed method procedures have been employed and the authors.

Table 3.3: Some areas where mixed method procedures have been employed

S/N	Areas	Authors
1	Narrative studies	Elliot (2005)
2	Experiments	Sandelowski (1996)
3	Case studies	Luck, Jackson & Usher (2006)
4	Network analysis framework	Quinlan & Quinlan (2010)
5	Context of an overarching problem or research question	Yin (2006)
6	A feminist lens	Hesse-Biber & Leavy (2007)
7	Action research	Christ (2009)
8	Visual methodology (such as documentary development)	Creswell & McCoy (in press)

Source: Culled from Tashakkori & Teddlie, (2010); Creswell, (2010).

3.2.5 Determining a Mixed Method Approach

The option of mixed method approach to adopt is influenced by decision choices. Authors such as Greene & Caracelli, (1997); Tashakkori & Teddlie, (1998) and Creswell, (2003) identified certain criteria for choosing this approach. Creswell (2008) however groups these under four main areas. These have been tabulated below in Table 3.4.

Table 3.4: Decision choices for determining a Mixed Method Approach

Implementation	Priority	Integration	Theoretical Perspective
No Sequence **Concurrent**	Equal	At Data collection	Explicit
Sequential- **Qualitative first**	Qualitative	At Data Analysis	
Sequential- **Quantitative first**	Quantitative	At Data Interpretation With some Combination	Implicit

Source: Creswell (2008)

Table 3.4, illustrates that four major decisions go into selecting a mixed method approach of inquiry. According to Creswell (2008), when selecting the particular option of this

approach to adopt, the following should be considered: the implementation sequence of the quantitative and qualitative data collection in the proposed study; the level of priority that will be accorded the quantitative and qualitative data collection and analysis; the stage in the research project where the quantitative and qualitative data and findings will be integrated; and the overall theoretical perspective which will be utilized should be considered. These considerations will guide and inform the decision on which strategy would be most appropriate, focusing on the research aim and objectives and also the time available for the research.

3.2.6 Types of Mixed Method Approach

Creswell (2008) identified six major variations of the mixed method approach. They include: sequential explanatory; sequential exploratory; sequential transformative; concurrent triangulation; concurrent nested and concurrent transformative variations.

The sequential explanatory variation is characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data where priority is given to the quantitative data. In contrast, the sequential exploratory variation, gives priority to the initial phase of qualitative data collection and analysis which is proceeded by the quantitative aspect of the study. The third variation in the sequential series is the sequential transformative model. This model also has two distinct data collection phases, one following the other. However, in this design either method may be used first, and the priority can be given to either the qualitative or the qualitative phase or even to both if sufficient resources are available.

The results of the two phases, qualitative data collection and analysis and quantitative data collection and analysis are integrated during the interpretation phase irrespective of which aspect precedes the other in the sequential series of the mixed method variations. Figure 3.5 illustrates a typical example of sequential mixed method procedures adopted from Creswell (2010) and Tashakkori and Teddlie, (2010). It outlines the various phases as well as the product of each stage.

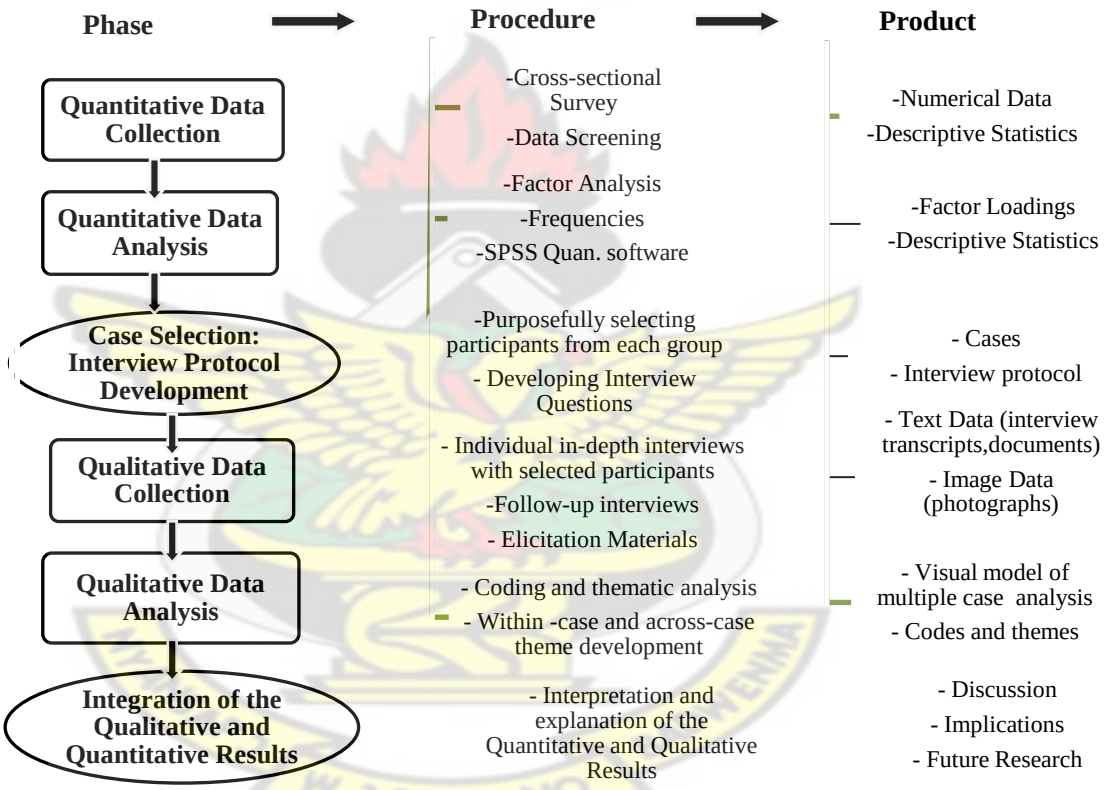


Figure 3.5: Typical example of sequential mixed method procedures

Source: Adopted from Creswell, (2010); Tashakkori & Teddlie, (2010)

The other three variations of mixed methods relate to the concurrent series. These comprise; the concurrent triangulation model which generally uses separate quantitative and qualitative methods concurrently as a means to offset the weaknesses inherent within one method with the strengths of the other method. The results of the two methods are usually integrated during the interpretation phase. The concurrent nested model can be identified by its use of one data collection phase, during which both quantitative and qualitative data are collected simultaneously. A nested approach usually has a predominant method that guides the project. Given less priority, the method (quantitative or qualitative) is embedded, or nested, within the predominant method (qualitative or quantitative). The data collected from the two methods are mixed during the analysis phase of the project.

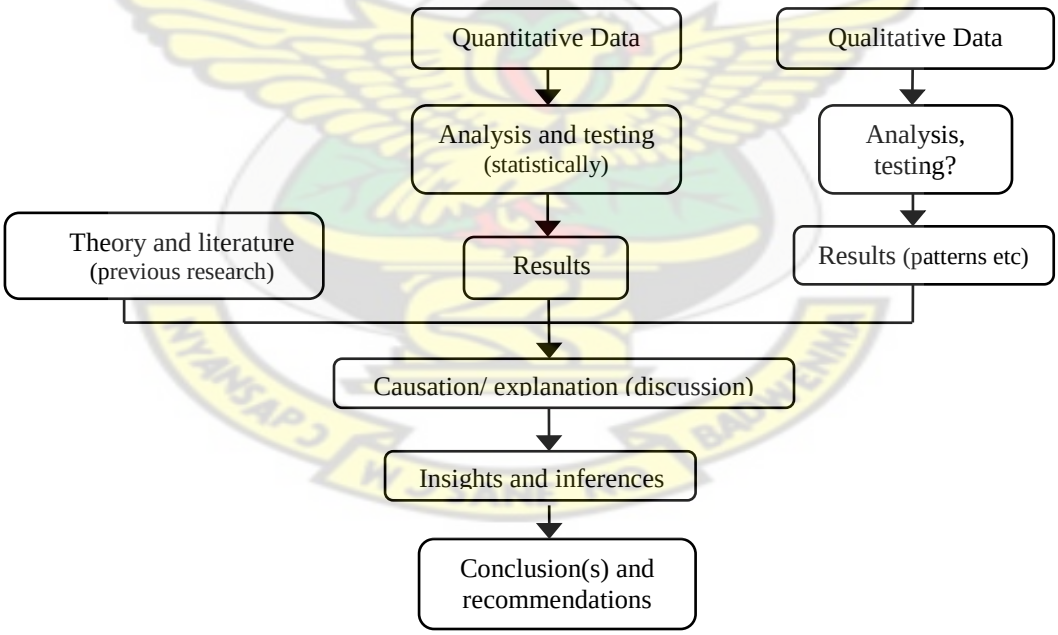


Figure 3.6: Concurrent triangulation mixed methods procedure

Source: Bryman (2004)

Creswell (2010) explained further that, the concurrent transformative approach is guided by the researcher's use of a specific theoretical perspective. It may take on the design features of either a triangulation or a nested approach. That is, the two types of data are collected at the same time during one data collection phase and may have equal or unequal priority. The integration of these different data would most often occur during the analysis phase, although integration during the interpretation phase is a possible variation. Figure 3.6 outlines a typical concurrent mixed methods procedure adopted from Bryman (2010).

3.2.7 Research Approach Adopted

Amaratunga, Baldry, Sarshar and Newton (2002) observed that research in the built environment is peculiar and as such consists of cognitive and behavioural components. They further observed that researches in the area of the built environment utilized either strong qualitative or more often, strong quantitative methodologies. Amaratunga et al. (2002) however argued that, the use of either method, be it qualitative or quantitative often fails to explore the components of built environment research. They therefore suggested that, utilizing a mixed method approach will counteract this weakness and also enhance research within the built environment. This position is supported by Dainty (2008); Abowitz and Toole (2010); and Azhar, Lukkad and Ahmad (2013) who articulate that, research in the built environment particularly the construction industry should consider mixed methods approach as an ideal choice whenever possible. This consideration, should however be made with recourse to what the study sets out to achieve. Issues relating to validity and reliability of the resulting data are improved and

causal inferences strengthened when mixed methods are utilized. To this end, the study adopted the mixed method research approach in order to achieve the research aim and specific objectives.

There are varying views on philosophical paradigms regarding mixed methods. For instance, positivism is associated with quantitative approaches while interpretivists utilize qualitative approaches. A merger of these two distinct traditions is the cause of debate among research methodology researchers. For instance, Guba and Lincoln, (1994 cited in Hall, 2012) posited that the opposing underlying paradigms of quantitative and qualitative approaches made it impossible to combine them in the first place. Contrary to this claim, the mixed method approach is being used in researches across disciplines (see Table 3.3) and is regarded as the third methodological approach.

Some authors have devised alternative ways to deal with problems relating to the choice of suitable paradigms for mixed method research approaches. Hall (2012), however classified the interventions of Tashakkori and Teddlie, (2003); and Creswell and Plano Clark, (2007) into three categories. The first category does not consider philosophical paradigms; the second suggests that alternative paradigms can be used together in one research project; and the third advocates that mixed methods, combining both quantitative and qualitative methods can be housed under the umbrella of one paradigm.

As stated in section 3.13, positivism was adopted as the underlying paradigm for this study. This tends to agree with the third category of mixed methods and paradigms. It

must however be noted that a number of researchers align with the first category. They advocate that pragmatism which relies solely on the research question is appropriate for mixed methods (e.g. Tashakkori & Teddlie, 2003; and Somekh & Lewin, 2005 cited in Mackenzie and Knipe, 2006). However, researchers such as Mertens, (2005 cited in Mackenzie and Knipe, 2006) and Saunders et al. (2009) who posit the use of a transformative approach in relation to mixed methods paradigms acknowledge that positivism can employ qualitative methods in addition to the predominant quantitative methods.

The concurrent nested model, a variation of the mixed method strategy outlined in section 3.2.6 was employed. As mentioned earlier, this variation could have either the quantitative or qualitative methods prioritized with the other method which is given less priority nested. The nesting aspect of this model, according to Creswell (2008) and Tashakkori and Teddlie (1998; 2010) imply that, the embedded method will either address a different question other than the dominant method or will seek information from different levels.

The nature of respondents selected for the study (Heads of SHSs, maintenance officers, and other professional stakeholders) required the utilization of different data collection methods because of the hierarchical levels involved. Creswell (2008) further stated that the concurrent nested model may be used to serve a variety of purposes. Often, this model accordingly is utilized to enable a researcher gain broader perspectives as a result of using the different methods as opposed to using the predominant method alone. For

example, Morse (1991) noted that a primarily quantitative design could embed some qualitative data to enrich the description of the sample participants. Likewise, qualitative data could be used to describe an aspect of a quantitative study that cannot be quantified. Figure 3.7 illustrates the variation of the concurrent nested model of the mixed methods strategy adopted for the study. That is, quantitative (QUAN) methods being the primary data collection method used and the qualitative (qual) nested within the quantitative methods. The data (both quantitative and qualitative) were integrated during the analysis phase of the research. Figure 3.7 below presents a summary of the concurrent nested process adopted.

Authors such as Morse (1991); Creswell (2008; 2010); and Tashakkori & Teddlie, (2010) assert that this mixed methods model comparatively has a number of strengths. These include the ability to collect the two types of data simultaneously during a single data collection phase which saves time. They further observed that, data collection in the sequential models requires one data collection phase preceding the other. The concurrent nested technique also offers the study with the advantages of both quantitative and qualitative data. By using the two different methods in this fashion, a researcher can gain perspectives from the different types of data or from different levels within the study.

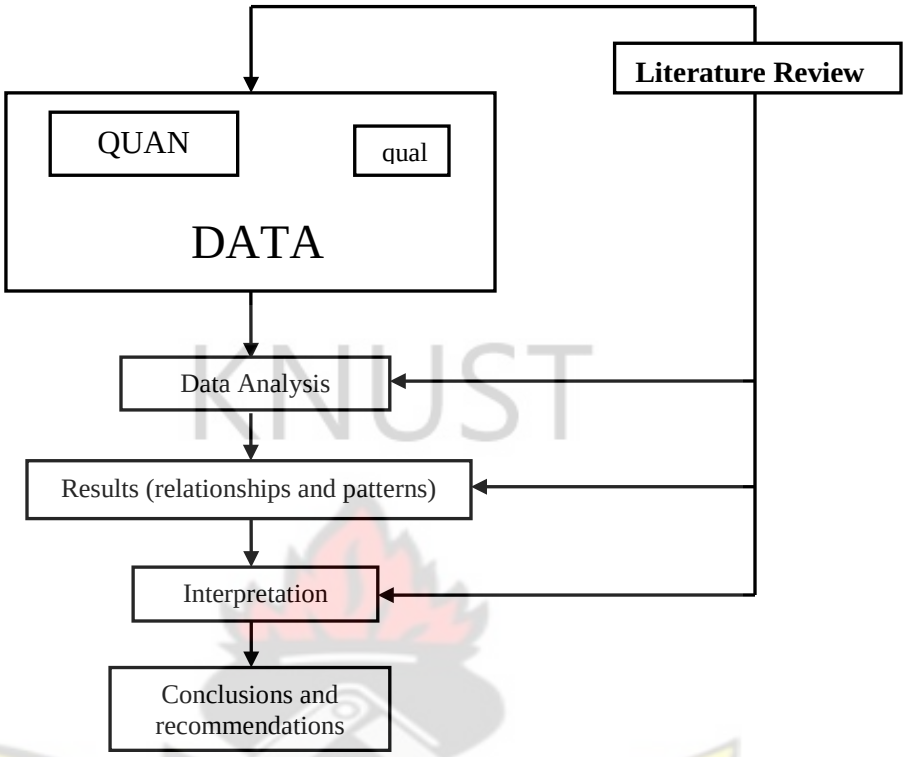


Figure 3.7: Concurrent Mixed methods process

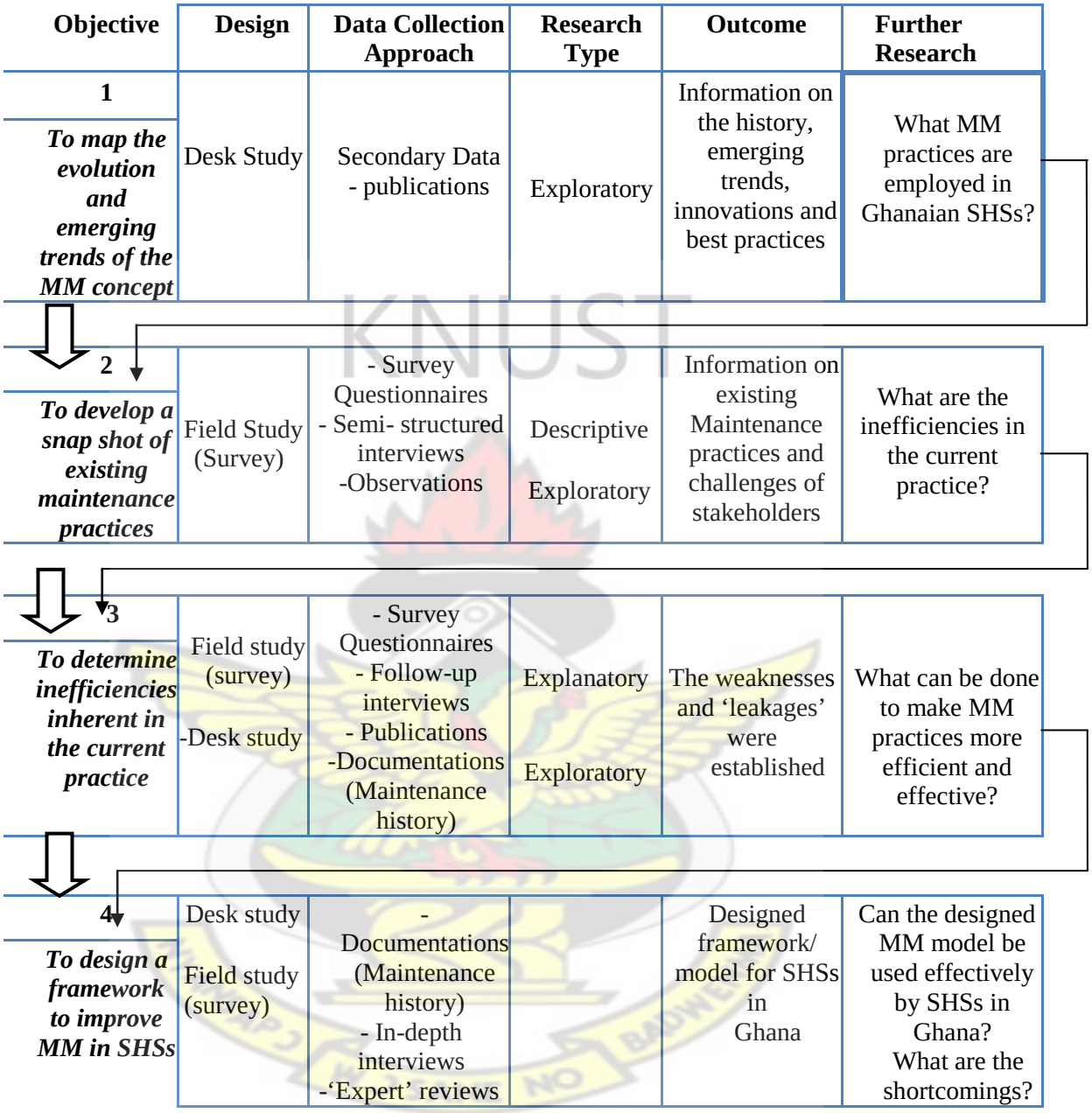
Source: Adapted from Creswell (2008)

The limitation to consider however when choosing this approach according to Creswell (2008) is that the data need to be transformed such that they can be integrated within the analysis phase of the research. Creswell further cautions that, care must be taken to ensure that the transformation of data does not alter the essence of the actual data. To curb this limitation, coding was employed. Both the qualitative and quantitative data were coded and questions addressing related issues grouped.

3.4 RESEARCH DESIGN ADOPTED

Section 3.1 established that the design of any research is influenced by a number of factors such as philosophical considerations relating to epistemology, ontology and axiology; theory and practical considerations. To this end, the positivist paradigm and mixed method approaches have been mentioned as the methodology this study adopted. The fact that the research aim and objectives play a vital role in the choice of methodology and methods has also been established in section 3.1. However with regards to the design of the research, having considered the influences as mentioned earlier, a number of options exist.

Bryman (2004) outlined five main research design options: experimental, cross-sectional, longitudinal, case study and comparative research designs. Yin (2003) on the other hand classified the options into experiment, survey, archival analysis, history and case study. Yin (2003) further identified factors such as, the type of research question; the control the investigator has over actual behavioural events; and the focus on contemporary as opposed to historical phenomena, influence the research design options. De Vaus (2001) viewing through the lens of social research identified two fundamental types of research, descriptive and explanatory. Fellows and Liu (2008), in the context of research methods for construction, identified explanatory, exploratory, descriptive and predictive as the four main types of research.



Objective	Design	Data Collection Approach	Research Type	Outcome	Further Research
1 ***To map the evolution and emerging trends of the MM concept***	Desk Study	Secondary Data - publications	Exploratory	Information on the history, emerging trends, innovations and best practices	What MM practices are employed in Ghanaian SHSs?
2 ***To develop a snap shot of existing maintenance practices***	Field Study (Survey)	- Survey Questionnaires - Semi- structured interviews -Observations	Descriptive Exploratory	Information on existing Maintenance practices and challenges of stakeholders	What are the inefficiencies in the current practice?
3 ***To determine inefficiencies inherent in the current practice***	Field study (survey) -Desk study	- Survey Questionnaires - Follow-up interviews - Publications -Documentations (Maintenance history)	Explanatory Exploratory	The weaknesses and 'leakages' were established	What can be done to make MM practices more efficient and effective?
4 ***To design a framework to improve MM in SHSs***	Desk study Field study (survey)	- Documentations (Maintenance history) - In-depth interviews -'Expert' reviews		Designed framework/ model for SHSs in Ghana	Can the designed MM model be used effectively by SHSs in Ghana? What are the shortcomings?

Figure 3.8: Research design adopted

The study employed a mixed methods strategy, characterized by descriptive, exploratory and explanatory elements which were influenced by the research objectives. Fellows and Liu (2008), present the nature of descriptive research in simple terms as the

documentation of the phenomenon of interest; explanatory research, as the explanation of causality; and exploratory research, as the investigation of the phenomenon and identification of variables, and the generation of hypothesis for further research. The research comprises a variety of data collection designs including questionnaire surveys, interviews, observations and desk study. Data from existing literature also aided the research, particularly the design of the framework. The research design adopted for the study is summarized in Figure 3.8. The design, data collection approach, research type and the outcome for each objective have been documented.

3.5 RESEARCH PROCESS

Fellows and Liu (2008) asserted that research is a dynamic process and must therefore be flexible. Early in the study, links between problems, theories, previous findings and methods have to be postulated. The links should form a coherent chain and the goal must be to maintain coherence and be complementary in relationship. They further added that, the results and conclusions will be robust when such an approach is adopted. The entire process commenced with a comprehensive review of relevant literature from pertinent books, journals, reports, conference proceedings and other publications regarding maintenance and MM. The aim of the literature review was to establish best practices and benchmarks on MM. Preliminary consultations with maintenance experts were sought to enhance the benchmarks established from the literature review. The established benchmarks were useful in the subsequent stages of the research. The research problem was then identified and the aim and objectives also developed.

The second major phase of the process comprised the field survey. This was kicked start with the sample selection. Here, the study area, sample population of SHSs, sample selection and respondents were determined. As mentioned earlier, SHSs in Kumasi and Cape Coast were considered for the survey. With regards to the respondents, heads of SHSs (or their representatives, particularly the assistants) and maintenance staff were the target. In cases where maintenance officers were non-existent, representatives of the unit were contacted.

The design of the data collection instruments; questionnaires and interview questions followed suit. The questionnaires were made up of both closed and open-ended questions. The interview questions were pre-determined and structured in nature but with room for follow-up questions. Both questionnaires and sets of interview guide were piloted before the actual data collection. The feedback from the piloting was taken into consideration during the drafting of the final set of questionnaires and interview questions for the various groups of respondents.

