

READINESS OF GHANAIAN CONSTRUCTION INDUSTRY TOWARDS DIGITAL
TRANSFORMATION IN GHANA: EFFECTS OF COMMUNICATION ON PROJECT
SUCCESS

By:

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A thesis submitted to the Department of Construction Technology and Management, Kwame
Nkrumah University of Science and Technology, Kumasi in partial fulfilment of the
requirements for the award degree of

MASTER OF SCIENCE IN PROJECT MANAGEMENT

July, 2019.

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgement is made in the thesis.

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ABSTRACT

Nowadays, digital tools are considered as vital for the productive management of construction projects. Digital transformation have immeasurable impact on the construction industry. Even though some firms today might see the better service of digital transformation to improve their business processes, the use of digital tools and infrastructure have frequently been described as comparatively inadequate and unproductive in relation to other industries. Hence, this research aims at examining the extent of willingness of the contractor organization in Ghana regarding digital transformation. It also provides an opinion of the scope and current practices of contractors in their usage of digital infrastructural tools, with the necessity for sufficient information with regards to the usage of ICT platforms, present degree of ICT system and ascertain the challenges the firms face toward digitalization.

The researcher adopted the survey method and used closed-ended questionnaires as the major tool for the collection of primary data. In totality fifty-one (51) questionnaires were retrieved out of the fifty-six (56) that was administered to the contractors. The statistical tool used in analyzing the questionnaire was the Mean/average score ranking and One sample T-test Score.

From the results, there is a sufficient level of familiarity among the contractors about the would-be advantages of digital transformation. Then again, recent ICT usage in most of the firms was established to be unsophisticated, with more advanced applications of ICT softwares lacking in most of firms. The research also shown that three (3) factors were identified as key challenges influencing the use of digital transformation by the contractor organizations. These three (3) factors were financial limitations, lack of dedication from the firm's management, and lack of training and technical support for contractors. The study lastly suggested some recommendations on the need for firm's internal policy and financial provision for digital transformation, better education and guidance for ICT usage in construction firms.

The study was concluded by recommending that construction practitioners should be properly sensitized on understanding and conceptualizing on how digital transformation and technology will impact construction processes and activities and ability to manage or work within digitally-savvy environments.

Keywords: Construction industry, Contractors, Digital skills and technology, Digital transformation, Ghana.

ACKNOWLEDGEMENT

My utmost appreciation goes to God Almighty for granting me the might, wisdom and overall good health during my program. In addition, I want to show my deepest gratitude to my Supervisor Dr. Barbara Simons for the immeasurable support in terms of my topic selection, assistance, direction, guidance and helpful criticisms throughout the research process.

Lastly, my appreciation goes to my family for their love and patience during the entire period of my study.

DEDICATION

This work is dedicated to God almighty and all contractors for their immense support throughout this study.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Organizations are in the phase of digital transformation, as industry players who are already functioning in a digital world expect to be able to communicate that way. Project management is all about effective communication between project teams and other stakeholders from project initiation to project closure. Information and communication technology is seen in recent times as one of the modern technologies that aid the smooth and timely flow of communication between contractors (Doherty 1997; Peansupap, 2005). According to Ganguly (2015), digitalization has become a matter of urgency for every business function and it is therefore necessary for these organizations to change from their archaic system of operation to a new digitized one from public relations to customer relationship management, human resource to managing projects.

The degree to which organizations integrate information and communication technology into every face of a business to gain economic benefit over competitors, improve on efficiency, create new business openings and generate high profits by exceeding client's expectation is known as digital transformation. One major challenge of digitalization is change; the human factor in the whole process of digital transformation. In other words, digital transformation is an innovation that ties company policy, technology, devices, and data science to transform business operation by increasing client's expectation to improve agility, revenue and cost (Bahl, 2015).

The Ghanaian construction industry is behind schedule with respect to research and development. The need for relationship software is very essential with regards to information and communication system where all stakeholders come together to share information, experience and project knowledge in one centralized system. Incorporating present structures and procedures into one centralized platform can influence how work executed. Thus, transforming to a dependable collaboration software is necessary to serve as the digital support for the construction process from initiation to closing. Examples are Project management software, PlanGrid, Coconstruct, Procore, e-builder, Building Information Modeling (BIM) amongst others.

For any organization that wants to be abreast with the modern trend of technology, digital transformation is an option and the Ghanaian construction industry is not exonerated from this wind of change. A practical example is the Uber Transport Company integrating ICT into their business model by offering customers with the convenience of booking transportation services online through their mobile application. Thus, transforming from the traditional way of doing business. In this regard, change management has to be tailored to meet the requirements in a digital world (Kohnke, 2016). Organizations are undergoing work process redesign, re-engineering and other methods of reformation. The big question however is the readiness of the Ghanaian construction firms towards this change? On this note, this study attempts to assess the readiness of the Ghanaian construction industry toward digital transformation. Particular attention is devoted to an analysis of communication issues on projects and its impact.