The study subsequently proceeded to the field to collect data. Primary data was collected using the survey approach. Data was elicited utilizing the designed tools which included questionnaires and interview guide. Self administration of the questionnaires and face-to-face interviews were employed in addition to desk study of related literature, visual observations of facilities among others. The data collected from the field survey, together with secondary data sought from existing relevant literature were then analyzed using the

Statistical Package for Social Sciences (SPSS) data analysis tool (version 16), utilizing descriptive statistics, t-tests and factor analysis techniques.

The above process provided the research with an overview of the existing MM situation in Ghanaian SHSs. This served as a major input for the third phase of the research process. In order to establish the inefficiencies inherent in the current maintenance practices, further interpretations of the findings were carried out using the MM benchmarks. This outcome, in addition to findings on improved methods of carrying out MM from reviewed literature was synthesized into the design and formulation of a conceptual procedural MM framework. The framework was validated by experts to enhance it. This was done using the iterative validation process established by Presley and Waltman-William (1993). Experts' consensus on the conceptual framework was sought. The conceptual MM framework was then produced after considering and inputting experts' consensus from the validation process. Figure 3.9 outlines the research process employed.

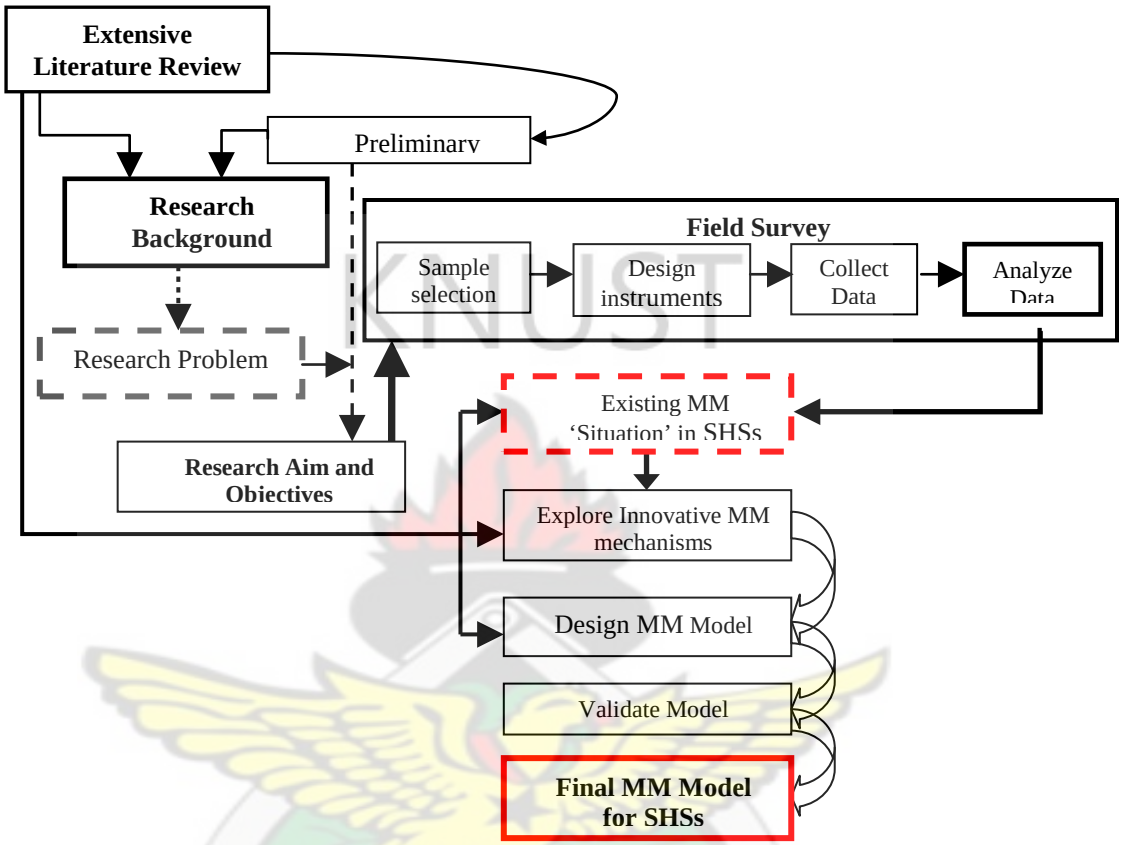


Figure 3.9: The Research process adopted

3.6 DATA COLLECTION

Research becomes a viable approach to a problem only when there is sufficient data to support it (Leedy and Ormrod, 2005). Thus, the importance of data in any form of research cannot be overemphasized. Fellows and Liu (2008) also stressed the importance of data in any research undertaking and advised that, it is necessary to consider the required data, sources of the data and how the data collection will be carried out right from the onset, particularly the planning stage of the research.

This section on data collection presents information on how data was sourced for the preliminary survey. It also documents the sampling technique and procedure for sample selection as well as the instruments of data collection for the field survey. The instrument employed in the data collection process included, survey questionnaires, interviews and observations.

3.6.1 Preliminary Data

A preliminary survey was conducted during the initial stages of the research process to complement the information gathered from literature, relating to MM in SHSs in Ghana. The preliminary survey was deemed necessary to furnish the research with firsthand information on the existing MM situation and also help focus the research on the real issues. Primary data was gathered from some MM practitioners in both industry and academia, officials from the Secondary division of the Ghana Education Service, selected heads and maintenance staff of SHSs. As part of the preliminary survey, the Metropolitan Education offices in both Cape Coast and Kumasi were contacted for lists of public SHSs in the two Metropolises.

The data gathered from the preliminary survey, coupled with secondary data from relevant literature provided the basis for the research problem and the formulation of the research aim and objectives. Information gathered from the preliminary interviews and observations also contributed immensely towards the formulation of questionnaires and pre-determined interview questions for the actual survey.

3.6.2 Sampling

It is usually uncommon for researchers to contact all the members of any particular group being studied. There is therefore the need to select a number which represents the whole in cases where the entire population cannot be covered. According to Leedy and Ormrod (2005), the process of selecting particular entities from variety of people and other groups is referred to as sampling. Sampling aims at creating a practical means that will enable the data collection process to be carried out in a sample that is a good representation of the population (Fellows and Liu, 2008). Leedy and Ormrod (2005) explained that the thought, precision and care that go into the design of the research and the selection of the population are essential to the success or otherwise of any research endeavour. They further pointed out that issues relating to population and sampling are critical to the success of any study. According to the Ghana Education Service (G. E. S.), there are six hundred and nine (609) public SHSs in Ghana. Public here refers to SHSs that are either owned or assisted by the central government. These public SHSs are made up of five hundred and sixty four (564) regular SHSs and forty five (45) belonging to the technical/vocational division. These SHSs are found in various parts of the country modelled on basically similar spatial provisions.

The study therefore adopted the multistage sampling of areas (a sampling technique proposed by the Survey Research Centre of the University of Michigan's Institute for Social Research, 1976) (See Leedy and Ormrod, 2005). The multistage sampling procedure commences with the selection of a primary area, followed by sample location

selection. This is then followed by chunk selection, segment selection and ends with a unit selection. In this vein, Ghana, being the primary area was divided into northern sector and southern sector out of which a region each was selected. That is, Ashanti region and Central region, representing the northern and southern sectors respectively. These regions were further reduced to the Kumasi and Cape Coast Metropolises where the total population of pubic SHSs in each of the two Metropolises was surveyed. Table 3.5 summarizes the total population and sample selected from the study areas.

Table 3.5: Population and Sample selection of SHSs

Region	Population	Metropolis	Population
Central	51	Cape Coast	11
Ashanti	80	Kumasi	19
		Total (selected)	30

Thirty (30) SHSs in total formed the sample for the study. These were made up of the total population of public owned/government assisted SHSs, eleven (11) in the Cape Coast Metropolis of the Central region and nineteen (19) in the Kumasi Metropolis of the Ashanti region. Table 3.6 indicates the respondents selected for the research.

Table 3.6: Respondents surveyed

Respondents' Description	Number per school	Number surveyed
Headmaster/Representative	1	30
Maintenance Officer/Representative	1	30
Total	**2**	**60**

3.6.3 Questionnaires

Structured and semi-structured questionnaires were formulated to elicit relevant information on the subject being investigated from the respondents. Two sets of questionnaires were designed such that, one set was utilized as a follow-up. The first set of questionnaires comprised sections which included respondent's profile, general questions on maintenance practices in the SHSs, and MM of infrastructure in the schools surveyed. The questions were predominantly closed-ended and fashioned such that, respondents only had to tick the description which was appropriate. There were however few questions which required filling-in by respondents. The second set of questionnaires which was a follow-up had two sections. The first section sought to elicit data relating to the profile of the schools. The second section which was the major section focused on the assessment of MM practices in SHSs. This assessment was based on twenty five (25) best practice criteria adopted from Buys and Nkado (2003); Crespo Marquez and Gupta (2005); Crespo Marquez (2007); Buys et al. (2009, cited in Jimoh and Iyagba, 2012); Lopez Campos et al. (2010); among others, as well as expert views.

The respondents were first asked to rank each best practice criterion (i.e. Perception based indicative assessment) based on the degree of importance by ticking the appropriate column on a five-point Likert scale. Here, benchmark 5 represented most important; 4, very important; 3, important; 2, less important; and 1, least important. The ranking of each of the best practice criteria gave an indication of the level of importance respondents attached to the variables being measured. The next step entailed rating the level of satisfaction/performance regarding MM practices by the respondents in their

respective schools also on a five-point Likert scale. Again, respondents were asked to tick the column which best depicted their rating of the level of satisfaction/performance. The ratings were; 5 - highly satisfactory, 4 - very satisfactory, 3 - satisfactory, 2 - fairly satisfactory, and 1 - not satisfactory. As part of the survey, the questionnaires went through a piloting phase and were subsequently amended prior to the actual survey.

Table 3.7 presents a summary of the survey instruments which were utilized in the survey, pairing the identification code (ID) and the issues they tackled.

Table 3.7: Summary of Survey Instruments

ID	Issue
A_1, B_1, F_3, D_6, D_{11}	Budgeting
A_2, B_2	Maintenance staff responsiveness
A_3, B_3	C MMS
A_4, B_4, Cv_1, Cv_2, Cv_3, Cv_4, Cv_5, Cv_6	Maintenance Communication
A_5, B_5	Craftsmen qualification
A_6, B_6	Organogram's Flexibility
A_7, B_7	Life Cycle Costing
A_8, B_8, D_{12}	Maintenance Policy
A_9, B_9	Maintenance officer qualification
A_{10}, B_{10}	Maintenance inspection
A_{11}, B_{11}	Maintenance tools and materials
A_{12}, B_{12}	Number of maintenance staff
A_{13}, B_{13}	Organizational structure
A_{14}, B_{14}	Planning maintenance activities
A_{15}, B_{15}, D_5	Maintenance Staffing
A_{16},B_{16}	Recording & Feedback System
A_{17}, B_{17}	Reports on maintenance
A_{18}, B_{18}	Research on maintenance
A_{19},B_{19}	Setting priorities
A_{20}, B_{20}	Setting Maintenance Standards
A_{21}, B_{21}	Sound maintenance system
A_{22},B_{22}, F_5	Top management awareness
A_{23}, B_{23}, M_6	Maintenance Staff Training
A_{24}, B_{24}, F_1	User/occupant awareness
A_{25},B_{25}	Maintenance Technology

3.6.4 Interviews

Interviews were conducted to complement efforts of the questionnaire in collecting primary data on the research. An interview guide was used to control the process. The respondents interviewed included the maintenance staff and heads of schools/ assistants, and experts on MM in the industry.

3.6.5 Observations

Observations were conducted on the SHSs campuses to capture information regarding the general outlook of the physical infrastructure. The state of buildings, facilities, roads, and other parts of the school demonstrated the impact of maintenance on the school.

3.7 METHODS OF ANALYSIS

Performance and importance levels of 25 best practice criteria were measured from respondents in the study area. These best practice criteria were established from literature and experts' input. The analysis covered a number of stages. The data collected was firstly coded and entered into the Statistical Package for Social Science (SPSS) tool for analysis. These stages included reliability testing, one-sample t-test and mean ranking. Factor analysis was then used for aspects of the analysis. The factor analysis was carried out to reduce the number of best practice factors into manageable components of correlated factors to aid the development of the conceptual framework.

3.8 MODELLING THE FRAMEWORK

Modelling according to Fellows and Liu (2008) is the process of constructing a representation of a designed or actual object, a process or system, or a representation of reality. A model must capture and represent reality as closely as practicable and must include essential features of the reality in respect of the purpose for constructing the model. Several models have been identified over the years for various disciplines. A process model is one such model and can be classified into four categories: typology model; variability model; timing model; and objective model which would be appropriate for different modelling objectives (Akasah & Amirudin, 2010).

Akasah & Amirudin (2010) further explained that, a typology process model is suitable for activity and resource focused processes such as those found in the case of the MM process of school buildings. A typology model can be sub-divided into three types: schematic, simulation or a mathematical model. The schematic process model, accordingly would be the most suitable model for representing the sequence of activities in the building MM process.

3.8.1 The MM Framework Modelling Process

The research aims at developing a MM framework, applicable to SHSs in Ghana. The modelling process outlined by Mihram (1972, in Fellows and Liu, 2008), outlined in Figure 3.10 was therefore adopted for the design of the MM framework. According to Fellows and Liu (2008), the first stage of the modelling process commences with the establishment of an objective. The next step is to analyze reality. Since a model is a

representation of reality and would be utilized by a group or organization, the current situation which comprises the system and processes already in place must be considered. Any drastic change that does not align with the existing procedures the users are accustomed to, can be a setback to the success of the framework. Research into improved ways of carrying out MM is also necessary and can contribute positively to the design of the model thus, the exploration of other MM strategies. This was then followed by the synthesis of all the components into the framework. These included lessons learnt from other MM strategies, strengths and weaknesses of the existing processes and systems, and MM best practices.

The verification stage of the modelling process involved among others, cross-checking to ensure that all the components of the proposed framework had been inputted and whether the structure of the framework is sound. The output from the verification procedure was subsequently incorporated into the framework prior to the validation. As noted earlier in Section 3.5, the framework was validated by experts to enhance it. Outputs from the validation process was then included in the framework. Figure 3.10 outlines the modelling process adopted in the formulation of the MM framework.

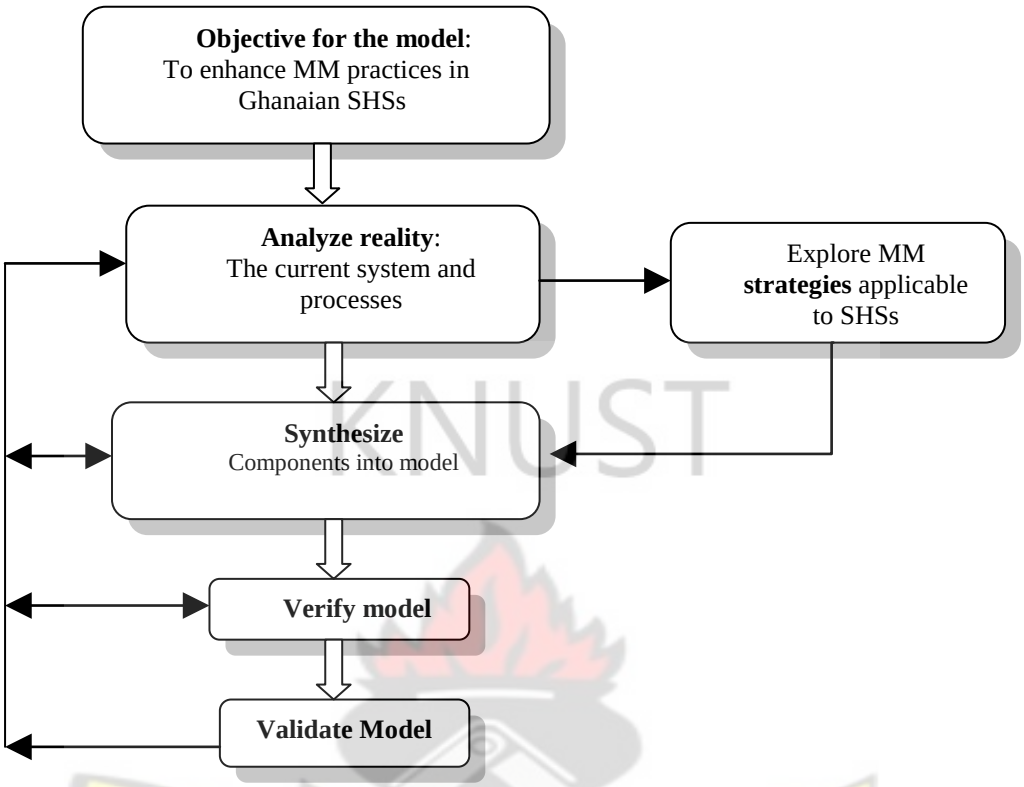


Figure 3.10: Modelling process to be adopted

Source: Adapted from Fellows and Liu (2008)

3.8.2 Expert Validation of Draft MM Framework

Stage III of the conceptual MMF development process was earmarked for validation by technical experts in Building maintenance and facilities management. The experts who were selected for the validation of the framework possessed 10 or more years of experience in the building industry with specialty in maintenance. The iterative validation process recommended by Presley and Waltman-William (1993) was adopted for the validation of the proposed framework. Presley and Waltman-William spelt out simple steps for the process. These include:

- Identifying the technical expert (minimum of three experts) in the maintenance management field;
- Submission of the draft framework to the experts at their separate locations;
- Experts review the information on the draft framework using ticks (√) in agreement where appropriate; (X) to indicate disagreement and (-) to indicate indifference with any of the presented information;
- Experts also complete a blank section attached to the framework, with suggestions and recommendations to improve the framework.

These steps were followed during the validation stage of the framework. The experts' inputs were incorporated in the draft to finalize it for recommendation.

3.9 SUMMARY

This chapter presented the methods employed in the research. It firstly discussed the design of the study, philosophical considerations and research paradigms. It then proceeded with the approach adopted for the research. It also outlined the choice of strategy and process, processes and techniques utilized in the data collection, data analysis, interpretation of the findings, and finally the procedure for the design of the MM framework.

The proceeding chapter, 4 analyzes and discusses findings resulting from the data collected from the respondents.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 INTRODUCTION

This chapter analyses and discusses findings resulting from the data collected from the respondents. The demographic data on respondents and the profile of the institutions are analyzed using descriptive statistics, specifically percentages. Existing MM practices are presented in tables, graphs and figures. Dependent variables on MM best practices were analyzed using one-sample t-test and ranked accordingly. Factor analysis was used to reduce the variables into clusters for easy management and utilization in the development of the MM framework.

4.1 ANALYSIS OF THE DEMOGRAPHIC DATA

The main aim of profiling the respondents was to help provide an understanding of their backgrounds and roles and responsibilities regarding the study so that, the credibility of data collected will be guaranteed. Tables 4.1 and 4.2 summarize respectively, the maintenance officers' qualification and years of experience in maintenance work in SHSs.

Table 4.1: Qualification of Maintenance Officer

Description of Qualification	Frequency	Percentage (%)
NVTI Grade 1 & 2 Certificate	11	36.7
Intermediate Certificate	5	16.7
Advanced Certificate	2	7.0
CTC Part 1 Certificate	4	13.3
CTC part 2 & 3 Certificate	1	3.0
Higher National Diploma Certificate	4	13.3
Bachelor of Science Certificate	3	10.0
Total	**30**	**100.0**

The qualifications of the maintenance officers/representatives revealed that 36.7% of them have NVTI Grades 1 and 2, making the highest group of maintenance officers/representatives. Further examination of the table showed that 76.7% (i.e. 36.7+16.7+7.0+13.3+3.0) have training mainly focused on hands-on jobs and not management oriented. TVET report (2007), indicated that NVTI and intermediate stages are pre-tertiary level qualifications, oriented mainly on competence-based skills acquisition for trainees. Thus, decision making and management responsibilities are not the focus of their training. The 23.3% (i.e.13.3+10.0) of officers have tertiary level qualifications, however it is important to note that only one of the bachelors holders studied mainstream estate management. The other two studied procurement and construction technology.

Table 4.2 indicated that 83.4% (i.e. 46.7+16.7+16.7+3.3) of maintenance officers have been working in the maintenance unit of SHSs for at least 6 years. Hence, a majority of the respondents in the category of maintenance officer/representative are relatively experienced. The respondents therefore have ample understanding of the maintenance management practices of the SHSs they work for. The challenges and successes associated with maintenance works in their schools are well known to these respondents and therefore give credence to their views regarding the maintenance management situation in their respective schools.

Table 4.2: Experience of Maintenance Officer

Years of Experience	Frequency	Percentage (%)
0-5 years	5	16.7
6-10 years	14	46.7
11-15 years	5	16.7
16-20 years	5	16.7
Over 20 years	1	3.3
Total	**30**	**100.0**

Respondents in both management and maintenance management positions were represented by the head of school or the assistant head in-charge of domestic affairs. The large percentage of 70% (i.e. 40+30) of respondents as indicated in Table 4.3 is indicative that, a large chunk of management has less than 10 years experience in management position. However 30% of management respondents have relative experience in maintenance management activities in SHSs. Maintenance management activities are mostly handled by the Assistant Headmasters in charge of Domestic affairs on behalf of management (See Figure 4.1). They liaise directly with the maintenance officer in carrying out day-to-day maintenance work.

Table 4.3: Experience of Respondents in Management Position

Years of Experience	Frequency	Percentage (%)
0-5 years	12	40.0
6-10 years	9	30.0
11-15 years	5	16.7
16-20 years	3	10.0
Over 20 years	1	3.3
Total	**30**	**100.0**

The survey also revealed that a number of SHSs have a maintenance committee in place to make decisions and recommendations especially for major maintenance work on the campuses.

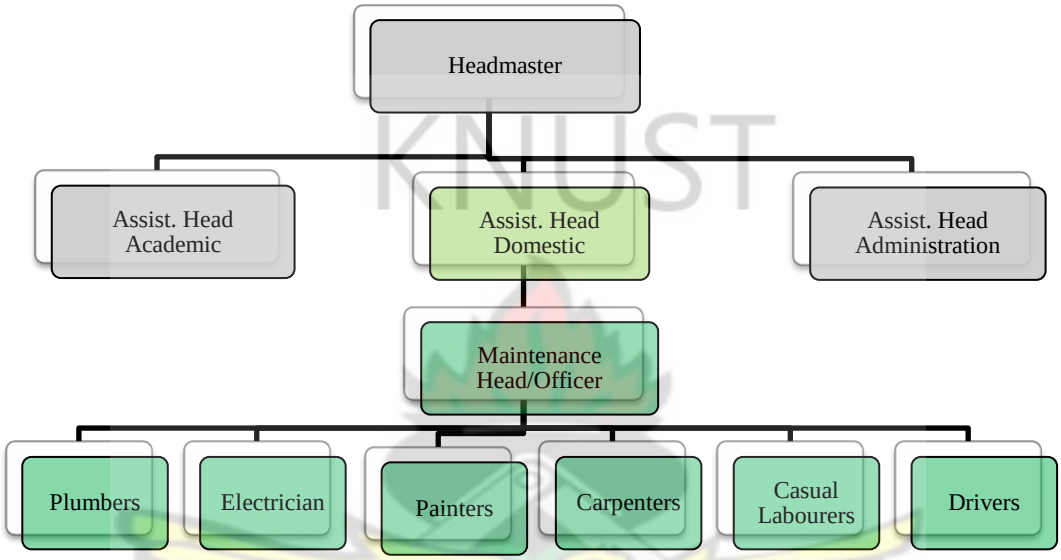


Figure 4.1: Typical Management Structure with emphasis on MM

4.2 PROFILE OF THE SHSs

The data on the profile of SHSs surveyed include the years of existence, gender distribution, residential condition, and facilities adequacy. The collection of this data was important to establish the maintenance issues generally associated with age, usage and adequacy of the built infrastructure of the respective SHSs. Profiling these characteristics will further contribute to establishing the various MM practices and hence aid the development of a consolidated current/existing MM practices. This has been discussed in later sections of this chapter.

4.2.1 length of Existence of SHSs Surveyed

The thirty (30) SHSs surveyed in this research have been in existence for various lengths of time. Table 4.4 summarizes the years of existence of the SHSs. Since the impact of age is significant in the maintenance condition of building infrastructure, it was necessary to capture information on the years of existence so as to enhance discussions in context. It is true that not all building infrastructure may have travelled those lengths of years. However, maintenance management being transitional may have played a role in one way or the other. Existence of SHSs was categorized into groups of 10 year periods beginning with 0-10 years and ending with SHSs which are over 50 years old.

Table 4.4: Years of Existence of SHSs

Age Distribution	Frequency	Percentage (%)
0-10 years	0	0.0
11-20 years	1	3.3
21-30 years	1	3.3
31-40 years	7	17.3
41-50 years	5	23.3
Over 50 years	16	53.3
Total	**30**	**100.0**

53.3% of the SHSs surveyed have been in existence for over 50 years. This is attributed to the legacy of colonialism through which missionaries set up these schools to run secondary education. Thus, built infrastructure was bequeathed to the then generation. The data further revealed that all SHSs surveyed have existed beyond 10years. Actually 6.6% (i.e.3.3+3.3) of schools surveyed are below 30 years. The larger percentage of SHSs above 30 years (i.e. 93%) in existence and still operational therefore gives a high credible cause to measure performance regarding MM best practices.

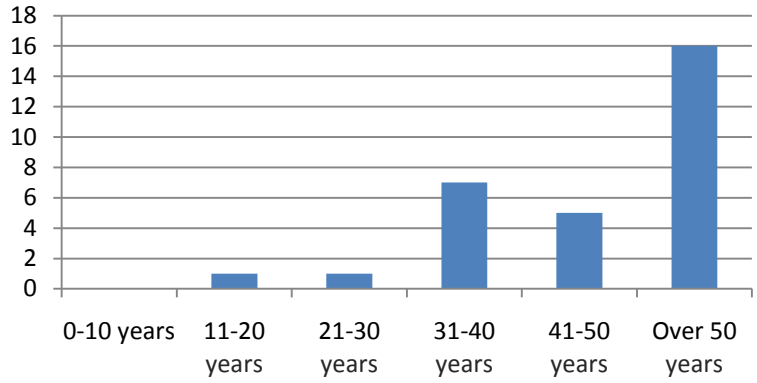


Figure 4.2: Age Distribution of SHSs

4.2.2 Gender Characteristics of Students in the SHSs surveyed

Table 4.5 presents data on the gender distribution of students in these schools. The data revealed that 53.3% of the schools surveyed admit both male and female students. 23.3% of schools admitted only Male students and 23.3% also admit only female students. Regarding students' population and its pressure on the building infrastructure, same sex schools made provisions for only one gender while mixed schools made provisions for both male and female students. This means that boys' dormitories are separate from girls' dormitories and same for infirmaries. It is however worth noting that the rest of the facilities such as classrooms, assembly halls etc. are the same thus no need for extra provisions.

Table 4.5: Gender Distribution of Students in the SHSs surveyed

Gender of Students	Frequency	Percentage (%)
Male Only	7	23.3
Female Only	7	23.3
Mixed (Male and Female)	16	53.3
Total	**30**	**100.0**

(Source: field survey, 2012)

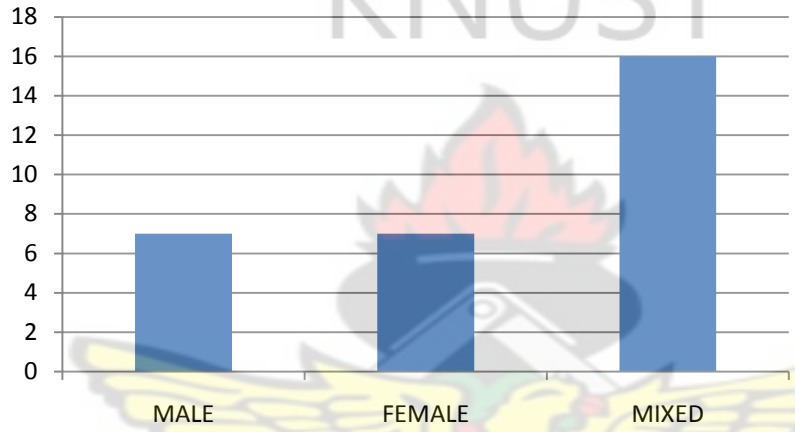


Figure 4.3: Gender Distribution of SHSs surveyed

4.2.3 Built Infrastructure of a Typical SHS Campus.

This section describes the physical infrastructure that exists in a typical SHS campus in Ghana as observed in the preliminary survey. The campuses are typically composed of academic facilities, accommodation facilities, recreational facilities, and road/access linkages. Other facilities include; religious, kitchen/dining facilities and service lines for water, electricity, and telephone. Transport services are supported by vehicles ranging from small cars, trucks to buses. It must be noted that the emphasis of this study is on the built infrastructure on these campuses.

The academic/learning facilities include buildings such as; classrooms, laboratories, assembly hall(s), library, workshops and administration block. These buildings provide spaces for both students and staff to carry out academic activities. Infrastructure to meet on-campus accommodation needs for both students and staff are provided through dormitory blocks, kitchen and dining buildings, and staff bungalows. Religious activities are accommodated in church/chapel buildings or mosques appropriately. Fence walls and main gate entry/exit define the boundaries of the SHS campuses.

The typical layout of a SHS campus is composed of academic area, students' living and recreational area, and staff residential area. These areas are then connected by road network for vehicular use as well as walkways for pedestrian use. The layout also makes provision for green areas or farmlands for students' practical training in agriculture related subjects.

4.2.4 Residential Status of Students in SHSs Surveyed

Table 4.6 presents the residential status of students in the schools surveyed. 86.7% of SHSs provide on-campus boarding accommodation for their students. 10% of the SHSs provide boarding accommodation for their students by rental means. Here, the school management rents privately owned houses/hostels to house their students. It is worth noting that 96.7% of the SHSs surveyed provide accommodation directly for their students. Only one of the SHSs surveyed does not have boarding facilities to house students. It is worth noting that even though most of the schools surveyed are primarily

boarding schools, it was gathered that a handful of students in some of the schools are non- boarding students.

Table 4.6: Residential Status of Students

Status	Frequency	Percentage (%)
Boarding (on campus)	26	86.7
Boarding (rental)	3	10.0
Non-boarding/Day	1	3.3
Total	**30**	**100.0**

(Source: field survey, 2012)

Provision of students' accommodation is cardinal to the training needs of SHSs. The provisions in the dormitories include; furniture (beds, built-in wardrobes, and cabinets), laundry spaces, lavatory facilities, artificial lighting installations, and cold water supply. These facilities/installations are used daily and thus, subjected to wear and tear. They therefore require constant repairs and sometimes total replacement. The high number of schools providing accommodation for students places emphasis on the need for prudent maintenance management practices.

4.2.5 Maintenance Staffing and Policy Situation in SHSs.

The survey also measured the staffing situation in SHSs regarding maintenance. As shown in Table 4.7, 63.3% of schools surveyed are not adequately staffed. The staffing covered maintenance management positions in the schools. The data also revealed that 13.3% of SHSs do not have maintenance units at all. Hence, MM activities for such schools are controlled mostly by members of the teaching staff, who are not particularly trained to carry out maintenance works.

Table 4.7: **Maintenance Staffing and Policy situation in SHSs**

Maintenance Staffing situation	**Frequency**	**Percentage (%)**
Adequately staffed	7	23.3
Not adequately staffed	19	63.3
No maintenance unit	4	13.3
Total	**30**	**100.0**
Status of maintenance Policy	**Frequency**	**Percentage (%)**
Written policy	15	50.0
Un-written policy	13	43.3
No maintenance policy at all	2	6.7
Total	**30**	**100.0**

(Source: field survey, 2012)

It was interesting to notice from the data that 50% of SHSs indicated that they have written policies regarding maintenance. 50% (i.e. 43.3+6.7) of schools also indicated that they do not have a written policy or no maintenance policy at all. However these SHSs undertake maintenance management activities. This can be interpreted to mean that managements of SHSs do not really appreciate the role of a written policy to guide maintenance management activities in the schools. There is however the recognition of the importance of a written policy by some schools, even though the field survey could not find a hard copy.

4.2.6 Frequency of Carrying out MM Activities on Buildings

Data on frequency of routine maintenance carried out on buildings in SHSs (See Table 4.8), revealed management's attention to the routine maintenance of the administration block of the campuses. This is indicative of the priority placed on scheduling for MM activities. The Administration Block recorded the highest mean of 4.567, indicating that,

management's priority regarding MM of school infrastructure is placed on buildings management deems important to the image of their respective schools.

Table 4.8: Frequency of Routine Maintenance carried out on Buildings in SHSs

Descriptive Statistics						
Major Buildings	**N**	**Min.**	**Max.**	**Mean**	**Std. Deviation**	**Rank**
Staff Bungalows	30	3.00	5.00	3.600	.932	4
Laundry	30	3.00	4.00	3.300	.466	9
Kitchen/Dining Hall	30	2.00	5.00	3.667	1.093	3
Classrooms/Assembly Hall	30	2.00	5.00	3.433	1.104	7
Laboratories	30	1.00	5.00	3.500	1.137	5
Students' Dormitories	30	2.00	5.00	3.867	.937	2
Administration Block	30	2.00	5.00	4.567	.935	1
Library	30	2.00	5.00	3.367	.809	8
Religious buildings	30	1.00	4.00	2.800	.664	11
Recreational Facilities	30	1.00	4.00	2.833	.699	10
Fence Wall/Gate House	30	2.00	5.00	3.467	1.224	6
Workshops	30	1.00	4.00	2.667	.959	12
Valid N (list wise)	**30**		**Avg. Mean**	**3.422**		

The students' dormitories recorded the second highest mean value of 3.867 for routine maintenance. It is common practice usually after every term, for school management to undertake maintenance works in the dormitories, while students are away on vacation. Plumbing fittings, lighting and electrical installations, and furniture (bunk-beds, cabinets, shelves etc.) are used daily by students during the term. Facilities in these dormitories are exposed to severe wear and tear due to the continuous use and therefore require routine maintenance. Some of the routine maintenance works include: fixing broken furniture; replacement of light bulbs; servicing septic system; and painting internal and external

surfaces. Replacement of louvre blades and torn mosquito nettings were also identified as some other maintenance works routinely carried out in the vacation periods.

As demonstrated in Figure 4.4, the Workshops, religious buildings and recreational facilities recorded the least mean values. This is an indication of priority setting based on the frequency of use of the building. Religious buildings, particularly, church buildings in these SHSs have been built with quality materials such as stone, reinforced concrete and timber. For instance, church buildings in most SHSs have been constructed with very high quality materials and technology and do not require frequent maintenance except day-to-day cleaning.

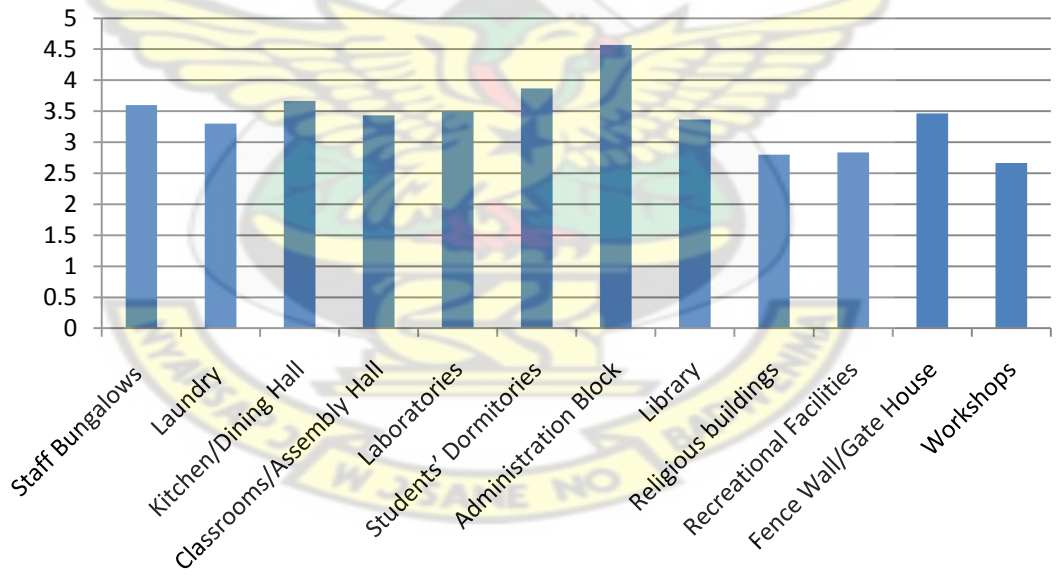


Figure 4.4: Frequency of Carrying out Maintenance Works on Buildings

Maintenance works on fence wall/gate houses of the SHSs points to the image building efforts by management of the schools. Main entry gates are considered very important in

defining the campuses of these SHSs to the public and thus management continues to place main entry as part of priority buildings for routine maintenance works in order to maintain the outlook. This pattern of carrying out maintenance works complements the data on existing MM practices discussed in section 4.3.

4.3 ANALYSIS OF EXISTING MAINTENANCE MANAGEMENT PRACTICES

4.3.1 Snap Shot of Existing MM Practices

The existing MM process in SHSs can be described as 90% corrective maintenance carried out on minor defective works. The structure of the process is made up of management, teaching and non-teaching staff, and students. The maintenance unit however works in concert with the maintenance committee in executing maintenance activities. The information revealed that, maintenance committees though established in most schools carry out their work depending on the availability of resources. The typical reporting system allows any member of the school that detects any maintenance problem to report to any person in authority and not particularly the maintenance unit. This prolongs the time of repair since most of the time the maintenance staff are not directly informed.

Management of a maintenance problem reported depends largely on the degree of defect, resource availability, and expertise of the maintenance staff. Almost 85% of maintenance staffs in the schools surveyed have never had any refresher training to update their capacities in their work.

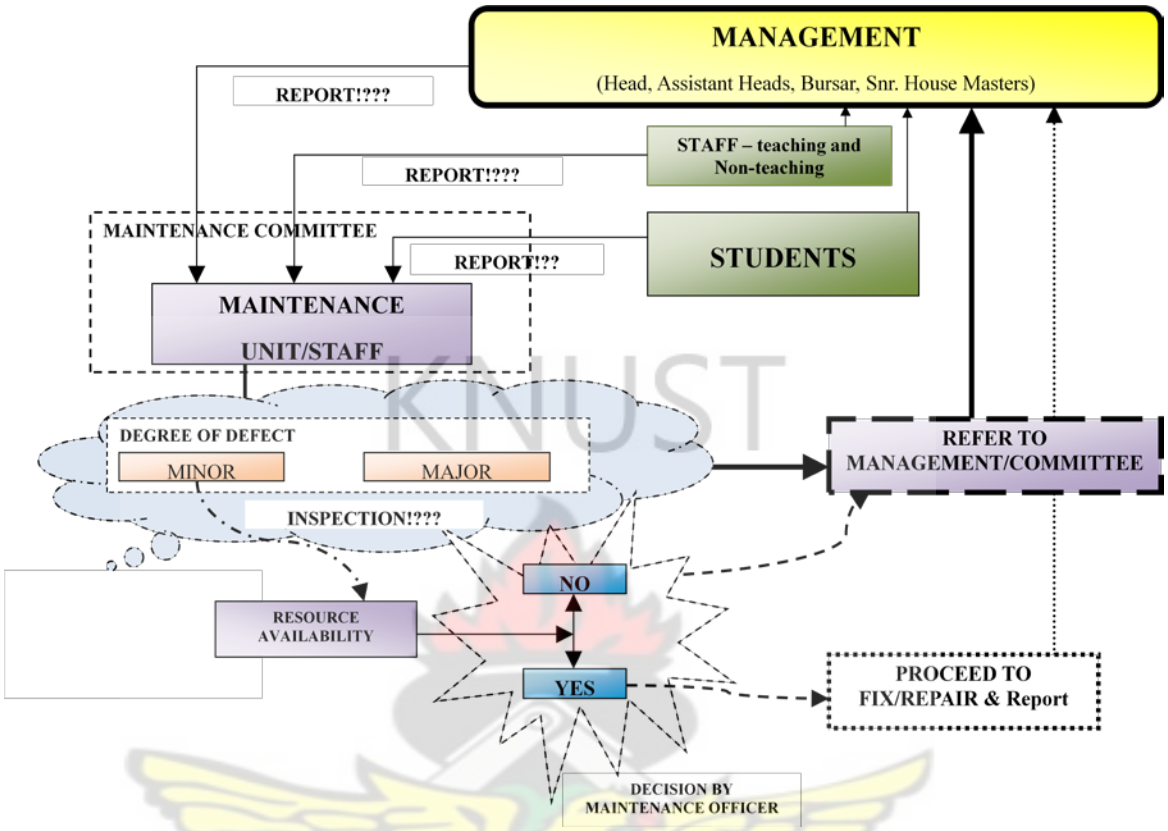


Figure 4.5: Maintenance management process in SHSs from field survey

As shown in Figure 4.5, the current model of MM in SHSs is quite undefined. Also, the hierarchy of communication that characterizes this model is not clear. Reporting and execution of maintenance problems is subject to the discretion of the maintenance unit. There are no clear timelines; inspection on maintenance conditions is particularly carried out when there is a maintenance problem. The discretion of the scale of defect of a maintenance problem lies with the maintenance officer. Unfortunately, the capacity of most maintenance staff to evaluate the extent of defects is inadequate. Responsibilities on MM are discussed in detail in the section on responsibility matrix (4.3.3).

4.3.2 Management Response Action to Maintenance Issues

Figure 4.6 is a summary of management's response action regarding maintenance management issues. The priority of a maintenance job is approached in three ways, categorized under the following conditions;

I. **Scenario 1:** if the maintenance job is considered urgent, management responds immediately. For instance, a broken water pipe in a building that allows clean water to be uncontrolled is considered urgent and management response is immediate in solving the problem.

II. **Scenario 2:** if the maintenance job can be deferred, management response can be delayed. For instance, the replacement of torn mosquito netting in a window may be deferred since it may not affect the function of the room it is covering.

III. **Scenario 3:** if the maintenance job is beyond the capacity of the maintenance unit, management usually outsources the work to experts to execute. For instance, the refurbishment of a building structure involving upgrade works, tendering and contracting, is beyond the capacity of the maintenance unit and thus out-sourced to experts using the national procurement process.

The data further revealed that the response action of management to maintenance issues is highly dependent on the availability of funds. Thus, when funds are not available a maintenance problem is compounded and the further delay may result in increasing the cost of repair or replacement.

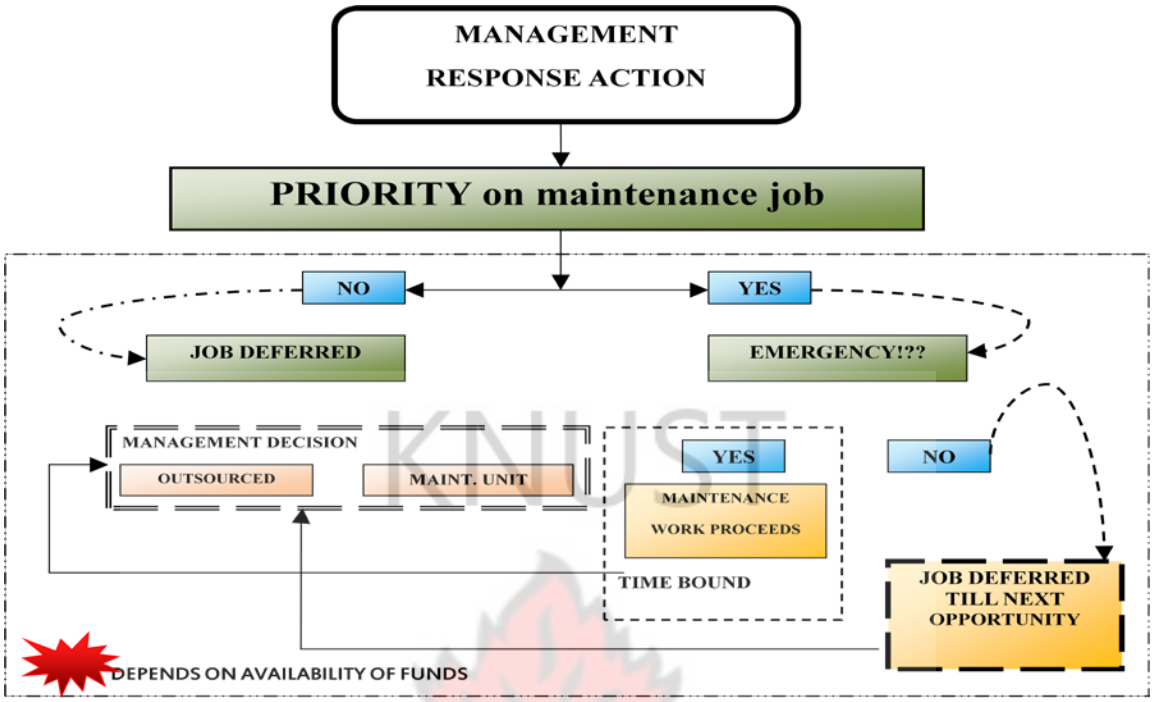


Figure 4.6: Management response action to maintenance issue

4.3.3 Responsibility Matrix (RM) and Inefficiencies of Current MM Practice in SHSs

It was necessary to appreciate the role(s) played by various individuals in the SHS community regarding maintenance management. The intention was to map the various maintenance management activities and identify who is responsible. Thus, the matrix helped to identify inherent inefficiencies. Table 4.9 therefore presents RM of the current maintenance management model in the SHSs surveyed. The matrix consists of various maintenance activities in three major phases adopted from Crespo Marquez and Gupta (2006). The phases are; maintenance planning, maintenance organization/execution and maintenance control.

The maintenance planning phase is made up of philosophy, policy making, strategies and budgeting. The matrix revealed that major decision makings on philosophy and policy direction are carried out at this stage of planning by top management staff (headmaster and assistant headmasters) and the maintenance officer of the institution. Minor roles such as typesetting, discussions and development of documentations are played by the teaching staff and administrative staff of the institutions. Strategies, forecasting and capacity planning are mainly played by the headmaster, assistant headmaster, and the maintenance officer. The bursar contributes primarily on the financial management and regulations in advice to the main players at this stage of the planning.

The activity of budgeting in this planning stage is mainly carried out by the following; the headmaster, the assistant headmaster (domestic), the bursar & accounts staff and the maintenance officer. The survey observed that, most schools hardly prepare budgets on maintenance. Instead, estimates are usually prepared when a maintenance problem arises. Maintenance officers therefore prepare cost estimates supported by *pro-forma* invoices from potential suppliers for presentation to the assistant headmaster (domestic). This method of budgeting is inefficient since it is not based on maintenance projections. Hence, a maintenance issue can delay and become worse since there are no initial allocations made to take care of the problem.

The execution phase as observed from the survey consists of routine housekeeping activities, minor repairs, rectifications, and scheduling. Routine housekeeping here refers to daily maintenance works on the built environment (campus). These include solid

(litter) waste management, sweeping and cleaning indoor and outdoor spaces. The RM revealed that the major role players are the students, prefects, senior house-master, janitorial staff, and kitchen staff. The technical staff in the maintenance unit also carries out routine maintenance of lawns, hedges, flowers, and removal of dead trees.

Table 4.9: Stakeholder roles in maintenance management activities in SHSs

		PHASES OF MAINTENANCE											
		Planning			Execution				Monitoring & Control				
	STAKEHOLDERS	Philosophy/Policy	Strategies /Capacity /Forecasting	Budgeting	Routine House Keeping.	Repairs	Rectification	Scheduling	Supervision & Quality Management	Inventories & Recording	Evaluation	Reporting	Routine Inspection
Management / Staff / Maintenance Staff / Students	Headmaster/Headmistress	X	X	X					Y				Y
	Asst Head- Admin	X	Y	Y									
	Asst Head- Acad.	X	Y	Y									
	Asst Head – Domestic	X	X	X		X	X	Y	X		Y		Y
	Senior House Master	Y	Y	Y	X				X			Y	X
	Bursar		Y	X		X	X					X	
	Teaching Staff	Y			Y							Y	Y
	Non – Teaching/Accounts Staff			X								Y	
	Kitchen Staff				X							Y	
	Administrative Staff	Y										Y	
	Maintenance Officer	X	X	X		X	X/Y	X	X	X	X	X	X
	Janitorial Staff				X							X	
	Technical Staff (Maintenance)				X	X	X	Y		Y		X	Y
	Prefects				Y				X			Y	Y
	Students (Senior & Junior)				X							Y	
	Outsourced Work					X	X			Y		Y	
	Legend: **X** – Major role; **Y** – Minor role												

Repairs and rectification refer to activities that involve corrective maintenance works such as repair to leaking pipes, broken door locks, power leakages, broken furniture (beds, tables and chairs), leaking roof coverings, etc. The main players here include the maintenance officer and the technical staff of the maintenance unit. The Assistant Headmaster (domestic) and the Bursar also play major roles in repairs and rectification maintenance activities. If the scale of work is beyond the capacity of the maintenance unit, the work is outsourced to an expert with the requisite capacity to carry out the work. For instance, where the rectification requires redesign and renovation of a building which involves architectural works, it will be outsourced to an architectural consultant to execute for the school.