1.2 PROBLEM STATEMENT

It is evident from the background that the eminence and developing roles of digital transformation in the Construction industry cannot be overlooked. Citing Mohamed et al. (2003), many construction firms in Ghana are still using the archaic means of record keeping, face-to-face meetings, physical exchange of paper documents like construction drawings, specifications and day-to-day site instructions. This makes their work process very slow due to the heavy drawing papers and copies they produce. Usually working with a lot of papers is time consuming, which the effective management of the records for easy access and retrieval. in situations where organizations completely rely on dispatch rider to deliver construction documents to clients, which is face-to-face can most often lead to delays as there are obstructions that might one way or the other prevent the timely delivery of the documents. Thus, through digitalization, organizations can drastically reduce the cost associated to the delivery of project documents to clients and other team members who are far reach. (Norman et al., 1981)

The construction firm is an open industry with many competitors (Boyd et al., 2019). Hence to remain competitive and exceed client expectations, organizations are expected to step up their business operations systems. As a result, a more refined methodology is required to deal with problems on project cost estimate and valuation, design modeling, engineering and other areas in which digital transformation have proved its greatest impact and immense application potential. Therefore, contractors can employ ICT as an enabler in support of the assimilation, collaboration, procurement, and process improvement in their operational process. Most limitations of contractors in the use of ICT applications are

associated to computer illiteracy, unsatisfactory ICT knowledge and the employee buy-in to embrace the change.

On this note, this study attempts to examine the degree of problems and application facing the use of digital transformation in the Ghanaian construction industry. Particular attention is devoted to essential requirements for digital transformation and digital transformation skills and channels.

1.3 AIM AND OBJECTIVES

1.3.1 Aim of the Study

The aim of the study is to find out how ready Ghanaian construction firms are towards digital transformation in the aspect of communication and how it affect the success of a project.

1.3.2 Objectives of the Study

The objectives of the study are:

- i. To assess the current use of digital transformation tool in the construction firms in Ghana.
- ii. To assess Information and Communication Technology infrastructure of local construction firms in the financial class in the Ghana.
- iii. To identify the factors hindering the use of digital transformation by contractors in Ghana.

1.4 RESEARCH QUESTIONS

The following research questions have been proposed to answer the above research problem,

1. What is the current state of digital transformation in construction firms in Ghana?
2. To what extent is digital transformation being used by construction firms in Ghana?

3. What challenges delay the use of digital transformation in construction firms in Ghana?

1.5 JUSTIFICATION

The lack of modern construction software in the construction industry is a major challenge that faces its practice in Ghana. Contractors have low level of the use of the software, and since most construction works are carried out on the site, the need of readiness inculcate this technology into their business process becomes a challenge.

Results from this study will provide adequate knowledge on the level of awareness of the concept of information and communication technology and the challenges affecting its implementation by Contractors. Afterwards, the outcome from this project will serve as basis for possible further studies.

1.6 SCOPE OF THE STUDY

The emphasis of the research was restricted to the Ghanaian construction. The study in effort was made to provide comprehensive insight on digital transformation and its effects of communication on project success. Ahadzie (2007) as cited by Donkor (2011) revealed that over seventy percent of (70%) Ghanaian contractors tend to operate formally in the Greater Accra and Ashanti regions and therefore contractors in any of these areas could be recommended for the research. The research population will be focused on all the classes of contractors from D1/K1 to D4/K4 contractors in the Accra Metropolis of Ghana. The choice of D1/K1 to D4/K4 contractors as main participants is because of the diverse capacities of construction works they carryout, industry experience, skilled professionals and recognize the value of ICT in their business operations.

1.7 RESEARCH METHODOLOGY

To achieve the objectives set out in this research, the survey method strategy was adopted. The major tool that was used in the collection of primary data was questionnaires. Structured close-ended questionnaires with a list of pre-determined answers were distributed to the respondents to gather primary data on the readiness of Ghanaian construction industry towards digital transformation. Additionally, there was a desktop survey of existing literature such as articles, journals, reports, textbooks, internet among others for secondary data. The purposive sampling techniques was adopted to target participants for the study.

The data received was analyzed using Statistical Package for Social Sciences (SPSS) Software and Microsoft excel.

1.8 SIGNIFICANCE OF THE STUDY

This research seeks to cover the readiness of digital transformation and effective communication on the success of construction projects employed in the Ghanaian construction industry and subject them to analytical investigation to allow for identification of contractor organizations in Ghana. It is also obvious that most of the contractor organizations in the country are lacking behind in terms of digital transformation. This research will help equip the contractor organization know the effects of using ICT in their operations with efficient and effective ways of managing site activities using technology so as to being able to compete with their overseas colleagues. By this, Ghanaian construction firms will be able to perform better on construction projects they undertake.

1.9 ORGANIZATION OF STUDY

This research work is structured in five chapters with a preceding preliminary section, which contains the title page, declaration page, certification, dedication page, abstract, acknowledgement, table of contents, list of tables etc.