Scheduling of maintenance activities is mainly carried out by the maintenance officer. Scheduling deals with assigning timelines to maintenance activities planned. The field survey also revealed that, the maintenance activities carried out are mainly minor works covering the built environment of the SHSs campuses.

Monitoring and Control forms the last phase of the RM. This phase contains supervision & quality management as one activity, evaluation, reporting, and routine inspection form the other activity groupings identified under the phase. Supervision & quality management activities according to the RM indicated that the Assistant Headmaster-domestic, the Senior House-master, prefects and the maintenance officer play major roles in this aspect. Routine daily maintenance activities are supervised by the first three players while the maintenance officer supervises more technical maintenance works.

Inventories and recording of maintenance works are the responsibility of the maintenance officer supported by the maintenance technical staff. In cases where the maintenance work is carried out by an expert, records of the works executed are handled by the expert. The RM revealed that the evaluation of maintenance works is expected to be done by the maintenance officer with supporting roles by the Assistant Headmaster-domestic. The maintenance officer is also directly responsible for producing maintenance reports after inspections and evaluations. Expenditure records on executed maintenance works are usually provided by the bursar and the accounts unit.

Unfortunately, the results also demonstrate that the qualifications of these maintenance officers are generally inadequate for management activities especially maintenance management. The RM demonstrated that the maintenance officer plays major roles in all the phases of the maintenance management process in SHSs.

4.4 PERCEPTION OF RESPONDENTS ON PERFORMANCE OF MAINTENANCE MANAGEMENT IN SHSs.

During the data collection phase of this research, it was necessary to measure the opinions of management members versus those of maintenance staff regarding maintenance management activities on the various campuses. This was deemed important since it identified the various areas of consensus and gaps, so they could be considered in the development of the framework. Respondents were asked to rate the level of performance of their respective schools on maintenance management. The ratings ranged from not satisfactory to very satisfactory on twenty-five (25) benchmarks on a Likert scale. The Likert scale was composed of the following; 1(≤1.00) = Not satisfactory, 2

(1.01-2.00) = Fairly satisfactory, 3 (2.01-3.00) = Satisfactory, 4 (3.01-4.00) = Very satisfactory, and 5 (4.01-5.00) =Highly satisfactory. Table 4.10 presents results on the comparative analysis carried out. The descriptive statistics include mean, standard deviation and rankings of the measured variables. The mean ranking of each variable was done to clarify the consensus or divergent perceptions on satisfaction levels with regards to performance on maintenance issues in the schools.

4.4.1 Management Perception on Performance Level on MM

Management's perception on MM performance levels in the schools, as per the results presented in Table 4.10 showed that management thought that budgeting (3.63), maintenance officer's qualification (3.63), and maintenance staff responsiveness (3.57) were *very satisfactory*. It is worth noting that even though some respondents ranked some of the factors *highly satisfactory*, the descriptive analysis did not yield any cumulative average mean in the range above 4.00. Management also indicated that the qualification of maintenance officers was *very satisfactory*. This may be influenced by the recruitment policy by GES on maintenance staff. So as far as the policy or directive remains, this perception will continue to be upheld by management.

Computerized Maintenance Management System (2.17), Users/occupants Awareness (2.17), and Maintenance Staff training (2.13) recorded the lowest mean values. Management thought the schools performance level on these factors was *satisfactory*. All SHS management acknowledged that the training of maintenance staff was

inadequate however they measured it satisfactory. User/occupants awareness to maintenance management issues was also thought to be satisfactory.

Table 4.10: Mean Comparison of Variables

		Management Staff			Maintenance Staff		
PERFORMANCE VARIABLE	**N**	**Mean**	**Std. Devn**	**Ranking**	**Mean**	**Std. Devn**	**Ranking**
Budgeting	30	3.63	0.718	1	3.83	0.834	4
Maintenance staff responsiveness	30	3.57	0.728	3	2.83	0.913	18
Computerized Maintenance Management System	30	2.17	1.085	23	2.53	1.279	24
Maintenance Communication	30	3.07	0.868	15	3.63	0.615	9
Craftsmen qualification	30	3.23	0.817	11	3.80	0.925	5
Organogram's Flexibility	30	3.43	0.626	7	3.73	0.868	7
Life Cycle Costing	30	2.97	0.850	16	2.83	1.392	19
Maintenance Policy	30	3.47	0.860	6	2.97	0.809	16
Maintenance officer qualification	30	3.63	0.809	2	4.30	0.535	1
Maintenance inspection	30	3.53	0.681	4	4.27	0.521	2
Maintenance tools and materials	30	3.23	1.006	12	3.20	1.448	13
Number of maintenance staff	30	2.33	1.124	22	2.57	1.040	23
Organizational structure	30	2.83	1.020	19	2.80	0.664	20
Planning maintenance activities	30	3.17	0.791	13	3.67	0.884	8
Maintenance Staffing	30	2.80	0.887	20	2.67	1.061	22
Recording & Feedback System	30	2.90	1.125	17	3.80	0.925	6
Reports on maintenance	30	3.50	0.938	5	4.13	0.681	3
Research on maintenance	30	2.87	1.167	18	3.13	0.899	15
Setting priorities	30	3.30	0.837	9	3.17	1.117	14
Setting Maintenance Standards	30	3.30	0.837	10	3.47	1.008	11
Sound maintenance system	30	3.43	0.898	8	3.60	0.724	10
Top management awareness	30	3.13	0.860	14	2.73	0.944	21
Maintenance Staff Training	30	2.13	1.279	25	2.87	1.332	17
User/occupant awareness	30	2.17	1.117	24	2.27	1.202	25
Maintenance Technology	30	2.73	1.172	21	3.20	0.805	12
Valid N (list wise)	**30**	**3.06**			**3.28**		

4.4.2 Maintenance Officers' Perception of MM Performance Level in SHSs

Table 4.10 presents a summary of the satisfactory levels regarding performance on maintenance management in the schools surveyed. Maintenance officers thought that qualification of maintenance officers was highly satisfactory (i.e. mean value of 4.30). Maintenance inspection was ranked second with a mean value of 4.27, while reporting on maintenance was ranked third with a mean value of 4.13. All these three performances were cumulatively ranked *highly satisfactory*. The results further revealed that the 'user/occupants awareness' (2.27), 'computerized maintenance management system' (2.53), and 'number of maintenance staff' (2.57) recorded the least mean values and ranked *satisfactory* on the performance scale.

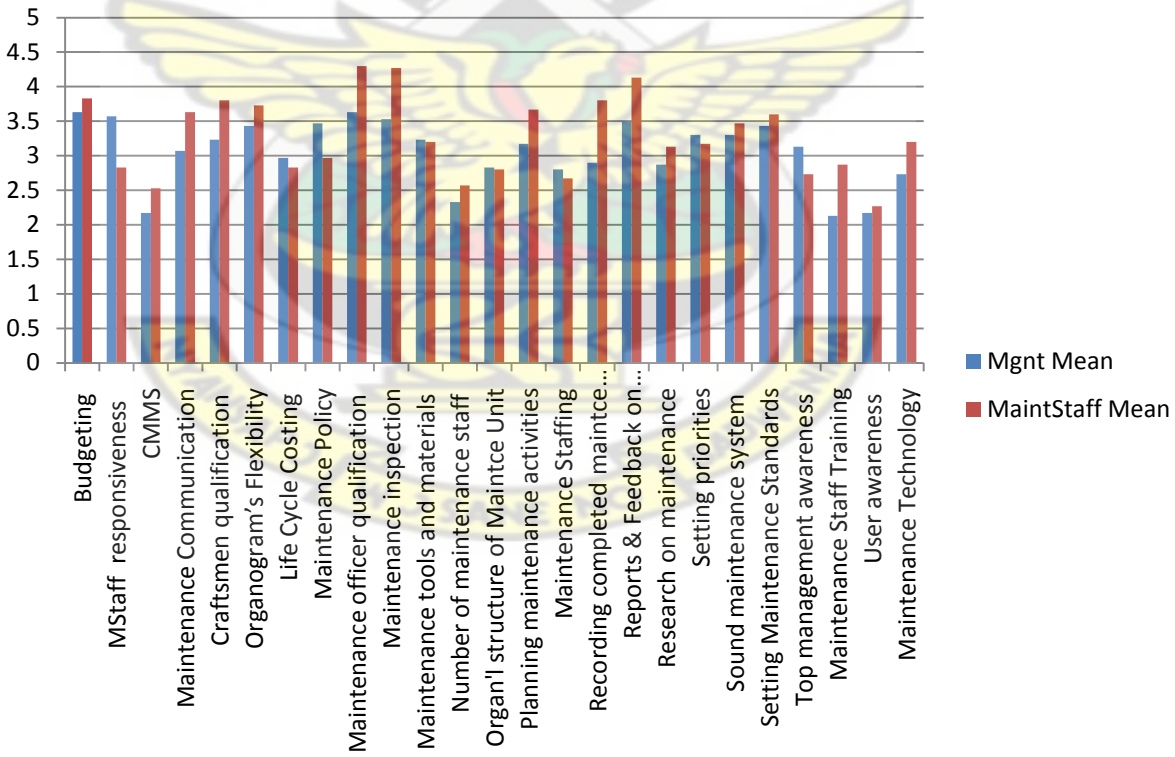


Figure 4.7: MM Performance levels compared

Maintenance officers' ranking of maintenance officers' qualification as highly satisfactory does not particularly commensurate with data collected on the qualifications of maintenance officers in the SHSs. For instance in Table 4.1, 36.7% of maintenance officers have NVTI Grades 1 & 2 certifications. As explained earlier this qualification is not adequate for carrying out maintenance management activities.

The results also showed that there was no consensus among the two groups of respondents on the performance of MM in the SHSs. The overall average mean perception of performance level of MM in the SHS indicated 3.06 (i.e. very satisfactory) while that of the maintenance officers perception of performance level of MM to be 3.28 (i.e. very satisfactory). This overall mean average for Maintenance officers is relatively high compared to the perception mean of management on MM. Figure 7 gives a graphic presentation of the comparative mean values on the 25 variables measured regarding perceptions on performance of MM in the schools surveyed.

4.5 ANALYSIS OF LEVEL OF IMPORTANCE OF MMBP BENCHMARKS BY RESPONDENTS

4.5.1 Reliability Test

Recommendations by prominent social scientists (Nunnally and Bernstein, 2007; Field 2005; Spector, 1992) support that Cronbach's reliability coefficient alpha should be computed when the data involved is collected through a Likert scale questionnaire. The reliability test is necessary to determine the internal consistency of the variables

considered in the questionnaire. The reliability test further validates the research instrument (Field 2000). The Likert scale was used to measure the constructs on the level of importance to maintenance management practices in SHSs. Cronbach's alpha coefficient is usually calculated to be between 0 and 1, where a value of 0.7 is described as acceptable and 0.8 described as good internal consistency (George and Mallery, 2003).

Statistical Package for Social Sciences (SPSS) software tool was used to compute the overall Cronbach's alpha coefficient for this research at 0.905. This demonstrates a very good reliability and internal consistency of most of the variables. Field (2005) however suggests that in order to guarantee the contribution of individual variables to the overall Cronbach's alpha coefficient, there was the need to conduct the test when the variable was deleted. Field (2005) further suggests that when the test is conducted with a deleted variable and the Cronbach's alpha value is higher than the overall value, the variable is deleted from the group of variables measuring their levels of importance to maintenance management. Table 4.11 presents analysis on the reliability and three best practice factors namely *'organogram's flexibility', 'reports on maintenance' and 'sound maintenance system' that* failed the Cronbach's test. These were not good constructs for assessing levels of importance of MM in SHSs.

Table 4.11: Reliability Tests of variables

Best Practice Criteria (BPC)	Reliability[a]	Remarks
	Cronbach's Alpha if item deleted	
Budgeting	0.897	Reliable
Maintenance staff responsiveness	0.899	Reliable
Computerized Maintenance Management System	0.902	Reliable
Maintenance Communication	0.904	Reliable
Craftsmen qualification	0.900	Reliable
~~Organogram's Flexibility~~	~~0.913~~	**~~Deleted~~**
Life Cycle Costing	0.893	Reliable
Maintenance Policy	0.902	Reliable
Maintenance officer qualification	0.901	Reliable
Maintenance inspection	0.902	Reliable
Maintenance tools and materials	0.899	Reliable
Number of maintenance staff	0.898	Reliable
Organizational structure	0.893	Reliable
Planning maintenance activities	0.904	Reliable
Maintenance Staffing	0.901	Reliable
Recording & Feedback System	0.905	Reliable
~~Reports on maintenance~~	~~0.909~~	**~~Deleted~~**
Research on maintenance	0.903	Reliable
Setting priorities	0.897	Reliable
Setting Maintenance Standards	0.904	Reliable
~~Sound maintenance system~~	~~0.906~~	**~~Deleted~~**
Top management awareness	0.899	Reliable
Maintenance Staff Training	0.897	Reliable
User/occupant awareness	0.900	Reliable
Maintenance Technology	0.904	Reliable

a. Cronbach's Alpha = 0.905 N of Cases = 60
N of Items = 25

4.5.2 One-Sample T-Test for Ranking Dependent Variables

The one sample t-test was carried out to determine whether the sample population regarded a best practice criterion is important or not. One sample t-test analysis establishes the significance of sample mean from a hypothesized mean (Ahadzie, 2007). The hypothesis is therefore set as follows;

H_0: U = U_0 Where H_0 represents the null hypothesis. U_0 represents the hypothesized or population mean. U represents the sample mean.

H_a: U > U_0 Where H_a represents the alternative hypothesis.

Tables 4-12 and 4-13 present results from the one sample t-test which according to Hair et al (1998), Reymont and Joreskog (1993) and Ahadzie (2007) usually presents the mean of the test group, degree of freedom for the test, and the t-value indicating the strength of the test. The tables also present standard deviation and standard error of the each criterion analysed. The sample size of 60 respondents is deemed relatively adequate for drawing statistical inferences (Field, 2005; Ahadzie, 2007).

For each criterion the null hypothesis was that the criterion was *unimportant* (i.e. H_0: U = U_0) while the alternative hypothesis was that the criterion was important (i.e. H_a: U > U_0). U_0 which represents the population mean is set at 3.5 test value with a significance level of 95% (Ling 2002 cited in Ahadzie, 2007). U_0 therefore represents a critical measure at/above which the criterion is considered important. According to Ahadzie (2007) where two or more variables have the same mean, the variable with the lowest standard deviation is ranked higher on the scale of importance. Ahadzie (2007) further suggested

that where the standard error of means is 'relatively close to zero' it is an indication that the sample chosen is an accurate reflection of the population. The standard errors therefore respond positively to this rule of thumb as shown in Table 4.12.

Table 4.12: Results of T-Test indicating One-Sample Statistics

BEST PRACTICE CRITERIA	N	Mean	Std. Deviation	Std. Error Mean
Budgeting	60	4.167	.905	.117
Maintenance staff responsiveness	60	3.967	.919	.119
Computerized Maintenance Management System	60	3.233	1.184	.153
Maintenance Communication	60	4.033	.758	.098
Craftsmen qualification	60	3.950	.746	.096
Life Cycle Costing	60	4.100	1.08	.140
Maintenance Policy	60	3.833	.867	.112
Maintenance officer's qualification	60	4.383	.640	.083
Maintenance inspection	60	4.350	.606	.078
Maintenance tools and materials	60	4.017	1.282	.166
Number of maintenance staff	60	3.617	1.195	.154
Organizational structure	60	3.600	1.210	.156
Planning maintenance activities	60	4.133	.566	.073
Maintenance Staffing	60	3.967	.956	.123
Recording & Feedback System	60	4.050	.909	.117
Research on maintenance	60	3.800	.732	.094
Setting priorities	60	4.000	1.058	.137
Setting Maintenance Standards	60	3.417	.962	.124
Top management awareness	60	3.767	.927	.119
Maintenance Staff Training	60	4.117	1.354	.175
User/occupant awareness	60	3.883	1.329	.172
Maintenance Technology	60	3.933	.821	.106

Table 4.13 also revealed that two criterion namely *Computerized Maintenance Management System* and *Setting Maintenance Standards* recorded mean values below the

population value of 3.5. They also recorded negative t-values as shown in Table 4.13. These two criteria were therefore eliminated from subsequent analysis thus, leaving 20 factors. The best practice criteria have been ranked according to the mean levels of importance (Table 4.14).

Table 4.13: Results of One-Sample Test indicating test significance

	Test Value = 3.5					
					95% Confidence Interval of the Difference	
Best Practice Criteria	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Budgeting	5.705	59	.000	.667	.433	.900
Maintenance staff responsiveness	3.929	59	.000	.467	.229	.704
CMMS	-1.744	59	.086	-.267	-.573	.039
Maintenance Communication	5.447	59	.000	.533	.337	.729
Craftsmen qualification	4.671	59	.000	.450	.257	.643
Life Cycle Costing	4.285	59	.000	.600	.320	.880
Maintenance Policy	2.979	59	.004	.333	.109	.557
Maintenance officer qualification	10.687	59	.000	.883	.718	1.048
Maintenance inspection	10.869	59	.000	.850	.694	1.006
Maintenance tools and materials	3.122	59	.003	.517	.185	.848
Number of maintenance staff	.757	59	.452	.117	-.192	.425
Organizational structure	.640	59	.525	.100	-.212	.412
Planning maintenance activities	8.660	59	.000	.633	.487	.779
Maintenance Staffing	3.781	59	.000	.467	.220	.714
Recording & Feedback System	4.682	59	.000	.550	.315	.785
Research on maintenance	3.175	59	.002	.300	.111	.489
Setting priorities	3.662	59	.001	.500	.227	.773
Setting Maintenance Standards	-.671	59	.505	-.083	-.332	.165
Top management awareness	2.228	59	.030	.267	.027	.506
Maintenance Staff Training	3.528	59	.001	.617	.267	.966
User/occupant awareness	2.234	59	.029	.383	.040	.727
Maintenance Technology	4.090	59	.000	.433	.221	.645

Table 4.14: Summary of T-Test with corresponding rankings

Best Practice Criteria	Mean	Std. Devn	Std. Error Mean	Ranking
Maintenance officer's qualification	4.383	.640	.083	1
Maintenance inspection	4.350	.605	.078	2
Budgeting	4.167	.905	.117	3
Planning maintenance activities	4.133	.566	.073	4
Maintenance Staff Training	4.117	1.354	.175	5
Life Cycle Costing	4.100	1.085	.140	6
Recording & Feedback system	4.050	.909	.117	7
Maintenance Communication	4.033	.758	.098	8
Maintenance tools and materials	4.017	1.282	.166	9
Setting priorities	4.000	1.057	.137	10
Maintenance staff responsiveness	3.967	.919	.119	11
Maintenance Staffing	3.967	.956	.123	12
Craftsmen qualification	3.950	.746	.096	13
Maintenance Technology	3.933	.821	.106	14
User/occupant awareness	3.883	1.329	.172	15
Maintenance Policy	3.833	.867	.112	16
Research on maintenance	3.800	.732	.094	17
Top Management Awareness	3.767	.927	.119	18
Number of maintenance staff	3.617	1.195	.154	19
Organizational structure	3.600	1.210	.157	20

As shown in Table 4.14, the highest ranked best practice criterion is *maintenance officer's qualification*. However, *organizational structure* emerged the least ranked criterion (i.e. 20th). These 20 best practice MM success criteria conform to best practices regarding maintenance management projects particularly for schools and academic institutions (Akasah et al., 2010).

It is not surprising that *maintenance officers qualification* was ranked first because respondents' views were that, recruiting a qualified maintenance officer will provide a basis for good MM even with limited resources. Respondents ranked the first 10 best practice criteria for a successful MM framework as most important with a mean 4.00 or above. Four of the first five include *maintenance inspection, budgeting, planning maintenance activities, maintenance staff training,* were ranked 2nd, 3rd, 4th, and 5th respectively.

Maintenance inspection involves a continuous process of identifying the maintenance conditions of buildings, facilities and installations through inspection. Respondents consider this activity to be very cardinal and a best practice for success in MM. Budgeting is also critical to an effective MM framework since carrying out maintenance works require finance. Budgeting allows for financial planning to meet payment requirements of maintenance works, and the acquisition of materials and equipment. Planning maintenance activities will allow management to schedule and manage limited resources efficiently to meet MM demands. Maintenance staff training was also deemed most important to a MM framework and thus, ranked 5th. Having a well trained MM staff that undergoes routine in-service training can contribute to the sustainability of the MM framework.

The rest of the first 10 best practice criteria for MM framework include *life cycle costing, recording & feedback system, maintenance communication, maintenance tools & equipment, and setting priorities* ranked 6th, 7th, 8th, 9th, and 10th respectively. Life cycle

cost of building infrastructure refers to the cost of acquisition; cost in operation, cost of maintenance, and cost of disposal of the building or building system (see Buys and Nkado, 2003 and Fuller, 2010). Respondents appreciated that in order to avoid "cheap-to-build-expensive-to-maintain" situations; MM framework would need to consider this criterion most important especially for new projects. Recording and feedback system was also considered by respondents as most important to a MM framework. Communication on maintenance management was also deemed most important to a MM framework as well as making available the requisite tools and equipment for the execution of maintenance activities. Priority setting deals with the sequence of carrying out maintenance work based on existing information on available resources such as funds, staff, technology and time.

Respondents ranked *maintenance policy* 16th. It is understandable that maintenance policy is ranked this low since about 50% of schools surveyed did not have any policy direction on maintenance management. Policies direct the course of a business and thus become the broad platform to detail maintenance actions such as planning, scheduling and executions. Surprisingly, respondents ranked *top management awareness*, 18th. The need for top management to be aware of maintenance management impact on school's activities cannot be over emphasized. Top management is not expected to carry out maintenance execution roles; however knowledge of MM is necessary for guiding decision-making processes on policy, recruitments and budgeting. The consequences of top management's poor awareness of MM affect accurate budgeting and thus insufficient funds for maintenance works. It will further lead to neglect of assets which require

maintenance and hence backlogs stored up for future attention at a huge costs (Grimshaw, 1986 cited in Buys and Nkado (2003); Spedding, 1994).

Respondents also ranked *number of maintenance staff* 19th. This may be attributed to recruitment opportunity for casual labourers for maintenance work on school campuses. Outsourcing maintenance activities is a way to manage workloads and acquire best output from experts. Thus, peripheral staff though required may not be cardinal to the core staff requirement for MM.

It is clear from the rankings, respondents' views on the critical criteria for an effective maintenance management framework. This is necessary to reduce these 20 criteria in manageable clusters through factor analysis.

4.6 FACTOR ANALYSIS OF DEPENDENT VARIABLES

Factor analysis is described by Coates and Steed (2001) and Field (2005) as a data reduction technique employed in reducing a large number of variables into smaller manageable sets of factors with underlying correlations. Ahadzie (2007) asserted that factor analysis is useful for eliciting 'clusters of related variables into a more easily understood framework'. Tables 4.15 to 4.20 and Figure 8 present results of the factor analysis.

After thorough reliability test conducted and presented in an earlier section (see Section 4.5.1) and one-sample t-test, 20 best practice factors qualified for factor analysis. As

shown in Table 4.15, BPF was used as the code to represent each of the 20 Best Practice Factors.

Table 4.15: Qualified Best Practice Factors for Maintenance Management

BEST PRACTICE FACTOR	BPF
Maintenance officer/manager's qualification	BPF1
Maintenance inspection	BPF2
Budgeting	BPF3
Planning maintenance activities	BPF4
Maintenance Staff Training	BPF5
Life Cycle Costing	BPF6
Recording & Feedback system	BPF7
Maintenance Communication	BPF8
Maintenance tools and materials	BPF9
Setting priorities	BPF10
Maintenance staff responsiveness	BPF11
Maintenance Staffing	BPF12
Craftsmen qualification	BPF13
Maintenance Technology	BPF14
User/Occupant awareness	BPF15
Maintenance Policy	BPF16
Research on maintenance	BPF17
Top Management Awareness	BPF18
Number of maintenance staff	BPF19
Organizational structure	BPF20

Source: Field Survey (2012)

Table 4.16: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.679
Bartlett's Test of Sphericity	Approx. Chi-Square	1156.00
	Df	190
	Sig.	.000

Source: Field Survey (2012)

The Bartlett's Test of Sphericity and sampling adequacy presented in Table 4.16 showed the Chi-Square of 1156.00 with an associated significance of 0.000 demonstrating that, the sample used is adequate. According Ahadzie (2007), the Bartlett's Test of Sphericity is used to establish the potential correlations of possible clusters that do exist in the factors. Another test of sample adequacy used in this analysis is the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO-test). The value of the KMO ranges from 0 to 1 where 0 represents *perfectly inadequate* and 1 represents *perfectly adequate* sample (Alese and Owoyemi, 2004). Field (2000) suggests that for a sample to be considered adequate the value of the KMO should be greater than 0.5. The KMO-test for this sample yielded 0.679 and thus indicates that the sample is fairly adequate.

Table 4.17: Test of Communalities

	Initial	Extraction
Budgeting	1.000	.670
Maintenance staff responsiveness	1.000	.744
Maintenance Communication	1.000	.780
Craftsmen qualification	1.000	.739
Life Cycle Costing	1.000	.848
Maintenance Policy	1.000	.823
Maintenance officer qualification	1.000	.674
Maintenance inspection	1.000	.782
Maintenance tools and materials	1.000	.839
Number of maintenance staff	1.000	.838
Organizational structure	1.000	.876
Planning maintenance activities	1.000	.672
Maintenance Staffing	1.000	.828
Recording & Feedback System	1.000	.742
Research on maintenance	1.000	.708
Setting priorities	1.000	.746
Top management awareness	1.000	.782
Maintenance Staff Training	1.000	.918
User/occupant awareness	1.000	.856
Maintenance Technology	1.000	.803

Extraction Method: Principal Component Analysis.

Table 4.17 presents the communalities involved in the sample. Communalities of the variables indicate the proportion of variance explained by common factors. The values range from 0 to 1 where 0 indicates that the common factors (extracted) show none of the variances in the variable, and 1 indicates that the common factors explain all the variance in the variable. The rule of thumb on communalities however is that; extraction values of

more than 0.5 at the initial iteration indicates that the variable is significant and thus can undergo further analysis or if otherwise then removed from further analysis (Field, 2005). The results of the communalities shown in Table 4.17 indicates that the average communalities after the extraction is 0.783 reinforcing adequacy of the sample size.

Table 4.18: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.085	40.425	40.425	8.085	40.425	40.425	6.225	31.123	31.123
2	3.140	15.698	56.123	3.140	15.698	56.123	2.898	14.488	45.611
3	1.831	9.153	65.276	1.831	9.153	65.276	2.347	11.735	57.347
4	1.426	7.131	72.407	1.426	7.131	72.407	2.274	11.370	68.717
5	1.185	5.926	78.334	1.185	5.926	78.334	1.923	9.617	78.334
6	.928	4.641	82.974						
7	.817	4.084	87.059						
8	.535	2.676	89.735						
9	.489	2.444	92.179						
10	.350	1.748	93.927						
11	.264	1.318	95.245						
12	.243	1.215	96.461						
13	.207	1.035	97.495						
14	.158	.791	98.286						
15	.106	.532	98.818						
16	.075	.375	99.193						
17	.063	.313	99.506						
18	.044	.221	99.727						
19	.033	.167	99.894						
20	.021	.106	100.000						

Extraction Method: Principal Component Analysis.

Table 4.18 shows the total variance explained. The eigenvalue was set at 1.00 while the factor loading was set at 0.5. These are conventionally high and recommended as suitable benchmarks for establishing the total variance (Field, 2005). Five main components were extracted under 1.185 eigenvalue minimum. The first principal component (Component

1) measured 40.43% of the total variance, Component 2 accounted for 15.70% of the total variance, and Component 3 accounted for 9.15% while Component 4 and Component 5 accounted for 7.13% and 5.93% of the total variance respectively. The clustering of variables contributing to a successful MMF for SHSs within five components established a cumulative sum of squared loading of 78.33%. This high cumulative proportion of the variance is more than the 50% minimum cumulative loading and thus, acceptable. To improve the interpretation of the Principal Component Analysis, the rotation component matrix technique was used as suggested by Norusis (1988). Table 4.19 therefore presents results of the rotated component matrix for further discussions.

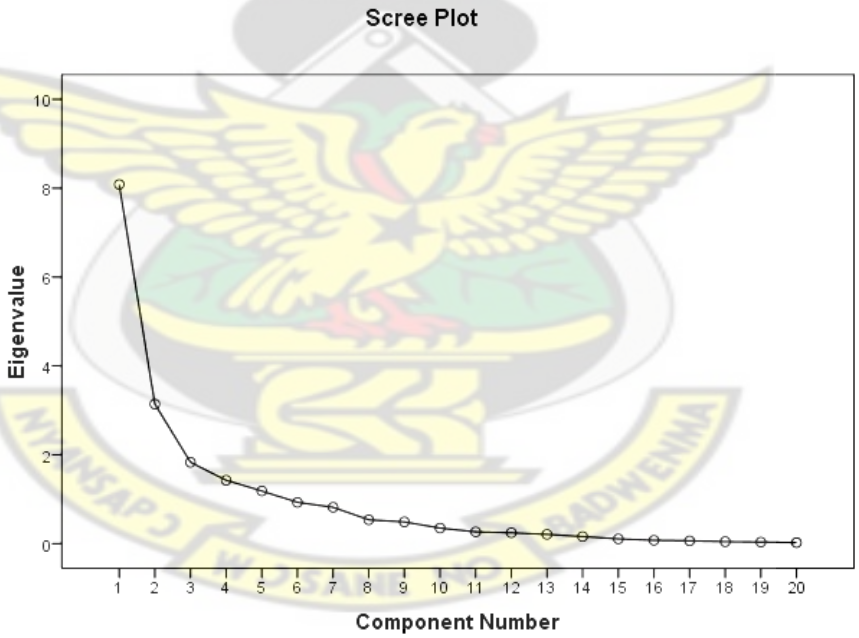


Figure 4.8: Scree Plot for Factor Analysis

A thorough examination of the associated relationships among variables of each component with regards to MMF resulted in the following interpretations; component 1 is named *resource management criteria*; component 2, *technical management criteria*;

component 3 is named *policy & standards criteria*; component 4 is also named *planning & execution criteria*; and component 5 is named *communication criteria*.

Table 4.19: Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
Maintenance Staff Training	.934				
User/occupant awareness	.906				
Life Cycle Costing	.893				
Number of maintenance staff	.871				
Maintenance tools and materials	.840				
Organizational structure	.797				
Budgeting	.738				
Maintenance Staffing	.650				
Maintenance Technology		.847			
Maintenance inspection		.829			
Setting priorities		.652			
Research on maintenance		.560			
Maintenance officer's qualification		.512			
Maintenance Policy			.876		
Maintenance staff responsiveness			.691		
Top management awareness			.654		
Recording & Feedback System				.804	
Planning maintenance activities				.773	
Maintenance Communication					.802
Craftsmen qualification					.712

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. **a.** Rotation converged in 7 iterations.

Section 4.7 presents further discussions on the results with respect to the components established from the factor analysis.

4.7 DISCUSSION OF RESULTS

4.7.1 Component 1: Resource Management Criteria

Component 1 consists of eight extracted best practice criteria variables. These include *maintenance staff training (0.934), user/occupants awareness (0.906), life cycle costing (0.893), number of maintenance staff (0.871), maintenance tools and materials (0.840), organizational structure (0.797), Budgeting (0.738), and maintenance staffing (0.650).* The indices in brackets represent the factor loadings resulting from the rotated component matrix as indicated in Table 4.19. The factors in this component largely share commonness that point to resources on maintenance management. The resources include human resource, material resources, tools and equipment as well as financial resources. Resources are fundamental to the smooth operation of any maintenance management system. Buys and Nkado (2003) identified that the absence or inadequate resource availability to maintenance departments adversely affects maintenance works. The role of resources to a successful MMF cannot be overemphasized. The absence of these resources is considered barriers to the implementation of maintenance systems (Hipkin and De Cock, 2000).

Resource management in SHSs in Ghana towards maintenance management is rather inadequate for any effective maintenance management system. For instance, the results showed that, a bulk of the maintenance staff lack the requisite qualification for executing most MM activities. Existing MM practices also revealed that carrying out maintenance works depends on availability of funds. Resource planning (for staff, finances, materials, tools and equipment) is therefore very important to the MM process in SHSs in Ghana.

Ebah (2000) observed that funds for maintenance works are never provided until a breakdown of a facility occurs. This is attributed to poor resource planning as stated earlier.

Maintenance staff training ranked number one in this component emphasizes the important role of a competent human resource in the maintenance management process in schools. Akasah and Amirudin (2010) citing Hamisah (2003) asserted that where there is a lack of understanding among school staff regarding maintenance, maintenance management becomes a problem. This further gives credence to the ranking of user/occupants' awareness as second in this component. User/occupant's awareness to MM issues is very important to efficient resource management in the MM process. Knowledge of human, material and equipment resources for maintenance management activities is necessary for promoting good MM practices.

4.7.2 Component 2: Technical Management Criteria

Component 2, named *technical management criteria*, contains *Maintenance Technology (0.847), Maintenance inspection (0.829), Setting priorities (0.652), Research on maintenance (0.560), and Maintenance officer's qualification (0.512).* These five extracted best practice factors point to the technical management aspect of maintenance management. Crespo Marquez and Gupta (2006) suggest that maintenance technology is anchored on studying technical issues that can contribute to improving maintenance works such as new repair and monitoring techniques in maintenance management. Technology is therefore required to identify or measure maintenance problems in MM

process, not surprising that it emerged number one in this grouping. Technology aids the process of repair or monitoring maintenance problems examples of which include; detecting leakage points in underground pipe lines, measuring integrity of reinforced concrete components, and detecting electrical leakages in power lines. Other maintenance technologies utilized in maintenance management include testing the quality of drinking water using the right chemicals, soil and solid waste management techniques. The utilization of computerized maintenance technology was observed to enhance maintenance management practice in schools across Malaysia. For instance, using maintenance technology reduced maintenance reporting time, time for detecting maintenance problems, and maintenance communication in schools surveyed by Akasah et al (2003).

Maintenance Inspection is ranked second in this component. Buys and Nkado (2003) asserted that, maintenance inspection establishes defects which can be attended to in time, so as to avoid expensive corrective maintenance work. As noted earlier most schools do not carry out maintenance inspections regularly or at all. SHSs lack a formal procedure for inspection of their buildings or components of buildings to identify defective parts. Maintenance inspection can be described as contributing to the data base of maintenance history in the schools.

Technology however supports this maintenance inspection process and thus not strange that the two are found in the same component. Maintenance officer's qualification is also located in this component and complements the two factors. Carrying out maintenance

inspection using the right maintenance technology depends on the right qualification of team members especially the maintenance officer's level of know-how. Unfortunately, a greater number of the maintenance officers do not have the requisite qualification to carry out all maintenance management activities effectively.

The ability to set priorities regarding maintenance works is also largely dependent on other factors in the component. Setting priorities on maintenance activities relies on knowledge accrued from inspection through the application of the right maintenance technique. Setting priorities on maintenance enables managers to manage resources prudently.

The last factor in this component is research on maintenance. Research on maintenance is a continuous process of finding out new and better ways of tackling maintenance problems in the maintenance management process. In order to build on old knowledge, it is assumed that information regarding the maintenance condition of a building exists through maintenance inspection activities. Thus, research on maintenance management by researchers (for instance Crespo Marquez and Gupta, 2003, 2006; Campbell, 1995; Wireman, 1990) continues to take place to meet the new demands of maintenance management problems. It is worth noting that in Africa maintenance management knowledge for schools particularly 1st & 2nd cycle schools is limited. For instance Osei Tutu & Afranie (1999) observed that the posture people have towards maintenance is one of the main banes to successful maintenance programs. Therefore research will offer a better understanding of the inherent problems (e.g. human attitude) of maintenance management.

Stakeholders in SHSs and the second cycle educational system therefore need to appreciate the role these technical factors play so that the right structures are put in place to improve maintenance management practice in the schools.

4.7.3 Component 3: Policy and Standards Criteria

Component 3 accounted for 9.15% of the total variance with the following factors making up the component. *Maintenance policy (0.876), maintenance staff responsiveness (0.691) and Top management awareness (0.654).* The direction of these factors point to policy and benchmarking based on knowledge. Thus this component was subsequently named *maintenance policy and standards.* BS 3811 defines maintenance policy as a strategy within which maintenance decisions are taken. Maintenance policy is therefore considered as that key that drives and directs maintenance activities in any organization. It therefore includes objectives, benefits and strategies regarding maintenance management (Crespo Marquez 2003; Campbell & Jardine, 2001; Campbell, 1995). It is therefore significant that *maintenance policy* emerged atop of the group of factors in this component.

Respondents have acknowledged the importance of policy guidelines to the maintenance management process in the schools. Unfortunately, the maintenance policies that exist in schools are limited in the sense that, the provisions do not take care of preventive maintenance requirements but basically corrective maintenance interventions. According to Crespo Marquez and Gupta (2006) and Akasah et al. (2003) maintenance policy sets standard to control the maintenance management process in organizations.

Maintenance staff responsiveness also emerged as the second most critical factor in this group. Staff responsiveness to maintenance issues is critical to achieving any policy provision regarding maintenance management (Campbell and Jardine 2001). When a maintenance problem is unattended to the problem compounds and will eventually grow out of control. Akasah and Amirudin (2010) suggested that sufficient understanding of maintenance issues especially policy direction among stakeholders improve maintenance staff responsiveness to maintenance problems in institutions.

Top management awareness is also another critical factor that is necessary in achieving successful maintenance policy and standards criteria. A snap-shot of the current practice of MM in SHSs revealed that top management play significant roles regarding maintenance activities. Top management awareness levels on MM will improve the inputs to the maintenance policy, affect caliber of staff to recruit, financial budgeting and priority setting (Buys and Nkado, 2003).

There is no doubt that maintenance policy remains the most critical factor in this group. However authorities and policy makers need to appreciate that top management awareness is equally critical. But the awareness regarding MM will not just be imbibed without training. Top management (i.e. head, assistant heads, and maintenance officer) will need adequate exposure to maintenance management procedures and process. The knowledge of the other critical factors and their role to improving MM process is an invaluable intervention to the sustainability of any MM framework.

4.7.4 Component 4: planning Criteria

Component 4 contains *recording & feedback system (0.804) and planning maintenance activities (0.773).* Even though recording & feedback system registered a higher factor loading, the group was labeled *planning criteria* because of the significant role planning plays in any maintenance management process in any organization (see Seeley, 1976; Jimoh and Iyagba, 2012). In fact, the results from the t-test showed that planning maintenance activities recorded an importance level with a mean value of 4.133 while recording & feedback recorded 4.05, at fourth and seventh on the scale of importance respectively. Planning maintenance activities is certainly critical especially for preventive maintenance. Unfortunately, school authorities practice corrective maintenance and consequently neglect preventive maintenance.

Planning at various stages; i.e. broader scope and narrowed down to activity level is not done by management. Planning maintenance activities saves cost, time and most often ensure quality and value for money (Lee, 1988; Buys and Nkado, 2003). As observed by Buys and Nkado (2003) maintenance planning to a large extent depends on maintenance historical data recorded over a period of time in that organization. This leads the discussion on the other critical factor in this group; i.e. *Recording & feedback system*.

Record keeping and feedback system in maintenance management is considered a critical factor because information is needed to inform managers on where maintenance is required. Crespo Marquez and Gupta (2006) asserted that record keeping serves as a databank for providing quality data on a particular maintenance history. The maintenance

management environment in SHSs is controlled by human resource. The need for feedback on maintenance works executed is necessary for the maintenance unit to evaluate performance and also keep track of frequencies associated with maintenance requirements. Sondalini (nd) suggested that feedback on maintenance reduces the time loss and thus safes cost of maintenance works. There is therefore the need to develop and implement a suitable feedback system for users and occupants of buildings and facilities in SHSs.

In order to develop an efficient and a suitable MM framework, recording and feedback system as well as planning maintenance activities are necessary.

4.7.5 Component 5: Communication Management Criteria

Maintenance communication (0.802) and craftsmen qualification (0.712) make up component 5 and labeled *communication management criteria*. Here, the first factor was considered and used in labeling this component. The t-test results indicated that maintenance communication recorded 4.033 of mean values while craftsmen qualification recorded 3.950. The choice of naming this component *communication management criterion* was done to emphasize the importance communication plays in the entire MM process.

Maintenance communication is a vital resource for enhancing maintenance scheduling in the MM process (Crespo Marquez, 2007). It involves the use of appropriate communication tools suitable for maintenance works. Crespo Marquez further observed that where there is direct communication and coordination among groups in a

maintenance organization, team members perform better and maintenance management outputs are good. The role of maintenance communication can therefore not be over emphasized. Constraints such as lack of logistics to enhance inter- and intra communication on maintenance could be an impediment to promoting maintenance communication. As explained earlier, management's appreciation of the role of communication in MM will help with resource allocation to meet such requirements. Currently communication is mainly carried out by oral means especially in reporting maintenance problems and discussions among maintenance staff. Some schools however utilize requisition forms to communicate between top management and maintenance staff. Instructions on maintenance works are mostly still given verbally and not documented. The communication can be improved through documentary write-ups using tools such as computer, printer and the necessary stationary with an improved filing system to support.

Craftsmen qualification is the second critical factor in this component and well placed on the heels of maintenance communication. Maintenance management activities require craftsmanship at various levels of the MM process. Expertise and specialization however cannot be isolated but in an organized entity, which require communication in a manner that promotes a healthy maintenance management environment. There is therefore the need to consider the qualification of the craftsmen involved in maintenance works so that no weak links occur in the communication chain. Weak links in a chain of communication stall the communication process and hence affect maintenance management (Crespo Marquez, 2007). Craftsmen qualification also allows for creation of

hierarchies among the human resource thus, further defining communication lines and responsibility lines. Akasah and Amirudin (2010) assert that hierarchies are necessary for increasing effectiveness of communication between all involved in the MM process. Management contribution to MM framework in the area of craftsmen's qualification is therefore one of the pillars to improving communication on maintenance issues.

4.8 Development of the Conceptual Maintenance Management Framework (MMF)

The conceptual maintenance management framework is a procedural framework built on the five components established in section 4.7. The five components include; 1) resource management criteria, 2) technical management criteria, 3) policy and standards criteria, 4) planning criteria, and 5) communication management criteria. These five criteria were established through a number of stages of analysis. These stages included reliability testing, one-sample t-test and mean ranking as well as factor analysis. The factor analysis was done to reduce the best practice factors into manageable components of correlated factors.

In Chapter 3, a guide to developing the MMF was presented in Figure 3.7. Modelling process adopted from Mihram (1972), suggested that the current MM system should be considered and synthesized into the final framework. Akasah and Amuridin (2010) also suggested that the inputs of the MMF should be identified from existing practices and integrated with best practices established from literature. Existing practices were established from the field survey through questionnaire survey, interviews, observations

and document analysis. The maintenance management best practice factors were identified and extracted from relevant literature such as, publications by Crespo Marquez & Gupta (2003), Buys and Nkado (2003), Creso Marquez (2007), Akasah and Amuridin (2010), Jimoh and Iyagba (2012) and Gomez Fernandez and Crespo Marquez (2012).

The consolidated set of factors in the five-component criteria was used as inputs regarding maintenance management activities to develop the conceptual maintenance management framework. As noted by Crespo Marquez and Gupta (2006), the MMF is the supporting structure and the basic system required to manage maintenance effectively. They further added that the Maintenance Management process is 'the course of action and series of steps'. The method adopted for the development of the conceptual maintenance management framework is described in the ensuing sections.

STAGE I: Existing MM Process

Stage I deals with establishing the inputs of the existing MM process. The existing MM process as practiced in SHSs surveyed is made up of a number of components. These components are considered as inputs to the existing MMF context. The context MMF was constructed based on the existing MM process established from the survey. The inputs have been labeled **C1** to **C13** (where C represents construct) include:

- School Heads (**C1**);
- Maintenance Committee (**C2**);;
- Maintenance Staff (**C3**);
- Users and/or Occupants (students and Staff) (**C4**);

- Buildings (**C5**);
- Equipment (**C6**);
- Materials (**C7**);
- Tools (**C8**);
- Costs (**C9**);
- Budgetary Allocations (**C10**);
- Inspections (**C11**);
- Reports (**C12**);
- Request Forms/Invoices (**C13**);
- Contractors (**C14**).

All these inputs make up the existing MM process towards the creation of an effective MMF. However, a number of weaknesses were also identified as affecting negatively the MM process. These include:

- Poor planning(**W1**);
- Poor Staffing (**W2**);
- Inadequate Budgeting (**W3**);
- Inadequate equipment/tools (**W4**);
- Inadequate MM know-how (**W5**);
- Inadequate Funds (**W6**);

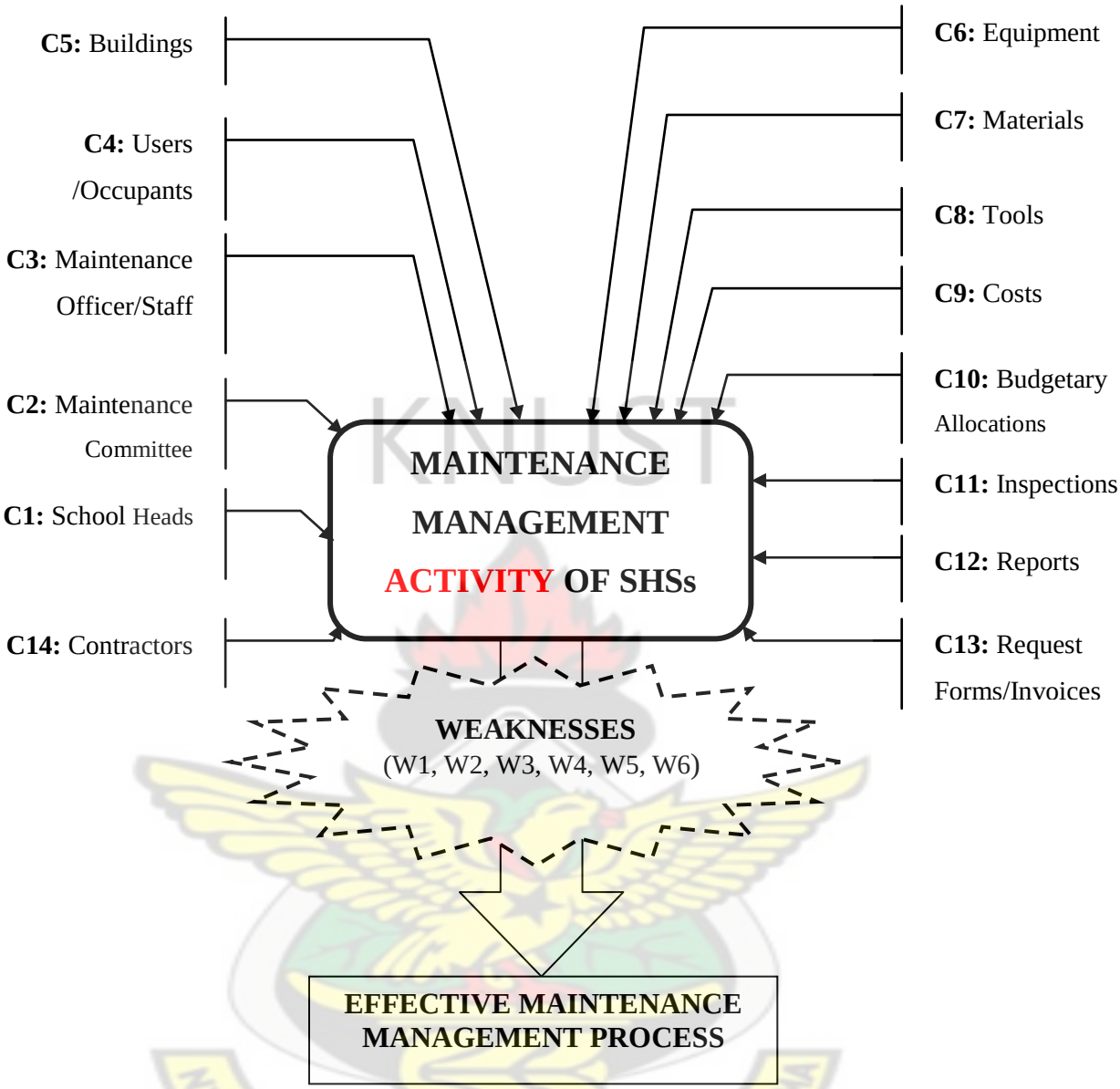


Figure 4.9: Existing MM process inputs.