Chapter One (1) delivers an introduction to the pressing issue under digital transformation in the construction sector and also highlights the challenges of digitalization in the Ghanaian construction sector. It outlines the aim and objectives of the research, justification and scope and finally organization of the study. Chapter Two (2) present part one of the literature review with specific focus on digital transformation among other governing factors, it also highlights key areas of concern within the scope defined in order to put the research on a better perspective. Chapter Three (3) addresses the logical choices available in research methodologies and details the research design and its elements. The methods and techniques used in data collection are also outlined. The second part will be devoted to the data process and analysis. Chapter Four (4) presents and analyses the data acquired from the survey. The findings from the research are also discussed. The chapter also shows how the research objectives are met. Chapter Five (5) presents the findings of the research and the limitations highlighted. The chapter concludes with recommendations for stakeholders in the construction industry and also recommendations for further research is also suggested.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a review of rich contemporary literature on the subject matter, with a particular attention on the terminology, origin, fundamental concept and conventional views on digitalization in general, and digital transformation in the construction sector in particular, among a number of prevailing factors. Further, by means of the evolving body of digitalization literature, the chapter presents an overview of the Ghanaian construction industry. In addition, it concisely describes Lastly in this section is the drivers for implementing digital transformation providing a working understanding of issues relation to ICT needs and the current role of digital transformation in construction. It concisely describes the drivers for implementing digital transformation in the construction industry, ICT tools and applications and the perceived challenges for its implementation.

2.2 NATURE AND FEATURES OF THE CONSTRUCTION INDUSTRY

The Ghanaian construction industry is dominated by physical infrastructure and asset-based-lending as a means for growth and development (Songwe, 2014). The industry contributes roughly 5% to 10% of Ghana's Gross Domestic Product (GDP) and hires closely 10% of the working population, (Asamoah and Decardi-Nelson, 2014). The construction industry is characterized by a collection of different stakeholder and this makes it complex, (Dadzie et al., 2012). The Chartered Institute of Building in Ghana estimates that there are over 1,600 building contractors working in Ghana since October 2012 (Oxford Business Group, 2014).

According to Levy (2007), the construction industry constructs permanent, exclusive, multifaceted structures such as homes, industrial units, offices, schools, roads, bridges etc. For other sectors of the economy such as commercial, education, accommodation needs, business activities, health etc. To thrive, they need the services of the construction industry. In addition, the construction sector contributes greatly to the socio-economic development by means of providing job employment openings for equally skilled and non-skilled workforce. As the population is dispersed across every region so the construction industry is dispersed due to the fact that people are building or developing structures everywhere irrespective of their locations and this provides employment at the various levels of the economy.

2.3 THE CONTRACTOR ORGANIZATIONS IN GHANA

According to the Ghana Ministry of Water Resources, Works and Housing, contractor organizations are categorized into financial class D1 to D4 and K1 to K4. As cited by (Amoah et al., 2011). Category 'D' represents general building contractors and category 'K' for civil works contractors. Generally, category D3/K3 as well as D4/K4 are defined as the small-scale building contractors (SSBCs) whereas D1/K1 and D2/K2 are generally described to as big firm. The classification is based on contractors practical and professional know-how, financial stability, past operations, equipment and plant asset (Laryea, 2010).

The following are the three groups of contractor in Ghana:

1. Those who construct residential building, industrial, commercial, and other structure.
2. Contractors who are into civil engineering like drains, infrastructures, conduits, etc.
3. Those with particular skill such as plumbing, electrical, mechanical etc.

According to Dansoh (2005), the Ghana ministry of water resources, works and housing classified contractors into groups (A, B, C, D, E, G, K and S) according to the type of

works they undertake. The categories are: Roads, Airports, and Related Structures (A); Bridges, Culverts and other Structures (B); Labour based road works (C); General building works (D); Electrical works (E); Plumbing works (G); General civil works (K); toughen conduits and edifice: (S). In each category, they are grouped into 4, 3, 2 and 1 financial classes in increasing order

2.4 INFORMATION AND COMMUNICATION NEEDS IN CONSTRUCTION

According to Murray et al., (2001), one of the industries that works with large records, documents and files is the construction industry. For example, project team are made up of experienced experts and stakeholders with routine activities and collection of paperwork. Most of these people require timely access to the usual project information as and when needed. Meaning, information plays a very important role on the success of every project, from initiation to completion as project stakeholders depend on this timely and accurate information to make informed decision, which in turn translate to achieving organizational goals and meeting clients' expectation. Now, most construction firms exchange information like construction illustrations, designs, bills of quantities, and programs by hand delivery.

2.5 COMMUNICATION NEED IN CONSTRUCTION

Effective collaboration and communication between project stakeholders during the entire project phase is not only important but also necessary for the successful accomplishment of the project. Thus, the improvement of communication in the construction industry has been a target of experts and scholars for many years. According to Guevara and Boyer (1981) and Bowden (2005), for the construction industry to function efficiently and effectively, contractors must have laid down different communication structures.