STAGE II: DRAFT MMF (LEVEL 1)

The draft MMF was developed in two levels (Level I and II) through the mapping of operations of the existing maintenance management process and the consolidated best practice MM criteria. The MM criteria established through the factor analysis were translated into five MM performance criteria (PC1 to PC5) and tabulated in Table 4.20.

Table 4.20: MM criteria & MM Performance

Item	**Component /Criteria**	**Code**	**MM Performance Unit**	**Sub-Activities**
1	Policy and Standards	PC1	Develop MM Policy & Standards	4
2	Planning	PC2	Undertake MM Planning	4
3	Technical Management	PC3	Carry out MM Technical Management	5
4	Resource Management	PC4	Manage MM Resources	8
5	Communication Management	PC5	Manage MM Communication	4

The five (5) main MM performance activities have sub-activities that were established from literature and field survey as presented earlier in this chapter. The weaknesses identified in the context MM framework in Stage I have been translated into this draft through the best practice standards established. The sub-activities under each main activity are presented in the following diagrams.

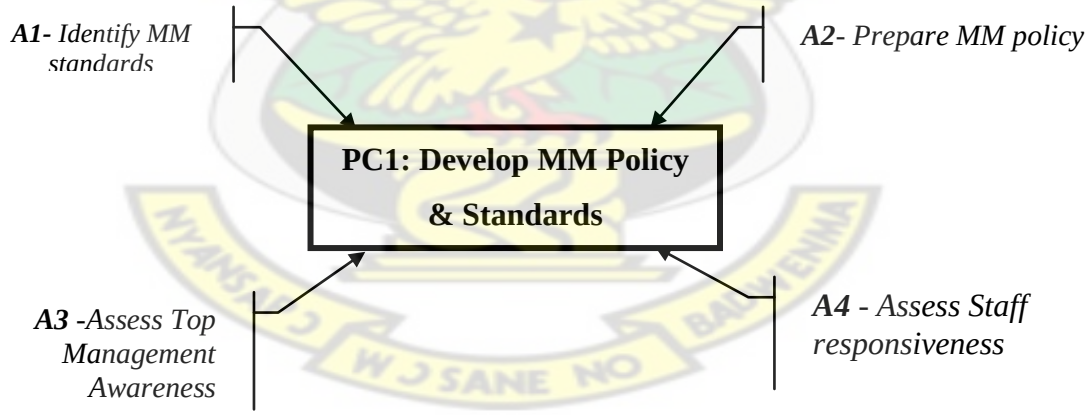


Figure 4.10: Inputs into MM Policy and Standards

The inputs considered in Figure 4.10 to develop the MM Policy and Standards include; *identify the MM standards (A1), prepare the MM policy (A2), assess top management awareness (A3), and assess staff responsiveness (A4)* to MM issues. Policy and Standards

play a major role in the development of any framework. Policy gives the general direction and broad expectations of management, regarding the maintenance environment of any school community. (Akasah and Amirudin, 2005; Buys and Nkado, 2003; Jimoh and Iyagba, 2012). Top management therefore in conjunction with the Maintenance officer, is responsible for developing the maintenance policy of the institution. It is necessary to assess top management awareness on MM because the traditional management staff members of SHSs in Ghana include teachers with backgrounds not in mainstream maintenance work. However, when top management is fully aware of the importance of MM to the wellbeing of the overall campus condition, then full cooperation and total contribution of top management can be guaranteed. Hence, the development of a comprehensive MM policy is anchored on the level of awareness of MM among top management and staff responsiveness to MM issues. These activities therefore are carried out in a stage described as the strategic level. The strategic level will be discussed in detail later in this chapter.

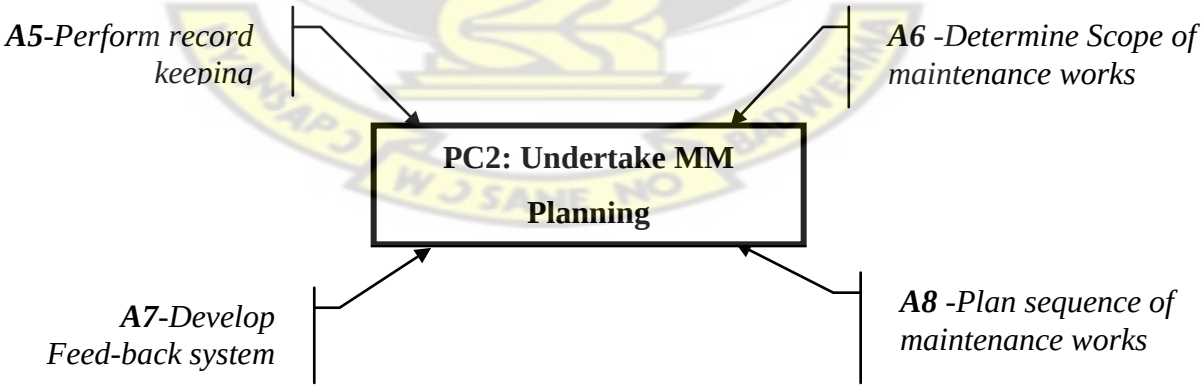


Figure 4.11: Inputs into MM Planning

Another important performance activity established for MM in schools is *PC2; Undertake MM Planning.* Figure 4.11 presents the sub-activities involved in this performance activity. There are four (4) sub-activities namely; *perform record keeping (A5), determine scope of maintenance works (A6), develop feed-back system (A7),* and *plan sequence of maintenance.* These four sub-activities will therefore play an important role in the execution and control phases of the framework.

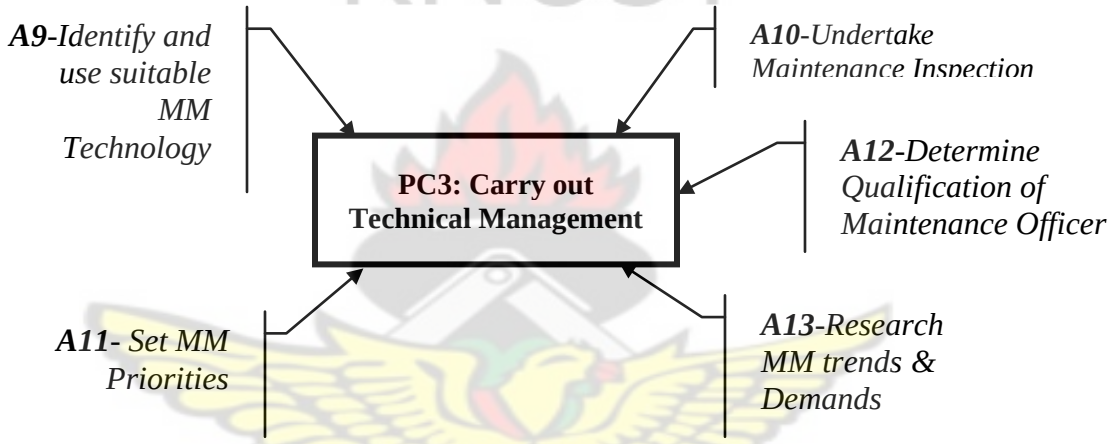


Figure 4.12: Inputs into Technical Management

Figure 4.12 presents the inputs regarding the main activity "*carry out technical management*". There are five (5) sub-activities under this main activity. These include *identify and use suitable MM technology (A9), undertake maintenance inspection (A10), set MM priorities (A11), determine qualification of Maintenance officer (A12), and research MM trends and demands (A13).* This main activity is considered also cardinal to any successful MMF since execution of any maintenance work depends highly on know-how and utilization of the right technique in carrying out the work.

Figure 4.13 presents another major MM activity which deals with resources on maintenance and related aspects. This main activity has eight (8) sub-activities under it. These include; *Prepare MM Organizational Structure (A14), Identify required MM Staffing (A15), Improve User awareness regarding maintenance (A16), Carry out routine Staff Training on MM (A17), Undertake Budgeting on MM activities (A18), Assess adequacy in Staff numbers (A19),Determine and acquire Maintenance tools & material needs (A20), and assess life cycle cost of buildings (A21).*

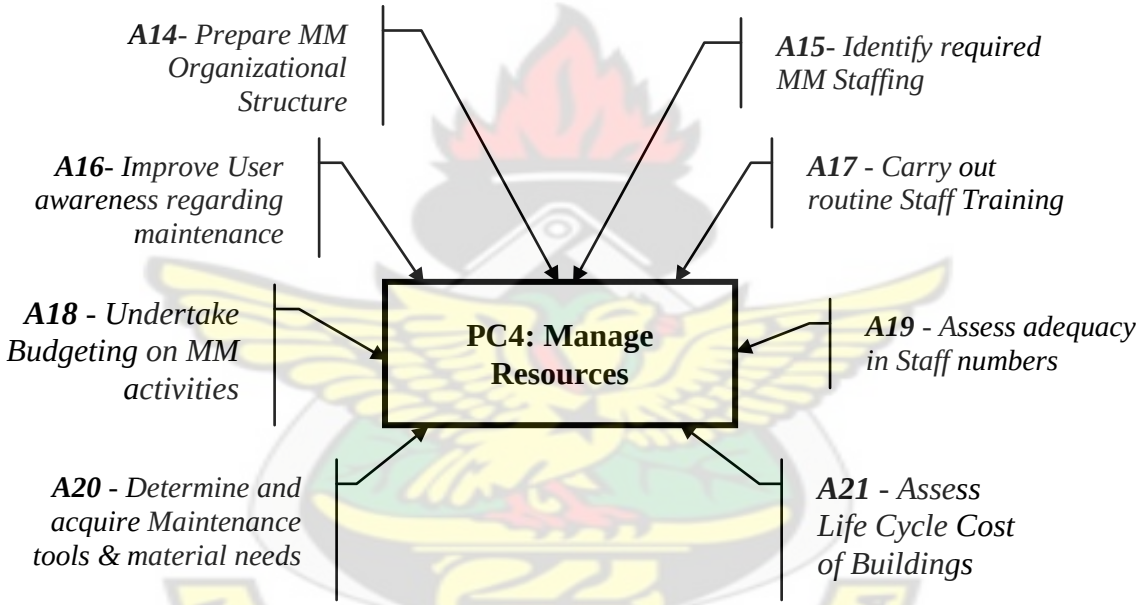


Figure 4.13: Inputs into MM Resources

Jimoh and Iyagba (2012) in a recent research on MM in tertiary institutions acknowledged that Communication lacked prominence in the MM process particularly in Nigeria. In the development of this MMF, communication plays a cardinal role in tying the other performance activities together. As shown in Figure 4.14, four (4) sub-activities were identified as contributing to a successful MM communication activity. These include; *identify MM Communication (A22), prepare Communication plan (A23),*

implement communication plan (A24), and Assess Craftsmen qualification (A25). For a successful communication plan on MM to be drawn, the stakeholders on the entire chain would need to contribute their expertise in the various sub-activities outlined in this paragraph. The weaknesses, challenges and inadequacies that exist in the traditional MM model practiced in the SHS are expected to be overcome by the above interventions.

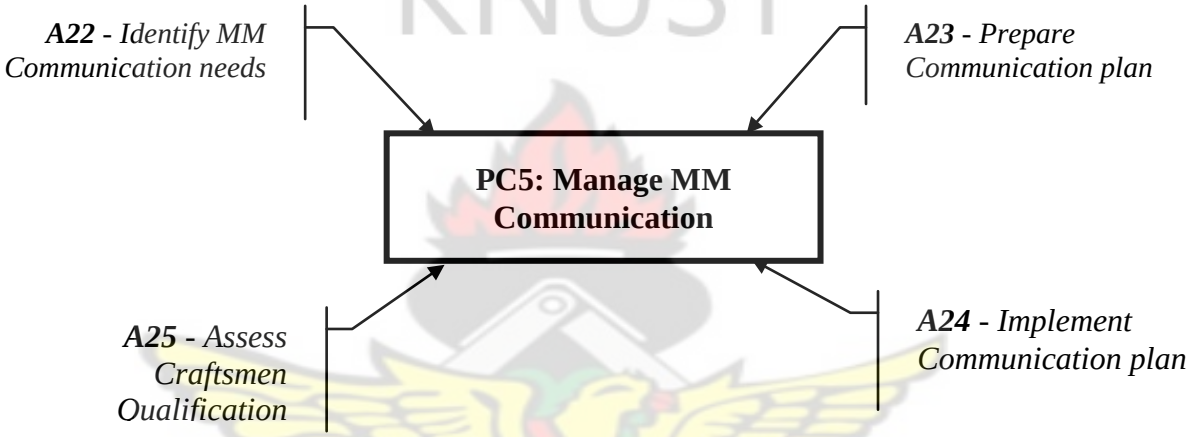


Figure 4.14: Inputs into MM Communication

Hence, the unplanned maintenance management which is common among SHSs would be controlled by the planning performance activity, while the communication gap would be bridged by the communication performance activity. Inadequacies in technical capacity and resources are expected to be overcome by careful consideration and utilization by management and other stakeholders in the MM process.

MM Input-Output Structure

The maintenance management input-output structure is made up of MM input items such as planning, budgeting, records, cost, etc. The MM output is an expected product that reflects efficiency and effectiveness and is usually subjected to review (Crespo Marquez and Gupta, 2006). Shown below in Figure 4.15 below

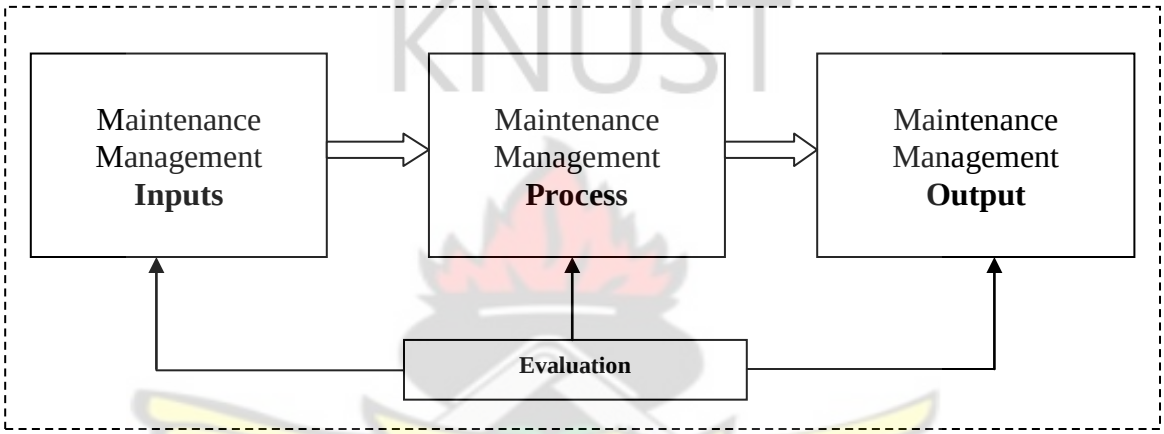


Figure 4.15: Input-Output MM Structure

STAGE II: DRAFT MMF (LEVEL 2)

Level 2 presents a draft MM Framework which has considered information from the context model, main and sub-activities of the level 1 draft MMF.

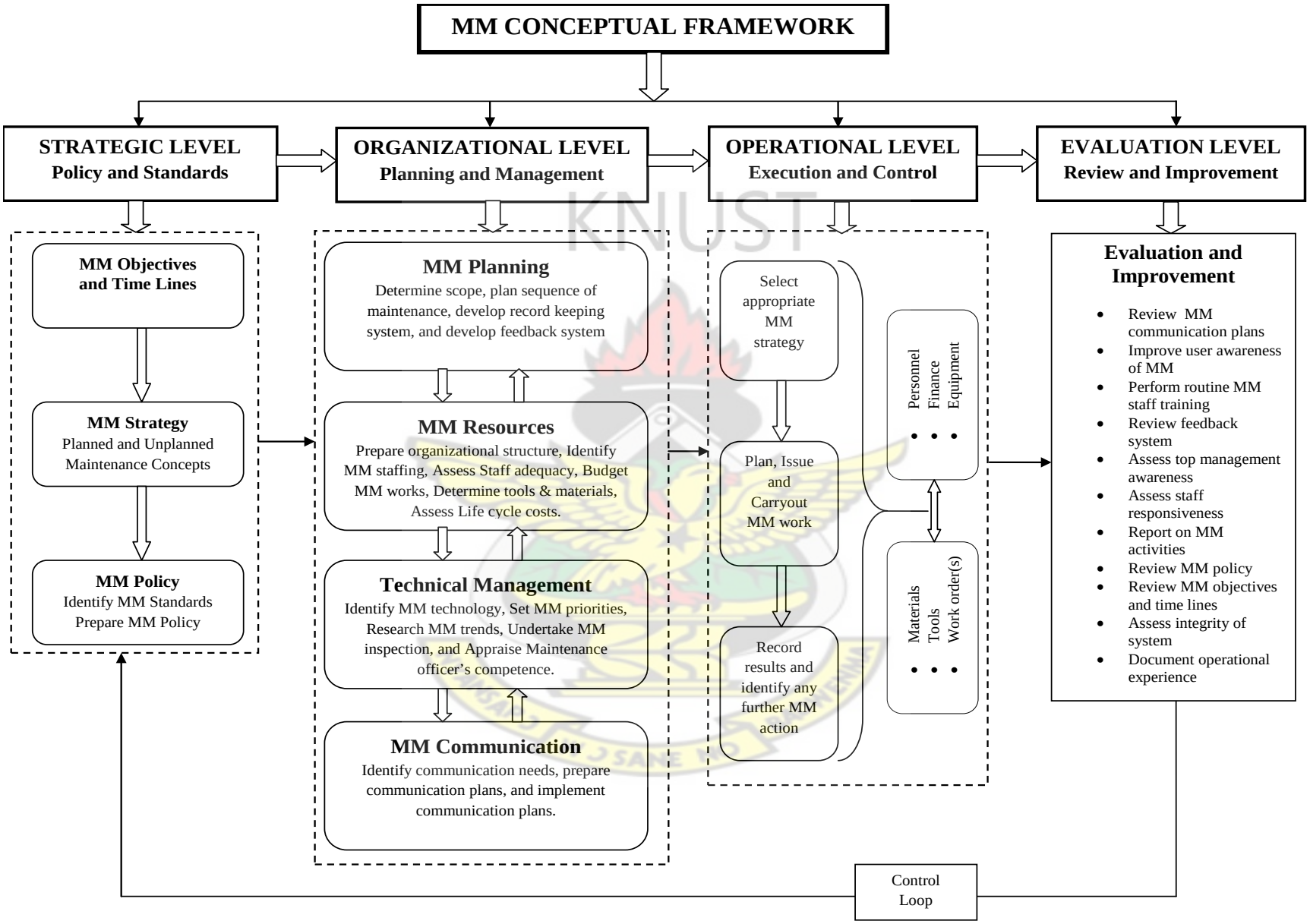


Figure 4.16: Conceptual Maintenance Management (MM) Framework for SHSs in Ghana

Vanneste and Wassenhove (1995), Kunya et al (2007), Crespo Marquez et al (2010), and Jimoh and Iyagba (2012) support the concept that a complete integration of maintenance management operations and information systems of institutions (or enterprises) is most appropriate for an efficient MM framework. Figure 4.16 demonstrates the conceptual MM framework developed from the various activities established previously. The framework is made up of mainly three phases discussed below;

PHASE - I:

This phase is considered critical to the success or otherwise of the entire MM process. It is described as the Strategic Phase of the framework. This strategic phase is made up of activities that include; management acknowledgement of the various MM concepts available, developing a MM policy using acceptable benchmarks in context and setting standards in the broader maintenance environment. The MM concepts considered in the framework include planned preventive maintenance, planned corrective maintenance, unplanned emergency maintenance, and unplanned corrective maintenance. The SHSs carry out very limited planned maintenance, basically painting works. Most of the maintenance management activities are therefore unplanned. This framework therefore seeks to support management in planning for maintenance works through the policy and standards development. The MM policy contains time function covering short-term, medium-term, and long-term maintenance activities. The phase however makes a generic provision of activities that help identify the MM policy needs and preparation requirements.

Top management such as the Head of school, assistant head(s), maintenance officer and maintenance committee are expected to perform the role of developing the policy with or without the support of external consultants. Capacities differ from school to school and hence should be considered in the proposed group of people to perform these tasks.

Phase-I of the framework therefore suggests that at the strategic level a suitable MM should be developed using the sub-activities to guide the process after establishing the MM objectives. The sub-activities include; identify MM standards, prepare MM policy, assess top management awareness, and assess staff responsiveness.

Note that this research has not focused on the details to be captured in the policy. This is however proposed for future research consideration.

PHASE-II:

Phase-II of the conceptual framework deals with organizing MM activities. This phase has four main activities organized into the following groups of activities; *undertake MM planning, perform technical management, manage MM resources, and manage MM communication.*

As noted earlier, the planning sub-activities involve decision-making which have short to long term impact on the maintenance culture of the school(s). For instance record-keeping which is a sub-activity provides information for both immediate and long-term use. The long-term use includes building a historical data bank that future MM activities may depend on. It is important to note that undertaking the MM planning entails the

collaboration of the top management (particularly Maintenance committee & Assistant Head-domestic) and the Maintenance Officer.

The phase also made provision for technical management activities in the framework. At the thrust of MM practice is the core activity of identifying problems, potential problems and rectifying and/or preventing their occurrence. The technique to use in diagnosing and solving MM problems is anchored on MM technology, carrying out maintenance inspection hinged on setting priorities and knowing the trends in MM. This technical aspect would be performed by the Maintenance officer and the maintenance unit. Where necessary a contractor/expert supports the process. The top management will be expected to facilitate the technical management activity for efficiency of the framework.

The MM framework would not succeed without the third activity group known as manage MM resources. MM resources include both human, financial and materials. These form the raw ingredients for the wheels of production on the MM framework. Organizing the necessary resources at the right time, right cost, and right quality is expected to facilitate the continuous efficient performance of the framework. The top management such as the school heads, maintenance committee, finance officer, internal auditor, and the maintenance officer will be expected to perform this main activity.

Another main activity placed in this phase is MM communication. Good MM communication is observed as a facilitator of management requirements of any maintenance management framework (Russel, et al 2006; cited in Lopez Campos et al.,

2010). In order to optimize the MM framework communication has to be managed properly through the involvement of all stakeholders. In this case school heads, maintenance committee, maintenance officer, maintenance staff, students, teaching and non-teaching staff have to interact regularly, formally, informally, verbally and non-verbally on MM issues. Poor communication among stakeholders can stall MM processes and thus compound the maintenance problem and hence cost since productivity would be affected. This framework therefore considers MM communication as equally cardinal to any MM process and hence must be well organized.

PHASE-III:

Phase III of the framework presents the execution and control level of the MM process. This phase is directly linked with the four (4) organized main activities in phase II. The describe sub-activities that are expected to be carried out at in a MM assignment. For instance sub activities such as identify MM communication needs, prepare communication plan, and implement communication plans are components under the execution phase of the framework that involve developing a communication system that promotes the course of an efficient MM framework. As noted earlier the scope of this framework deals with the broader MM works while detailed plans are recommended for future research.

This phase also presents the various internal linkages that exist between sub-activities as shown through the numbering system of A5-A25. It is important to note that the sub-

activities are not independent of each other but complement one another depending on the requirements of the maintenance problem.