2.6 DIGITAL TRANSFORMATION AND THE CONSTRUCTION INDUSTRY

2.6.1 Definition

Digital transformation is a concept introduced in 2000 by Patel and McCarthy. Eversince, the exact definition of the term has changed, with past authors such as Patel and McCarthy (2000) often concentrating on areas such as e-commerce and digital marketing or digital literacy (Lanshear and Knobel, 2008). As any method of organizational change, digital transformation is related to people, processes, strategies, structures, and competitive dynamics. It symbolizes “global accelerated process of technical adaptation by individuals, businesses, societies and nations” (Khan, 2016; Collin et al., 2015; Tapscott, 1996; Westerman et al., 2014). The foundation of digital business transformation is organizational change (Wade, 2015 and Maedche, 2011). Like any other organizational change, there should be a reliable structure connecting people, processes, and technology enabling organizations to effectively direct this transformation (Bonnet and Nandan, 2015, p. 2).

2.6.2 Digital Transformation in Construction Industry

Currently, the construction industry is undergoing a model of change from the archaic system of operations to digitally managed information technology system, which other businesses such as telecommunication, retailing etc. Emphasizing on this, Bahl debated that no business is exempted from the force of digital interruption, even highly businesses such as financial industries are experiencing severe intense force to such as financial services, are under severe pressure to reorganize their business operations and processes. In addition, this wave of disruption is not just for companies, even the society is feeling the heat of transformation towards a better future that is digitally driven. Hence, technologies are changing businesses today and is making clients/consumers to break the normal norms of any business and every business requires a digital orientation, meaning a digital focus in

all business processes and functions. In order to still be in competition, the construction industry needs to change its operational strategy. This has to happen rapidly because most clients and/or consumers are going digital. Roughly 40% of the world population today are digital and those that cannot keep up with pace may be running the risk of being pushed out of 94 business by competitors that respond rapidly (Norris, 2001).

2.6.3 Need for Digital Transformation in the Construction Industry

The need for digital transformation is of the essence in every business organization be it small or big (Pramanick et al., 2019). A lot of businesses are incorporating digital transformation into their process due to the problem of time constraints, complications and operational breakdown. Evidently, the aim of these digital integration is to sustain information sharing amongst project teams, individual and groups since the construction industry requires the use of sustainable systems enabled information and communication technologies (Edmondson and Nhembard, 2009).

According to Bowden (2005), constructor organizations are currently benefiting from the new prospects of improving their business process and procedures due to the use of digitalization at exceptional phases of project release, thus, developments in communication techniques and the practice of information technologies offer immense possibility for improving the overall operations of the construction industry. Citing (Isikdag et al, 2007), digital transformation is seen as the core means to implement drastic modification in the construction business systems. According to the Roadcon Project (2003), projected developments and impressions could be foreseen in many ICT-based areas such as: planning design, procurement and site process. Initiating ICT and computerization on site. Business processes comprising of project management, contractual and legal issues;

monitoring and operations measurements, as regards e.g. the conformity with customer needs or the management of investment, operation, maintenance. An enhanced use of communication, teamwork and knowledge sharing tool for smooth and transparent use of ICT and process improvement through best opportunities progress monitoring.

2.6.4 Role of Digital Transformation in the Construction Process

According to Peansupap (2004), the advantages presented by digital transformation on construction project are well acknowledged in research journal, books and works. Some of these benefits are increased access to better information and communication, which helps contractors in making the right decisions in their business operations.

The role of implementing digital transformation are emphasized in the next phases of the construction development:

2.6.4.1 *Tender stage*

One of the benefits that ICT provides during the construction development is the promotion and distribution of proposal forms, selecting the most deserved proposal, etc. It also helps in the circulation of contract documents as well as tender communication; offers a convenient atmosphere to assess proposal replies across regular models and avoid illegal access through built-in security devices.

2.6.4.2 *Design and construction stage*

According to Cowel (2005), the need for instant access to real time information during the construction and design phase of project is very important. One would agree with Samuelson (2003), that the use of ICT support in the main activities of the construction and design phase has become a tactical issue for the construction industry to improve efficiency and productivity in the process. According to e-Business Market Watch (2005), for the overall

deadline of a project to be met, project managers and contractors' handle the exchange of documents between members. It is very important for each project team member to have the updated project documents at the right time. The use of ICT software's is necessary at this stage as it will improve work productivity, lessen the risk of errors by making sure that every project member is working with the most updated drawings and other documents; in addition, the use of ICT software at this stage saves time in the request and approval process, by permitting the design team to add their suggestions to the drawings online and lastly, eliminating the possibility of misplacing important files, by maintaining all current and past versions in one central location.

2.6.4.3 Trading (e-Commerce)

The procurement of construction materials involves the considerable resources as well as evaluating quotations from both regular and potential suppliers. Procurement is an extensive process because constructors deal with a wide range of suppliers with different quotations formats. With the use of e-commerce or web-enabled software gives contractors some form of flexibility to procure materials electronically by computerization of document delivery and communication. According to Woksepp and Olofsson (2007) and e-Business Market Watch (2005), these significant roles of ICT in construction firms, studies indicate that the IC utilization ratio is still comparatively low.

2.7 DRIVERS FOR IMPLEMENTING ICT IN CONSTRUCTION

Currently, most of the construction firms are motivated to adopt and advance in digital tools due to the enormous benefits it brings. This supports the finding undertaken by Rivard (2000) and Peansupap (2004) that an increasing trend of firms using ICT in the construction industry. ICT brings the benefits of increased in output. Some of the benefits that ICT brings are; increase in output as a result of improved operational efficiency leading to

reduction in project cost, ICT also assist in data assimilation which decreases the amount of information of information processed via the internet. Additionally, it improves teamwork between project members particularly when team members are sited in diverse geographical areas (Ahmad, 2002; Sriprasert and Dawood, 2002b). It also improves customer services and creates potential business prospects (Skibniewski and Nitithamyong, 2004).

2.8 THE USE OF ICT ON SITE AND PROCESS IMPROVEMENT IN CONSTRUCTION

According to Samuelson (2003) and Lofgren (2006), ICT has played a very significant role in the improvement of output in the construction industry. However, due to the nature of construction activities, the possibilities for productivity improvements are often reflected within the efficiency in running the construction business processes. Describing from this, the use of digital tools in the construction sector mostly results in efficient project management, system integration and workflow development, improved communication processes, resource development and further effective Customer Relationship Management (e- Business Market Watch, 2004). Digitalization in the construction involves the use of computers to replace and/or enhance a variety of processes, which comprises of surveying, equipment control, site inspection and the installation of manufactured units using Global Positioning System (GPS) technologies and advanced robotic systems have been applied successfully in recent times (Ahmad and Perkinson, 2005). Task automation provides productivity enhancements in Delivery of required information e.g. Method statements; Production of reports e.g. Daily progress reports; Alerts e.g. Notification of safety hazard; Data collation reduces number of administration staff required.

2.8.1 ICT - Based Interaction and Project Management Systems in Construction

Citing e-Business Market Watch (2005), a lot of different digital tools like ICT project management and mobile transmission systems have shown their worth in the construction industry. This includes standardization, coordination and reformation work process, distribution of information etc.

According to the e-Business Market Watch (2005), ICT solutions for Project management, planning and resource management with special relevance for construction companies are displayed in the use of:

- i. Electronic ordering of materials and supply, logistics management, etc. The use of portable electronic gadgets promotes proficient interaction and organization amidst large geographical locations.
- ii. Job structuring devices and quality control assessment. For instance, an all-inclusive project management technique allows the firms to strategize their operations, hence prevent serious commotions in work activities.
- iii. Combined monetary solutions and estimate programs for budget and resource spending. For example, a money system combined with project administration solution that multiplies productivity and eradicates idleness and surplus, as it allows the companies to accurately identify where expenses are being incurred throughout the enterprise.
- iv. Design system 3-D modular-based with digital information attached for all phases of the construction process and conception of all work. This device allows for better communication between construction companies and customers about project expectancies for final buildings.

2.8.2 ICT for Data and Business Assimilation in Construction

It is obvious that businesses and social trends are compelling the construction industry through a phase of digital transformation. In the attempt to cut down project cost together with the growing technical complexity of projects, all these create a demand for the integration of construction project information (Brown et al., 1996). Integration refers to data, applications and software products that provide integration frameworks and associated tools. Internal integration enables the sharing of data and business functions across applications internally in a company (Ramboll, 2008).

Previously, business software's for ICT have been closely direct and task-oriented, simplifying business activities and processes such as document handling, order registration, and resource and production planning. Such software's have enhanced efficiency and output considerably. Now, contractor organizations have become extra knowledgeable about the significance of the process and business integration. As the firm expands, the demand to share information across departments and business areas becomes more critical; therefore, firms focus on the combination of systems to provide a means of interconnecting these broadly dispersed and often-proprietary systems. Data assimilation through the use of ICT can lessen the amount of information managed and decreasing double entry of data by transmitting information through the use of internet/intranet protocols. This use of ICT can provide immense advantages during the course of the project design, construction, and operation (Sriprasert and Dawood, 2002).

The impact of successful integration through ICT according to e-Business Watch (2005) involves but not limited to:

1. The flow of information in the company by establishing a sound platform for strategic decisions and permits instant access to critical data.
2. Integration between vendor management systems, e-procurement systems and design.
3. Planning tools supports coordination between stockholdings, requirements and materials or component needs.
4. Integrated systems for resource management, logistical planning and project planning support efficient use of human resources, machinery, materials and transport facilities.
5. Access to real-time information from integrated project management systems, calendars and vendor management systems support realistic time and cost calculations when negotiating a new project or preparing a public tendering.
6. Time and cost savings because of a limited need to manually re-enter data into multiple systems.
7. Integration solutions enable companies to create a “single view” of all their enterprise data and an infrastructure for ensuring that applications can exchange and update business-critical data no matter where it resides.

Notwithstanding this unique contribution however, a number of obstacles caused by internal and external circumstances complicates improved integration of ICT systems. As most companies in the construction sector are rather small, general barriers such as lack of

competencies and lack of technical expertise affect most practitioners (Volgesang et al., 2019).