The control mechanism in the MM framework includes checks-and-balances inherent in the activities coupled with the component of constant evaluation of the system to measure performance of the framework. Top management, maintenance committee and maintenance officer are the main stakeholders for this aspect of the framework. However where necessary an expert is involved in the evaluation process to eliminate the challenge of bias from within. The success or failure of this conceptual MM framework depends highly on the human resource (whether group or individual). As observed by Akasah and Amirudin (2010), the human resource is the tool that is required to change an input to an output and the total contribution, cooperation and support from all stakeholders in the SHS.

STAGE III: EXPERT VALIDATION OF DRAFT MMF

Stage III of the conceptual MMF development process entailed validation of the framework by technical experts in building maintenance and facilities management. As stated earlier in sub-section 3.8.2 of Chapter three, the iterative validation process recommended by Presley and Waltman-William (1993) was adopted in this case. Even though Presley and Waltman-William recommended a minimum of three experts as ideal for any iterative validation process, four experts were contacted during the process. The experts were selected purposively based on their years of experience; that is, ten or more years in the building industry with specialty in maintenance and/or related areas.

The Validation Process

The first step in the iterative validation process is to identify the technical experts who will partake in the process of reviewing the draft framework. The experts included the following: one building and infrastructure maintenance expert; one development officer from an educational institution with training in building maintenance; one conservation and restoration expert; and one built environment expert with expertise in plant and equipment management. The draft framework was then submitted to them at their separate locations.

However, prior to the submission of the draft framework, a validation review assessment form was developed. This form was attached to the draft framework submitted to the experts for review. The review assessment form had six sections with questions on the framework: Part 1, captioned overall, contained three questions regarding the main structure of the framework; Part 2, titled strategic level was made up questions on the strategic stage of the framework; Part 3, organizational level which contained questions on the organizational stage of the framework; Part 4, operational level asked questions on the operational phase of the framework; Part 5, tackled questions on the evaluation level of the framework; and finally, Part 6 asked general questions such as the flexibility and usefulness of the framework. Each section had three to four assessment questions with a corresponding column where the experts were required to tick **(√)** in **agreement**, cross **(**X**)** in **disagreement** with any of the provisions at the various levels or **(-)** for **Indifference** in answer to all the questions posed. A blank section was also provided to

cater for experts' comments, suggestions and recommendations to improve the framework.

The draft framework together with the assessment forms were delivered in person to the experts. They were first given some time to study the framework after which they ticked in *agreement*, *disagreement* or *indifference* where appropriate.

Results

The completed assessment forms retrieved from the reviewers enabled a collation of their responses on the MM framework which have been presented in Table 4.21. RV01 represents reviewer number 1, RV02 represents reviewer number 2, RV03 represents reviewer number 3, and RV04 represents reviewer number 4.

Regarding 'Part 1: Overall' section of the assessment of the MM framework, All the reviewers agreed that, the provision of levels which include *strategic, organizational, operational and evaluation* are suitable. They further agreed to the order in which the levels appear and are arranged in the framework. The reviewers also all agreed to the main phases of *MM Policy and Standards, Planning and Management, Execution and Control, and Review and Improvement* as suitable and appropriately located and ordered in the framework. The third question in this section which dealt with whether or not constant evaluation and review of the framework was needed recorded maximum agreement among reviewers.

Part 2 of the assessment recorded agreement on all questions except question 4. RV02 was indifferent to the question on setting MM limits and objectives by management. Three reviewers however agreed to the provision in the framework for management to set limits and objectives for MM under the strategic level. Hence the majority of the reviewers support this provision regarding MM limits and objectives. Reviewers unanimously agreed to the rest of the provisions referred to under the framework.

Assessment of 'Part 3: Organizational Level' sought to measure the agreement of experts regarding the components captured under the *planning and management phase* of the framework. Reviewers all agreed that the themes indicated were suitable and appropriate and further agreed that the linkages between the themes were appropriate. On the activities to be performed during the execution and control phase of the framework, reviewer all agreed that the activities were comprehensive enough under the phase.

Part 4 of the assessment dealt with 'Operational Level' of the framework. The assessment sought to find out from reviewers whether the provisions were appropriate. As indicated in Table 4.21, reviewers unanimously agreed to all but question 15. Question 15 sought to find out whether the framework can be implemented by personnel responsible for MM in SHSs in Ghana. Two reviewers agreed that the framework can be implemented by personnel of the SHSs responsible for maintenance; one reviewer however disagreed, while the other reviewer was indifferent. RV02 however indicated that with capacity building efforts in place the MM personnel in SHSs would be able to implement the framework.

‘Part 5: Evaluation Level’ comprised questions that sought to assess the provisions made under the Evaluation and Improvement phase of the framework. All reviewers agreed that the provisions under this phase were suitable and appropriate. However, one reviewer (i.e. RV02) was indifferent to the question on the ability of management and/or consultants evaluating performance of the framework against established best practices. The reviewer, in a face-to-face discussion, thought that top management of SHSs needed some level of training to be able to carry out performance assessment. The explanation to this provision is that a consultant is expected to carry out the performance assessment of the framework from time to time to measure and identify weaknesses for improvement. This would be carried out with the support of the top management of the SHSs as stakeholders.

The section of the assessment that sought general appraisal of the MM framework were captured in ‘Part 6: General’. Reviewers all agreed that the framework is flexible, simple and self explanatory, and can meet the MM needs of SHSs in Ghana for which it has been developed.

Table 4.21: Results of Expert Assessment of the MMF

ID	REVIEW QUESTIONS	RV01	RVO2	RV03	RV04
	PART 1:OVERALL				
1	Do you agree that the main levels in Maintenance Management (MM) framework include; strategic, organizational, operational, and evaluation levels?	√	√	√	√
2	Do you agree that the main phases include: MM Policy & Standards, Planning & Management, Execution & Control, Review & Improvement phases?	√	√	√	√
3	Do you agree that there is the need for constant evaluation and review of the MM framework?	√	√	√	√
	PART 2: STRATEGIC LEVEL				
4	Do you agree that management defines time limits and set objectives regarding MM?	√	–	√	√
5	Do you agree that Management/Maintenance Staff identify suitable MM strategy for MM work?	√	√	√	√
6	Do you agree to the theme on MM Policy & Standards as part of the **Strategic Level?**	√	√	√	√
7	Do you consent that Maintenance concepts are important to the development of MM policy and standards?	√	√	√	√
	PART 3: ORGANIZATIONAL LEVEL				
8	Do you agree to the themes under the **planning & management phase** which include; i) MM Planning ii) Technical Management iii) Manage Resources, and iv) MM Communication?	√	√	√	√
9	Do you agree to the linkages of interaction between the themes under the **planning & management phase** of the framework?	√	√	√	√
10	Do you agree to the sets of activities that have to be performed under each criterion during the execution and controlling phase?	√	√	√	√
	PART 4: OPERATIONAL LEVEL				
11	Do you agree to the selection of an appropriate MM strategy under the execution and control phase of this level?	√	√	√	√
12	Do you agree to the sequence of *"select strategy – plan - issue & carry out MM work - record results - identify further actions"* as suitable for execution & control?	√	√	√	√
13	Do you agree to the inputs of personnel, equipment, materials, tools, finance and work order, as suitable for execution of a MM task?	√	√	√	√
14	Can areas of the framework that need fine-tuning be fine-tuned by stakeholders for implementation?	√	√	√	√

15	Can implementation of the framework be done by personnel responsible for MM in SHSs in Ghana?	√	**X**	√	–
	PART 5: EVALUATION LEVEL				
16	Do you agree that review of the phases of the framework should be constantly carried out?	√	√	√	√
17	Do you agree that Performance assessment of the MM framework should be done according to the expectations of top management with their involvement?	√	√	√	√
18	Should performance assessment of the MM framework be done according to the expectations of maintenance staff with their involvement?	√	√	√	√
19	Can school management and/or consultants with stakeholders evaluate performance of the framework against established benchmarks?	√	_	√	√
	PART 6: GENERAL				
20	Is the framework flexible to meet expectations of School management?	√	√	√	√
21	Can the framework aid the MM practices of SHSs in Ghana?	√	√	√	√
22	Is the framework simple and self-explanatory to be used by SHSs management?	√	√	√	√

Legend: (√) = agree; (X) = disagree; (-) = indifferent

Improvement to the Framework

Further comments by the reviewers presented in Table 4.22 were also considered in the improvement of the framework. RV03 suggested the need for a *control loop* in the framework to indicate the continuous nature of the process of maintenance management in the building industry. There was no control loop in the draft MM framework. The 'Strategic Level' which marks the beginning phase of the framework should connect with the 'Evaluation Level' which marks the end of a cycle. The control loop therefore will create the opportunity for the cycle to continue from the starting point a maintenance phase is completed.

Table 4.22: Experts' Further Comments during face-to-face meeting on the MM Framework

Reviewer	Further Comments/Suggestions
RV01	• Framework is comprehensive enough for implementation at the senior high school level. • Provisions of the framework give a good platform for the execution of MM activities in SHSs. • Re-emphasized that review of MM framework was cardinal to the sustainability of the framework.
RV02	• The reviewer observed that the capacity levels of MM personnel in schools need improvement for successful implementation of the framework. This view was also captured in the recommendations in Chapter 5 of this work. • Also recommended an earlier work on factors affecting maintenance in Ghana. Fortunately, one of the reviewers is the author of the said work recommended.
RV03	• Suggested the inclusion of *review of MM objectives and time lines* to the evaluation and improvement section of the framework. • Also recommended the inclusion of *documentation* as part of the activities under review and evaluation. • Recommended the introduction of a *control loop* to reflect the continuous nature of the framework.
RV04	• Suggested that areas of the framework that need fine-tuning can be done by stakeholders during implementation.

In the 'evaluation and improvement phase' the following were omitted; review of MM objectives, review of MM timelines, and documentation. These sub-themes have now been considered and introduced to form part of the evaluation and improvement phase of the framework.

Figure 4.16 therefore incorporates all the reviewers' comments, observations and suggestions gathered during the review period. Earlier versions of the MM framework prior to this reviewed one have been presented in Appendix D.

4.9 SUMMARY

This chapter presented, discussed and analysed the findings resulting from data collected from the field survey. Demographic data, profile of the institutions surveyed, among others were analyzed using descriptive statistics. Existing MM practices have also been presented in tables, graphs and figures. MM best practice factors were analyzed using one-sample t-test and ranked accordingly. Factor analysis was also utilized to further reduce the variables into clusters for easy management and utilization in the development of the MM framework. The development of the MM conceptual framework resulting from the analysis and subsequent validation information has also been presented.

Chapter 5 which follows this chapter will present the conclusions and recommendations for the entire research.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter brings to closure the research process of developing a maintenance management framework for public Senior High Schools (SHSs) in Ghana. Maintenance management is a national challenge and cuts across sectors of the Ghanaian society. The interest area of this research was on the education sector of the nation with particular focus on second cycle institutions categorized as public schools. The study area covered two metropolises namely Kumasi and Cape Coast representing northern and southern sectors respectively.

The cost of providing second cycle education is increasing in leaps and bounds annually. School authorities are faced daily with having to manage with limited resources to meet the growing demands of the increasing students' population. Maintenance management has been observed by many researchers as an instrument, and if utilized well, can contribute positively to reducing life cycle cost and improve operational efficiency in a productive environment (Kunya et al, 2007; Crespo Marquez et al., 2009; Akasah & Amuridin, 2010; Lopez Campos et al., 2010; Jimoh & Iyagba, 2012).

5.2 DEFINITION AND KEY COMPONENTS OF MAINTENANCE MANAGEMENT (MM)

The secondary data collected revealed that there are many definitions to MM. However all the definitions point to common principles regarding operational efficiency, effective use of resources and ultimately prolonging the useful life of the building or infrastructure. MM is said to include, but not be limited to, concepts such as; preventive maintenance (PM), inventory and procurement, work order system, computerized maintenance management systems (CMMS), technical and interpersonal training, operational involvement, proactive maintenance, reliability centered maintenance (RCM), total productive maintenance (TPM), statistical financial optimization, and continuous improvement (Wireman, 1998). Duffuaa et al (2006) simply defined MM as a simple input-output system that uses manpower, management, tools, equipment and other resources to meet a desired output.

Unfortunately, in a learning environment like SHS where the core business is training second cycle human resource for tertiary level education, MM tends to suffer from neglect. This has been attributed to a number reasons described in the earlier chapters. School management's attention is not on MM and sadly the parallel management line on maintenance issues is also weak and inefficient. In the context of the school environment, MM is defined as the concept of maintenance where school authorities play an active part in creating a suitable maintenance system and making available resources required to perform maintenance activities with an opportunity for review and onward improvement of the process.

5.3 REVIEW OF RESEARCH OBJECTIVES

The main aim that guided this thesis was to develop a maintenance management (MM) framework to enhance the maintenance practices of Senior High Schools (SHSs) in Ghana. Four objectives were developed to assist in the realization of the main aim. The extent to which these objectives were achieved is presented in this section.

5.3.1 Objective 1: To map the evolution, emerging trends and best practices of MM within the construction industry.

This objective was mainly achieved through extensive literature review on MM. The literature revealed new developments and evolutions in the field of MM in diverse industries such as aviation, automobile, production lines in factories and more recently in the building industry. MM trend changes included some of the following; attention to MM processes innovation in the technical aspects of MM, utilization of standard languages for exchange of information in the MM field, computerized maintenance management system (CMMS), constant evaluation and improvement of the MM process among others. The literature further revealed that CMMS for instance was yet to gain prominence in the building industry especially in the developing countries. The review also established MM best practices that serve as benchmarks for executing MM especially in the building industry.

This aspect of reviewing relevant literature to map out MM evolution, trends and establish benchmarks contributed to an appreciation of the secondary information which

abound in the area of MM and therefore created the platform to make applications of the existing knowledge in the research.

5.3.2 To develop a snap shot of existing MM practices prevalent in Ghanaian SHSs

This objective was successfully achieved by carrying out a field survey of selected schools in the study area, eliciting relevant data to meet this objective. This was made possible through a questionnaire survey and interviews conducted during the field survey. The findings revealed that the MM practices prevalent in Ghanaian schools were mainly unplanned emergency and corrective maintenances. Unfortunately the existing MM practices are fraud with numerous challenges, problems and inadequacies which further reinforced the significance of the entire exercise. The survey also revealed that, the maintenance officers carry a lot of responsibilities and they were also poorly trained and poorly qualified. Reporting maintenance problems and general communication on MM was weak and uncoordinated.

Schools surveyed have facilities such as boarding, recreational, academic/learning, workshops, laboratories etc. making up the infrastructure of the campuses with most schools having inadequate budgets for maintenance works. The findings that emerged from the field survey on this second objective elucidated the existing MM situation in SHSs and can therefore be said to be convincingly achieved.

5.3.3 To determine the underlying inefficiencies inherent in the current MM practices in SHSs in Ghana

This third objective was fully fulfilled by the use of best practice MM benchmarks in a questionnaire survey that enabled respondents to rate the performance of their schools on the 5-point Likert scale of 25 best practice criteria. As explained earlier, the best practice criteria (benchmarks) were established from literature and used to prepare the questionnaire. An earlier survey conducted on the existing MM practices also complemented the process of identifying inherent inefficiencies in the current MM practices. Some of the inefficiencies included lack of a robust communication line on MM, inadequate budgeting, lack of qualified MM personnel, lack of review system on MM among others. A major inefficiency in the existing MM was that, preventive maintenance was hardly practiced but rather corrective and emergency maintenance practices were prevalent. This objective was largely achieved and the information was useful in the development of the conceptual MM framework.

A number of tests were conducted on the data collected. Some of the test included reliability test to measure internal consistency of the variables, one sample t-test to rank variables in order of importance. Actually, the t-test afforded the opportunity to remove variables that fell below the test value of 3.5. Prior to the t-test, the reliability test also eliminated some variables since they were considered not contributing to the overall reliability of the best practices. Thereafter, 20 best practice factors emerged and were subjected to factor analysis to reduce them to manageable components based on their levels of correlation (see chapter 4). The factor analysis yielded 5 components, of

variables measuring the same underlying effect. This aspect of the third objective went beyond qualitative information to deal with empirical analysis of the data to identify and justify the inefficiencies as well as make suggestions based on the analysis.

5.3.4 To design a procedural conceptual framework to assist Ghanaian SHSs enhance their MM practices.

This is the final objective of the research which relates to developing a conceptual MM framework which will serve as a framework towards the improvement of MM in SHSs in Ghana. Results emanating from the data analysis and observations made through literature gave the required ingredients for the development of a conceptual framework for MM. Strategizing, organizing, execution and control, and evaluation were identified as the main building blocks for an efficient MM framework. The units under these blocks included five performance activities extracted from the factor analysis conducted in chapter four. They were basically policy and standards, planning, technical management, resource management, and communication management. Each main activity however had a number of sub-activities in the execution and control phase that would be performed by a number of stakeholders in the SHSs MM system. The framework gave an opportunity for review and subsequent improvement to meet new demands with changing times.

The conceptual MM framework seeks to give a general guidance on carrying out MM activities in the SHSs. It is expected to offer a more improved MM process that would contribute to increasing productivity, life cycle cost of infrastructure, proper and efficient management of the 'limited' resources, and particularly promote preventive maintenance

practices. The conceptual MM framework was validated by MM experts in the industry. The aim of the validation process was mainly to improve the conceptual framework and recommend it for use by for SHSs in Ghana.

5.4 CONCLUSIONS

The conclusions arrived at are summarized below:

- The policies directing maintenance activities in SHSs were limited and skewed towards mainly unplanned corrective and unplanned emergency maintenance. The maintenance plans were also short-term in nature and not sustainable to the useful life of the built infrastructure.
- The research established that the main performance activities suitable for developing an efficient MM framework for SHSs in Ghana include; MM policy and standards criteria, MM planning criteria, technical management criteria, MM resources criteria, and MM communication criteria.
- Twenty best practice factors emerged (out of the initial twenty-five) as the most influential factors that contribute to an efficient MM framework in SHSs. They include; *Maintenance officer's qualification, Maintenance inspection, Budgeting, Planning maintenance activities, Maintenance Staff Training, Life Cycle Costing, Recording & Feedback system, Maintenance Communication, Maintenance tools and materials, Setting priorities, Maintenance staff responsiveness, Maintenance Staffing, Craftsmen qualification, Maintenance Technology, User/occupant awareness, Maintenance Policy, Research on maintenance, Top Management Awareness, Number of maintenance staff, and Organizational structure.*

Maintenance officers however require further training in maintenance management concepts and trends so that they can improve their knowledge base regarding MM.

- Maintenance units in SHSs are poorly resourced in terms of tools, equipment, workers. A large number of workers in most of the SHSs are tagged 'casual-worker', practically labourers who mainly conduct non-management activities. There is the need to engage more qualified officers with middle level management skills especially graduates of estate management from the polytechnics can significantly improve the MM process.
- The weaknesses in the existing MM process in SHSs were compounded by the legacies of an existing built infrastructure bequeathed to the schools at practically no cost, hence the level of attention that should be given to maintaining these infrastructure is not inherent in general management practices of school heads and management committees.
- Based on observations conducted across the SHSs, most of the maintenance units came across as 'after thoughts'. The spatial conditions of most of the units do not support any efficient MM process. Make-shift spaces were created to accommodate maintenance activities in most of the schools.
- Interview sessions with school heads also revealed that their perception of MM was limited to corrective and unfortunately there was no concrete cost value placed on maintenance activities. There is a general lack of evaluation of the MM process among school authorities. This certainly will be overcome by the improved MM framework proposed.

- Communication on maintenance issues was still verbally controlled among stakeholders. Only invoices were observed to be prominently emanating from the maintenance unit. Record keeping, report and writing reports on maintenance using modern communication technology such as computers and printers was seen by stakeholders as a luxury.

5.5 RECOMMENDATIONS

The main aim of this research is to develop a MM framework to enhance the maintenance practices of Senior High Schools (SHSs) in Ghana. The conceptual MM framework will only be successful if all stakeholders, especially top management, lead the way. The following recommendations have been suggested;

- School authorities need to perform an audit of the maintenance system in their respective schools to identify cost implications of the problems associated with the MM system.
- Recruitment of qualified staff is cardinal in any successful MM framework. School authorities therefore need to appoint well qualified and experienced maintenance staff. This is necessary because critical activities on the framework would be performed by the maintenance officer. Such activities include preparing detailed maintenance plans, scheduling activities and performing supervisory roles.
- School authorities also need to create the platform for routine training of maintenance staff to improve their capacity. Maintenance committees in SHSs made up of mainly teaching staff members; also require routine training on

maintenance management. In fact all stakeholders in the MM environment require routine training on MM.

- There is the need to review the sources of funds for carrying out maintenance works. Alternative sources of funds such as internally generated funds through levies and rental of facilities during vacations for commercial benefits could augment fund availability for sustaining the MM framework.
- The adoption of school blocks by 'old' student groups could improve the life span of buildings within the campuses. It is a known fact that the *'old-boyism'* on SHSs in Ghana has become an ego-culture among school leavers and can be harnessed to promote MM in SHSs. This concept is not new since some SHSs have had support from old students of the schools in painting selected buildings, supplying vehicles, equipment and tools.

5.6 CONTRIBUTION TO KNOWLEDGE

This research made contributions to the body of knowledge in the conclusion and recommendations section in 5.5. These additional contributions outlined below are significant to the relevance of this research.

1. The contribution of this research lies mainly in the development of a conceptual framework for carrying out MM in SHSs.
2. The research made recommendations on ways to improve MM practices in SHSs.
3. The research further identified and outlined areas that require further research. These areas include; MM policy, alternative funding options, detailed maintenance plans, and new curricula for MM training requirements.

5.7 LIMITATION TO THE RESEARCH

The research was not devoid of challenges such as those encountered by researches of similar nature. The limitation of this research is related to the sample selection which was limited to SHSs in Kumasi and Cape Coast Metropolises. These two Metropolises represented the northern and southern sectors respectively. It would have been interesting to include SHSs across other parts of the country especially the less-endowed institutions but the challenge of resources and time could not permit that.

5.8 RECOMMENDATIONS FOR FURTHER RESEARCH

It is important to note that the limitation of time could not permit an exhaustive study of the maintenance management practices in SHSs in Ghana. To this end, the following areas are recommended for further research to improve the total package of maintenance management practices in SHSs.

1. A major factor uncovered as impactful on the MM process was budgeting. Management identified that lack of adequate funding was impeding efforts at maintenance management work. **There is therefore the need to research further to identify alternative funding methods for maintenance management activities in the 2nd cycle institutions in Ghana.** New ways of mobilizing requisite finance for MM activities is necessary for improving the MM practice and requires further research.

2. There is the need for an applicable MM policy to be developed for SHSs taking into consideration the peculiarities that may be found in the various public senior

high schools in Ghana. **The recommendation for further research could be the "development of an applicable maintenance management policy for SHSs in Ghana".**

3. Another area that this research could not cover lies in the area of **"developing detailed maintenance management plans tailored for the day-to-day maintenance activities of schools".** As observed in the survey, maintenance units were operating without detailed plans in their everyday MM works. This will therefore improve and control the daily MM activities on/off school campuses.

4. Another area of concern that needs further research deals with capacity building of the human resource in SHSs regarding MM. Most maintenance managers in the schools revealed that they did not have any routine capacity building or in-service training on issues relating to MM. This is partly because the platform is not there from either public or private sources to train MM staff. It is recommended for future study regarding **establishing the potential for routine capacity needs and training of the human resource base on MM in SHSs.** This is intended to imbibe more improved ways of managing maintenance challenges to MM workers so as to improve the overall MM practice in SHSs.

5. The need for estate/facilities managers in Ghana cannot be over emphasized. However, training institutions in mainstream tertiary level do not have a categorical program to meet the training requirements of maintenance managers. There is therefore the need **to develop an appropriate MM curriculum for**

training middle-to-upper level man-power to meet the yawning gap that exists in MM practice in Ghana.

5.9 SUMMARY

This chapter presented the conclusions and recommendations to the entire study. Definitions and key concepts of maintenance management, and a review of the research objectives have been outlined. It also documented some contribution to knowledge, limitations of the research and recommendations for further research.

The research sought to develop a conceptual maintenance management framework to enhance maintenance activities in Senior High Schools in Ghana. This aim was achieved and a conceptual framework developed accordingly. The framework was designed specifically for SHSs in Ghana but is flexible and can be adopted by other organized educational institutions whether public or private to enhance their maintenance management practices.