2.8.3 ICT for External Collaboration, Communication and Knowledge Management

Clearly, digital compatibility with external partners can play a defining role in facilitating external collaborative processes and cooperation (Hassan et al., 2005). According to Saxon (2003), ICT enabled collaborative working is a prime tool for driving a revolution in the construction industry. Similarly, it confirmed that, ICT can be used as the enabler of Collaboration and Knowledge Management – through the establishment and use of Knowledge Discovery in Databases, Knowledge Management Systems, Knowledge Warehouses, Enterprise Planning and Management Systems, Decision Support Systems, Virtual Engineering Teams, Groupware Applications, Object Oriented CAD (Sarshar and Isikdag, 2004).

Over the past two decades, the availability of hardware and software programs to enhance communication have steadily increased, and more professionals involved in construction projects are introducing collaborative software solutions to support their specific operation (Peansupap, 2004). Furthermore, it is worth noting that, ICT – enabled cooperation and collaboration offer various potential benefits depending on issues such as the complexity, numbers of external relations including partnerships and type of shared information. This is possible through a number of ICT solutions, which are in the form of seamless and fluid data exchange and online access for all relevant agents attached to a construction project (e-Business, 2005). Some of these ICT solutions include;

1. Virtual project fora or Teleconferencing to enhance communication between partikes involved in construction projects. A virtual project forum constitutes an online organizational frame that helps to coordinate and manage a project and contains all

associated information. It serves as a databank and makes all relevant information accessible to organisations participating in the construction project.

2. 3-D modeling technologies to improve, for example Business Consumer communication. These technologies provide instant information exchange between all involved parties in case of changes. Research points to the importance of reducing discrepancies in the construction process between clients' expectations and contractors and designers interpretations of clients' wishes (European Commission, 2004B).
3. Mobile online devices to facilitate data transfer between construction project participants. With access to a virtual project forum, the devices allow operators to request drawings, communicate with other stakeholders or calculate the consequences of construction changes.
4. Online construction project monitoring in virtual groups and electronic calls for tenders and bidding to promote ICT usage in B2A (Business to Administration) co-operation (European Commission, 2004A).
5. Business to Business communication in the construction process to enable quicker data transfer, advanced visualization and faster alterations during the construction planning process.

This process undoubtedly underscore the importance of interoperability of the companies' ICT systems, which defines their ability to manage and communicate electronic product and project data between collaborating firms and within individual companies design, construction, and maintenance and business process systems.

2.8.4 ICT for E-Procurement and E-Commerce in Construction

One more positive note about Information and Communication Technologies is that the technology can be used as a tool to enhance electronic procurement in the construction sector (Sarshar and Isikdag, 2004).

This aims to overcome the administrative and communication problems with the many millions of trading documents (such as invoices, tenders and orders) currently exchanged on paper in the construction industry.

Electronic procurement in construction can be classified into electronic Tendering (e-tendering) and electronic purchasing (e-purchasing). E-tendering is the use of electronic means throughout the tendering processes, i.e. finding and selecting bidders or suppliers, works or services while E-purchasing is the use of electronic means in the process of purchasing goods, works, services and utilities. E-tendering facilitates the access of construction companies of prior notices and publications of tenders in their own and in other countries, enabling them to place bids on projects internationally. Specialised e-market places, e-portals and search machines pinpoints potential customers vendors and public tender competition, supporting a wider market perspective among companies. E-procurement therefore, can have an impact on the creation of a market (Alshawi and Ingirige, 2002).

The right implementation of e-procurement systems can increase transparency and access to tender notices. For instance, during the invitation for the bidding period, ICT innovation tools can be useful for publishing the bidding information on a website which can save printing and advertising cost.

2.8.5 ICT Tools and Applications in the Construction Sector

Having discussed current roles and drivers for implementing ICT in the construction industry, it is now prudent to look at some of the important ICT tools and applications being used by the construction sector. Ashore (2006) hinted, Information and Communication Technology (ICT) should support the entire construction process of construction from inception through to the operational maintenance of the building asset.

This involves using ICT tools and technology to create, communicate and exchange information and data among the various participants in the project team. Again, project models that supports improved coordination and management of information throughout the project life cycle has gained increased recognition and that, contractors among the building team can also use ICT throughout the entire process of their operations (Sarshar, 2003).

Generally, the use of ICT on a construction project can be classified into communication systems and technical decision support systems (Farag et al., 2009). Quoting from Doherty (1997), Farag et al (2009), the communication domain involves all the common means of communication which are now computerized, while the technical decision support domain involves other computer applications other than for communications. Drawing from this, the following section discusses key ICT tools and applications for the construction sector.

2.9 ELECTRONIC COMMUNICATION AND DATA EXCHANGES SYSTEMS IN CONSTRUCTION

According to Harris and McCaffer (2001), the most significant impact that ICT has had on management of information resources in construction is perhaps in the area of communication. Computers and web-based technology has offered the potential for great advances in transferring information accurately and quickly, and in some instances, approaching the goal of real time information flows (Marosszeky, 2002). Indeed, this has made the use of the Internet and computer-

aided communication very essential for closer collaboration among the construction project partners. Traditional forms of communication in organizations are carried out through face-to-face interaction; paper-based drawings.

Today, the use of electronic communication is doing similar thing through electronic formats. Electronic communication (e-communication) is a system used as a means of sending or retrieving messages through computers of internet connections. The introduction of different e-communication tools may alter the firms operations, providing firms with innovative venues for influencing their management processes. The communication processes (i.e. exchange of information) can occur either internally or externally to the firm. Intra-organizational e-communication is in its simplest mode mere electronic mails via internet, while more enhanced e-communications over intranet or local networks can be streamed either in different forms: text, audio and/or visual.

The following highlights some of the communication and Data exchange tool in the construction industry:

- i. Project Extranets or Project Specific Websites
- ii. Electronic Data Interchange (EDI)
- iii. Information Systems and Applications
- iv. Administration, Business and information management systems
- v. Computer Aided Design and Visualization systems
- vi. Computer aided estimating systems
- vii. Site management tools, planning and scheduling systems

2.10 IMPLEMENTATION OF DIGITAL TRANSFORMATION IN THE CONSTRUCTION INDUSTRY

One of the important areas that needs attention in the construction industry is the proper implementation of information technology. Nevertheless, a lot of these construction industries have already begun transforming from paper-base to digital by implementing some form of automation and/or ICT.

Then again, this create the need for players in the industry to consider expanding their technology programs to include ICT technologies which will utilize real-time data including those collected on site to improve management and decision making functions (Hampton, 2005). According to Perkinson (2006), contractors can multiply their competitive advantage by incorporating these technological tools in their business process by generating an entire organizational work base tool for analyzing the project in the field of: Project performance control, Material and equipment management, and human resource management.

In addition, some remarkable advantages of incorporating digital transformation for use as a total jobsite management tool may include: real-time monitoring and documenting of construction operations, reduced paperwork, improved project management capabilities in terms of tracking people, equipment, and assets, early detection and fast response time to problems, standardization of data collection and management, kmore accurate performance data which can be used for planning of future projects, creation of a history of baseline for dispute resolution, and reduced contractor reporting requirements because the owner/engineer can continuous observe what is happening on site (Perkinson, 2006).

2.11 FACTORS AFFECTING THE USE OF DIGITAL TRANSFORMATION IN CONSTRUCTION

Digital transformation is an area where increased investment is necessary in order to remain competitive in the market, increase efficiency, reduce timescales and cost, and raise the entry level for a contracting business. Despite the numerous benefits digital transformation offers, most building construction industries invest little in ICTs and is usually slow to exploit their benefits.

This slow digital transformation interest can be explained as being a function of; the complex nature of the construction industry; ICT immaturity levels; financial constraints; poor availability of tools for evaluating benefits of using ICT; and a lack of understanding of the ICT implementation process. In recognition of these effects, Caglar (2005) indicated that, ICT deployment in the construction industry depends on the following key factors: value of the project, technological capability of the parties, use of ICT in past project – previous experience, number of parties – greater number and diversity should lead to greater use, clients demands, desire for better and effective communication, partnering and desire for better collaboration, information overload and desire to reduce the paper work, wish for greater transparency.

2.12 BARRIERS TO IMPLEMENTING DIGITAL TRANSFORMATION BY CONTRACTOR

According to the Roadcon Project (2003), some of the major barriers that prevent the use of various ICT tools in the support of its business operations need to overcome for the construction industry to advance. To this effect, some of the significant barriers such as lack of a coherent ICT strategy, low ICT competencies and lack of resources especially in SMEs, reactive approach to ICT strategy, differing demands from customers for systems and functionalities, switching costs related to replacing old systems with new integrated solutions has been cited. Furthermore, some

studies have also identified various factors that explain the reluctance of the construction industry to adopt and use ICTs (Rivard, 2000).

According to Acar et al (2005), three of these factors best characterize the overall attitude of construction firms towards ICTs. He observed that apart from technical and financial problems (e.g. continuous demand for upgrading and high investment costs); cultural and psychological factors are increasingly receiving attention as barriers to the widespread adoption of ICTs (Backblom et al., 2003).

Secondly, the fact that construction professionals are often satisfied with their traditional business methods and tools is a common barrier (Doherty, 1997; Samuelson, 2002). Thirdly, there is no single magic ICT solution for the whole construction market. The type of the ICT solution required by construction firms is likely to depend on the context of the work done (Egbu and Botterill, 2002).

Similarly, E-business Watch Report (2005) on the construction industry cited that implementation of ICT collaborative systems is hampered by a number of barriers such as:

- i. Legal and contractual issues regarding for example data ownership and copyright holders, the legal validity of contracts, and digital signatures.
- ii. Oral culture and traditions where information is typically shared face-to-face.
- iii. Lack of shared standards for information exchange.
- iv. Lack of financial resources, ICT competencies and knowledge about the cost and financial benefits of ICT investments.

Zeng et al., (2007) categorized these into organizational structures, individual behaviour and the technical requirements of data in the industry as some of the barriers that hinder the flow of

information among the participants in a construction project. These barriers can be classified as follows; financial barriers: general lack of finance, high cost of ICT investments, maintenance cost, budget constraints etc. Organizational barriers: lack of business incentives, poor ICT strategies, lack of training, lack of appropriate ICT support. People barriers: lack of business incentives, poor ICT strategies, lack of education/training/continuous professional development, cultural issues, reluctance to changes in business processes.