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APPENDICES

Appendix A

Survey Questionnaires

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

Department of Building Technology

An academic questionnaire prepared for personnel of Senior High Schools in Ghana to support an MPhil research on the topic:

MAINTENANCE MANAGEMENT OF EDUCATIONAL INFRASTRUCTURE IN GHANA: DEVELOPMENT OF A FRAMEWORK FOR SENIOR HIGH SCHOOLS (SHSs)

QUESTIONNAIRE FOR HEADS OF SHSs

Dear Sir/Madam,

This questionnaire has been prepared for selected SHSs in Ghana with the sole aim of gathering relevant information regarding maintenance of buildings, facilities and infrastructure in general. The ultimate aim of the investigation is to aid the researcher in developing new paradigms of executing maintenance activities in SHSs.

The information collected through this questionnaire will be used solely for academic purposes and treated with all the confidentiality it deserves. I deeply appreciate the time you will spare to complete this questionnaire. Please answer all questions and use N/A where non-applicable so that the questionnaire can be utilized as responsive.

Thank you for your immense cooperation, support and contribution.

……

Genevieve Ekua Eghan

PART 1: PROFILE OF THE INSTITUTION/SCHOOL

i. Population (Students):……

1. How long has the school been in existence?
   a. 0 – 10 years [ ]
   b. 11 – 20 years[ ]
   c. 21 – 30 years[ ]
   d. 31 – 40 years[ ]
   e. 41 – 50 years[ ]
   f. Above 50 years [ ] Please specify years:……
2. Which of the following best describes the gender of the student population?
   a. Male only [ ] b. Female only [ ] c. Mixed [ ]
3. How will you describe the residential status of students in your school?
   a. Boarding on campus [ ]
   b. Boarding (rental) [ ]
   c. Non-boarding/Day [ ]
   d. Other, please specify…….
4. Would you describe your school as fully equipped in terms of facilities and buildings such as classrooms, dormitories, staff accommodation, telephone, power and water supply etc.? a. Yes [ ] b. No [ ]

PART 2: MANAGEMENT AND MAINTENANCE OF INFRASTRUCTURE

5. Is the maintenance department/unit of your school fully staffed?
   a. Yes [ ] b. No [ ] c. No maintenance department/unit [ ]
6. In the preparation of annual budgets for the running of the school, are allocations made specifically for maintenance activities?
   a. Yes, allocations are made [ ]
   b. No, allocations are not made [ ]
   c. Yes, but inadequate [ ]
   d. Maintenance funding is outside our mandate [ ]
7. Is there a reporting mechanism in place for maintenance issues to be communicated in your school?
   a. Yes [ ] b. No [ ]
8. How would you rate the state of maintenance of buildings on your campus?
   a. Very Highly maintained [ ]
   b. Highly maintained [ ]
   c. Fairly maintained [ ]
   d. Poorly maintained [ ]
   e. Very Poorly maintained [ ]
9. From Management point of view, please rate the following causal factors in order of importance (impact) on maintenance on your school's infrastructure. **The scale of 5 to 1 where 5 = Very Important and 1 = Unimportant**

	FACTORS	Unimportant	Less Important	Moderately Important	Important	Very Important
CODE		1	2	3	4	5
F1	**Socio-cultural;** attitudinal behaviour of users, vandalism					
F2	**Environmental;** weathering, corrosion, dirt accumulation					
F3	**Economic;** absence or inadequate funds for maintenance					
F4	**Technical;** specifications and workmanship at construction time					
F5	**Managerial;** delays in decision making, long bureaucracy					

*Please **tick** the appropriate response/answer to Question 10*

1. How would you describe the involvement of the following categories of people in the maintenance of school infrastructure? The scale is ranged from **Not involved (1)** to **Very Involved (5).**

CATEGORY OF PEOPLE	Not Involved	Less Involved	Moderately Involved	Involved	Very Involved
	1	2	3	4	5
Management					
Teaching Staff					
Non-teaching staff					
Students					

2. Which of the following is/are source(s) of funding for the execution of maintenance activities in your school?
   a. Internally Generated Funds (IGF) [ ]
   b. Government of Ghana/GETFund [ ]
   c. Private Donations/Sponsorship [ ]
   d. Levies (PTA, students etc) [ ]
   e. Other please specify……
3. The activity of maintenance requires a maintenance policy, general maintenance plan and specific maintenance plans to guide personnel in their work. Which of the following would you select as the best description of maintenance policy in your school?
   a. Written maintenance policy [ ]
   b. Un-written maintenance policy [ ]
   c. No maintenance policy at all [ ]

PART 3: COMMUNICATION IN MAINTENANCE MANAGEMENT

4. As the head of the school, how important are the following? Please rank them from **Unimportant (1) to very important (5)**

CODE	COMMUNICATION VARIABLE	Unimportant	Less Important	Moderately Important	Important	Very Important
		1	2	3	4	5
CV1	**Listening** to staff/students complaints and reports on maintenance					
CV2	**Giving feedback** as soon as possible on way forward regarding a maintenance problem					
CV3	**Holding regular review meetings** for updates on maintenance					
CV4	**Unannounced visits** to maintenance unit/workshop/facilities					
CV5	**Creating a written appraisal form** for routine evaluation of maintenance state of buildings and facilities; e.g. Paper questionnaire to be filled out by students and staff.					
CV6	Introduction and utilization of **suggestion boxes** regarding maintenance					

5. Which of the following communication tools do you utilize in your maintenance work?
   a. Telephones (mobile, fixed) [ ]
   b. Writing tools [ ]
   c. Verbal (oral) messaging [ ]

Appendix B

Follow-up Questionnaires

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
COLLEGE OF ARCHITECTURE AND PLANNING
Department of Building Technology

An academic questionnaire prepared for Senior High Schools in Ghana to support an Mphil. Research on the topic:

"DEVELOPMENT OF A FRAMEWORK FOR MAINTENANCE MANAGEMENT IN GHANAIAN SENIOR HIGH SCHOOLS (SHSs)"

Dear Sir/Madam,

This questionnaire has been prepared for selected SHSs in Ghana with the sole aim of gathering relevant information regarding maintenance of buildings, facilities and infrastructure in general. The ultimate aim of the investigation is to aid the researcher in developing a framework for executing maintenance activities in SHSs.

The information collected through this questionnaire is solely for academic purposes and will be treated with confidentiality. I deeply appreciate the time you will spare to complete this questionnaire.

Thank You.

Genevieve Ekua Eghan

PART 1: PROFILE OF THE INSTITUTION/SCHOOL

Population (Students):……

1. How long has the school been in existence?
    a. 0 – 10 years [ ]
    b. 11 – 20 years [ ]
    c. 21 – 30 years [ ]
    d. 31 – 40 years [ ]
    e. 41 – 50 years [ ]
    f. Above 50 years [ ]
    g. Please specify years……..
2. Which of the following best describes the gender of the student population?
    a. Male only [ ] b. Female only [ ] c. Mixed [ ]
3. How will you describe the residential status of students in your school?
    a. Boarding on campus [ ]
    b. Boarding (rental) [ ]
    c. Non-boarding / Day [ ]
    d. Other, please specify……..
4. Would you describe your school as fully equipped in terms of facilities and buildings such as classrooms, dormitories, staff quarters, telephone, power and water supply etc?
    a. Yes, fully equipped [ ]
    b. No, not fully equipped [ ]

Please **rank (tick)** the following according to the **level of Importance** in maintenance management (MM). **The rankings are;**

1 = *least important,* 2 = *less important,* 3 = *important,* 4 = *very important,* and 5 = *most important.*

ID	ISSUES / FACTORS	1	2	3	4	5
A1	Budgeting					
A2	Calibre of maintenance staff					
A3	Computerized Maintenance Management System					
A4	Communication on maintenance issues					
A5	Craftsmen qualification					
A6	Flexibility of organizational chart					
A7	Life Cycle Costing (useful value of the building)					
A8	Management procedure regarding MM					
A9	Maintenance officer/manager's qualification					
A10	Maintenance inspection					
A11	Maintenance tools and materials					
A12	Number of maintenance staff (adequate)					
A13	Organizational structure of maintenance unit					
A14	Planning maintenance activities					
A15	Staffing of Maintenance department					
A16	Recording completed maintenance works					
A17	Reports on maintenance					
A18	Research on maintenance					
A19	Setting priorities					
A20	Sound maintenance system					
A21	Standards (maintenance expectations)					
A22	Top management awareness					
A23	Training of Maintenance staff					
A24	Training of students on maintenance issues					
A25	Technology (maintenance techniques)					

Please **rate (tick)** the following according to the **performance level** of maintenance management in your institution. **The ratings are;**

1 = *not satisfactory*, 2 = *fairly satisfactory*, 3 = *satisfactory*, 4= very *satisfactory*, and, 5 = *highly satisfactory*,

ID	ISSUES / FACTORS	1	2	3	4	5
B1	Budgeting					
B2	Calibre of maintenance staff					
B3	Computerized Maintenance Management System					
B4	Communication on maintenance issues					
B5	Craftsmen qualification					
B6	Flexibility of organizational chart					
B7	Life Cycle Costing (useful value of the building)					
B8	Management procedure regarding MM					
B9	Maintenance officer/manager's qualification					
B10	Maintenance inspection					
B11	Maintenance tools and materials					
B12	Number of maintenance staff (Adequate)					
B13	Organizational structure					
B14	Planning maintenance activities					
B15	Staffing of Maintenance department					
B16	Recording completed maintenance works					
B17	Reports on maintenance					
B18	Research on maintenance					
B19	Setting priorities					
B20	Sound maintenance system					
B21	Standards (maintenance expectations)					
B22	Top management awareness					
B23	Training of Maintenance staff					
B24	Training of students on maintenance issues					
B25	Technology (maintenance techniques)					

Appendix C

Framework Validation Assessment

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

Department of Building Technology

Mphil. Research work on the topic:

MAINTENANCE MANAGEMENT (MM) OF EDUCATIONAL INFRASTRUCTURE IN GHANA: DEVELOPMENT OF A FRAMEWORK FOR SENIOR HIGH SCHOOLS (SHSs).

MM FRAMEWORK VALIDATION ASSESSMENT

Dear Sir,

This validation assessment form has been prepared for selected MM experts with the sole aim of acquiring experts' inputs regarding a maintenance management framework (MMF) developed from the research. This assessment however, is to aid the researcher fine-tune the conceptual MMF formulated to enhance MM practices in SHSs in Ghana.

The information collected through this validation process will be used solely for academic purposes and treated with all the confidentiality it deserves. I deeply appreciate the time you will spare to complete this form.

Thank you.

…….

Genevieve Ekua Eghan

Conceptual Maintenance Management Framework Validation Assessment Form –

Please **tick** where appropriate.

ID		Yes	No	Indifferent
	PART 1: OVERALL			
1	Do you agree that the main levels in Maintenance Management (MM) framework include; strategic, organizational, operational, and evaluation levels?			
2	Do you agree that the main phases include: MM Policy & Standards, Planning & Management, Execution & Control, Review & Improvement phases?			
3	Do you agree that there is the need for constant evaluation and review of the MM framework?			
	PART 2: STRATEGIC LEVEL			
4	Do you agree that management defines time limits and set objectives regarding MM?			
5	Do you agree that Management/Maintenance Staff identify suitable MM strategy for MM work?			
6	Do you agree to the theme on MM Policy & Standards as part of the **Strategic Level?**			
7	Do you consent that Maintenance concepts are important to the development of MM policy and standards?			
	PART 3: ORGANIZATIONAL LEVEL			
8	Do you agree to the themes under the **planning & management phase** which include; i) MM Planning ii) Technical Management iii) Manage Resources, and iv) MM Communication?			
9	Do you agree to the linkages of interaction between the themes under the **planning & management phase** of the framework?			
10	Do you agree to the sets of activities that have to be performed under each criterion during the execution and controlling phase?			
	PART 4: OPERATIONAL LEVEL			
11	Do you agree to the selection of an appropriate MM strategy under the execution and control phase of this level?			
12	Do you agree to the sequence of *"select strategy-plan, issue & carry out MM work-record results and identify further actions"* as suitable for execution & control?			
13	Do you agree to the inputs of personnel, equipment, materials, tools, finance and work order, as suitable for execution of a MM task?			
14	Can areas of the framework that need fine-tuning be fine-tuned by stakeholders for implementation?			
15	Can implementation of the framework be done by personnel responsible for MM in SHSs in Ghana?			
	PART 5: EVALUATION LEVEL			
16	Do you agree that review of the phases of the framework should be constantly carried out?			
17	Do you agree that Performance assessment of the MM framework should be done according to the expectations of top management with their involvement?			
18	Should performance assessment of the MM framework be done according to the expectations of maintenance staff with their involvement?			
19	Can school management and/or consultants with stakeholders evaluate performance of the framework against established benchmarks?			
	PART 5: GENERAL			
20	Is the framework flexible to meet expectations of School management?			
21	Can the framework aid the MM practices of SHSs in Ghana?			
22	Is the framework simple and self-explanatory to be used by SHSs management?			

Comments_____

_____

_____

_____

THANK YOU VERY MUCH

Appendix D

Draft MMF- Earlier versions

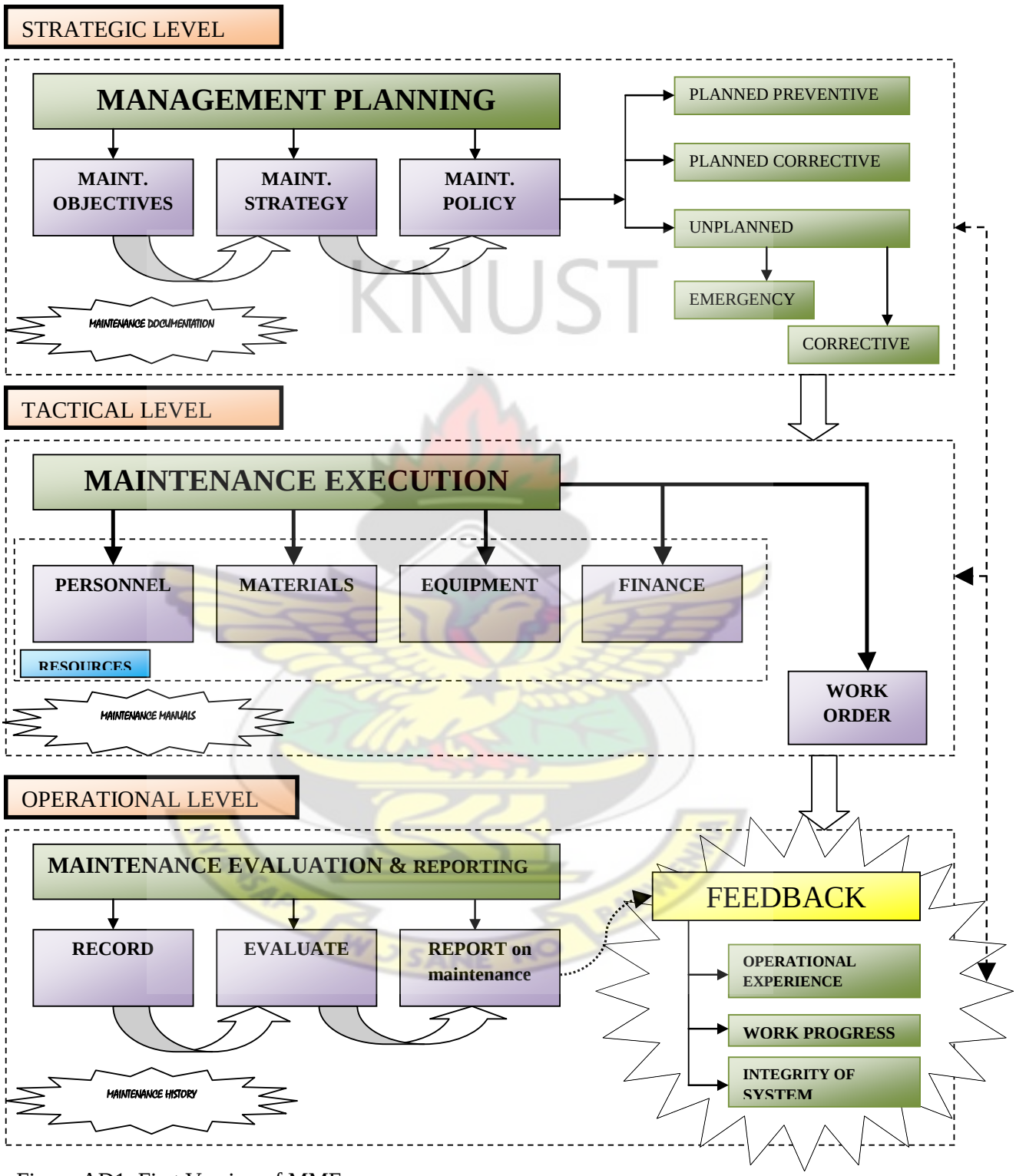

Figure AD1: First Version of MMF

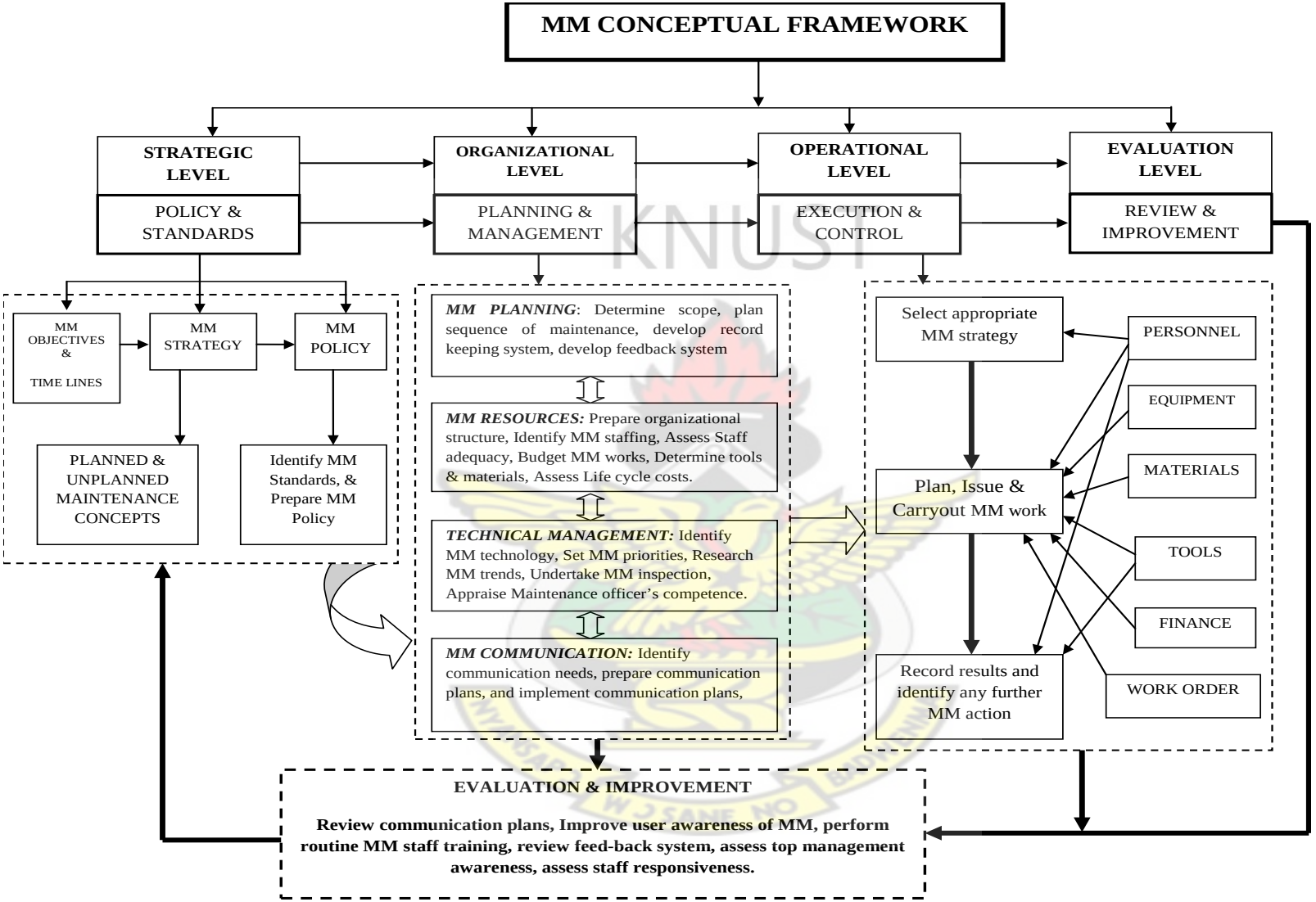

Figure AD2: Second version of MMF

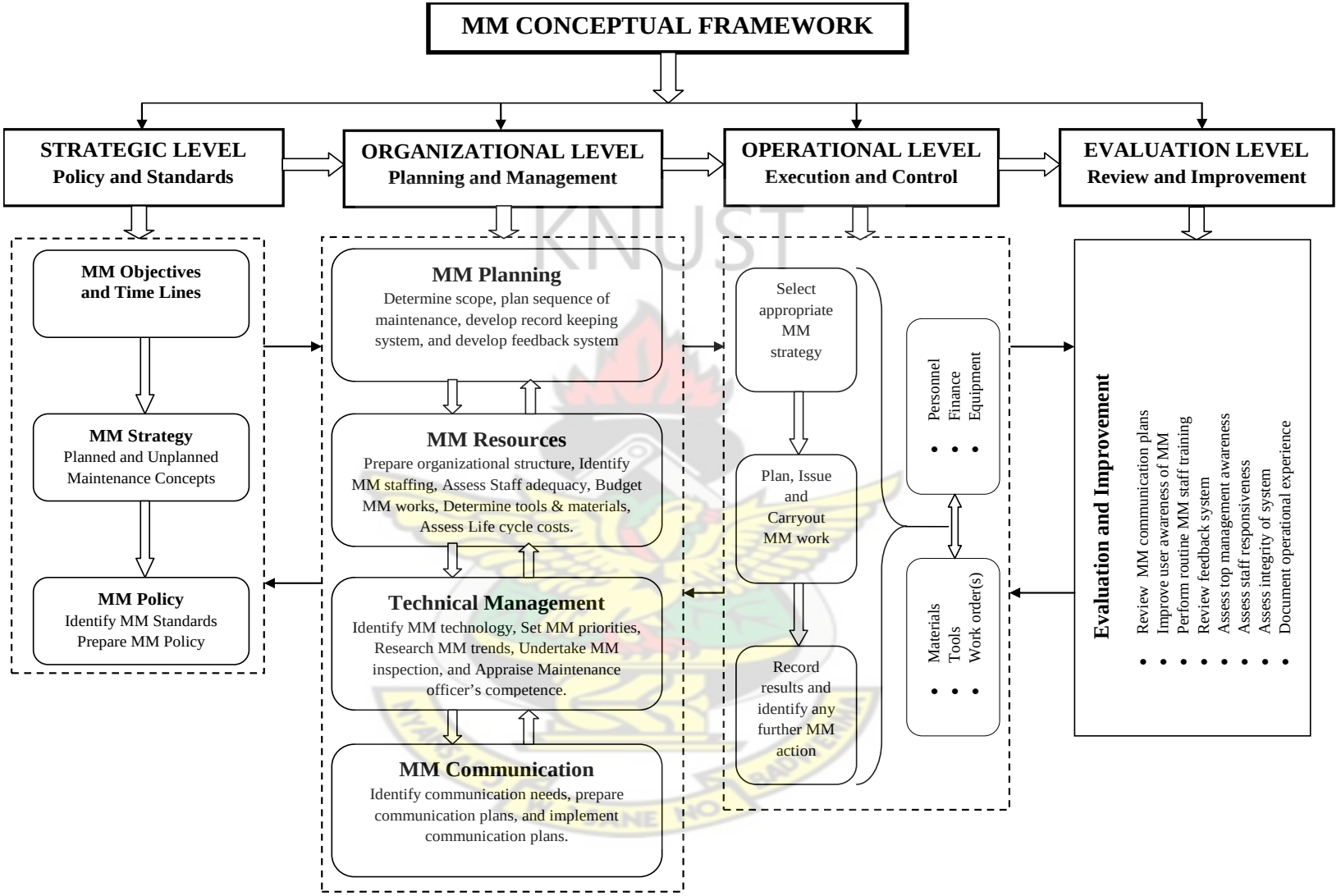

Figure AD3: Third version of MMF