On the other hand, the importance given to ICT training, re-design of current processes and support from software vendors appeared as the most critical factors for successfully implementing ICT (Isikdag et al., 2008). Technology barriers: difficulties in using new technologies, lack of support from ICT providers (or ICT department), incompatibility. interoperability problems: lack of (use of) standards, inefficient use of software, ill-defined processes and infrastructure related problems. Legal barriers: risks for liability, lack of legal support for use of ICT, security of ICT transactions, other issues for electronic information and documentation.

2.13 SUMMARY OF CHAPTER TWO

The presentation so far has discussed literature on major applications, importance and barriers to the use of digital transformation including a brief discussion on contractor organizations in the Ghanaian construction industry. Drawing from that, the section will focus on the research methodology adopted.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This section now introduces and discusses the research outline and the methodology adopted for the study following the literature review presented in Chapter two (2). A number of processes are involved and discussed in this research. In concluding the chapter, a summary of the statistical technique used in analyzing the data is also presented.

3.2 RESEARCH STRATEGY/APPROACH

A quantitative strategy was adopted in this research due to the fact that quantitative research follows a deductive approach in relation to theory and is concerned with the design measurement and sampling (Naoum, 2002). The strategy employs the use of statistical techniques to identify facts and casual relationships. Quantitative research is also objective in nature and based on testing a hypothesis or theory composed of variables (Naoum, 2002). Frechtling and Sharp (1997) as cited by Naoum (2002), characterized the common data collection techniques used in quantitative research as questionnaires, tests and existing databases. Hard and reliable data are often collected in quantitative research and therefore emphasizes on quantification. The question, which this research sorts to explore was on the readiness of contractors towards digital transformation and the effects of communication on the success of construction projects.

3.3 DATA COLLECTION METHOD

In order to achieve the aim and objective of the study, well-structured close-ended questionnaires were constructed to gather information from class D1K1 to D4K4 contractors registered with the Ghana Association of Building and Civil Engineering Contractors, Accra. The questions were ethical and feasible.

The wordings were without bias and the questions provided multiple-choice options which gave the respondents the opportunity to present their ideas by way of selecting from the options provided. Close-ended questionnaires were used because they are easy for respondents to answer and it helps researchers analyze their data easily (Glasow, 2005).

3.4 RESEARCH DESIGN AND ITS JUSTIFICATION

The design of the research involved the following steps

1. Questionnaire design
2. Sampling technique/Sample Selection
3. Determination of sample size
4. Pilot Questionnaire
5. Main Questionnaire administration
6. Data Analysis tools

3.4.1 The Questionnaire Design

Based on the current literature review and research objectives, a structured questionnaire was prepared and self-administered to the various respondents. All questionnaires have closed-ended questions to ensure consistency of respondent feedback.

For the purpose of the study, questions were grouped under five main sections.

1. Background of respondent
2. Background knowledge
3. ICT infrastructure status
4. Level of usage of information and communication technology
5. Reason hindering the use of Digital Transformation in Your Organisation

Section A, “Background of respondents” dealt with the demographics with respect to the construction firm’s financial class, years of experience in construction, professional background of respondents and educational qualification. This aspect was considered necessary in order to ascertain the reliability and credibility of the data received. Section B “Background Knowledge” asked more specific questions in relation to the respondents’ knowledge on the subject matter. This aspect covered the number and types of construction projects undertaken, the respondents’ knowledge on the concept of digital transformation, the extent to which digital transformation is being used in the organization and how they perceive the role of digital transformation with respect to the overall business strategy. Section C “Firms’ ICT infrastructure status” enquired more the types of objective of this study. This aspect covered firms’ ICT hardware platforms, software in use, operating systems, communication and network platforms and ICT workforce. Section D “Level of usage of Information and Communication Technology” investigates about the level of ICT usage by the firms. This is in relation to proportion of tasks and activities carried out digitally or by the computer and usage of ICT tools and applications within the construction firms. It employed the five-point type Likert ordinal scale to measure the level of usage by responding firms from “Never” to “Always”. That is, 1=Never, 2=Not always, 3=Average, 4=Quite always, 5=Always. The final Section E, “Factors hindering ICT usage” asked responding firms to identify reasons hindering the use of digital transformation by contractors in the construction industry.

3.4.2 Sampling Technique Used

Chien (2010) citing Naoum (1998) indicated that there are two main criteria that to be taken into account when selecting the research sample. First, what the researcher wants to know? Second, about whom do you want to know it? Following these recommendations, the study adopted purposive sampling technique to select contractors and respondents.

This was preferred because purposive sampling allows the researcher to select respondents who have good knowledge about the subject in question. Besides, looking at the nature of the industry, the study seeks to solicit information from a section of the population of contractors in Ghana who by virtue of their financial class and nature of works have the capacity and requisite personnel to invest and use ICT for their operations. This resulted in the selection of contractors in financial Class D1K1 to D4K4. Again, the identification of key respondent to the questionnaires was purposive. This was important because the study wanted to elicit. This was important because the study wanted to elicit views of respondents who have specific expertise and hence may require specific ICT software for their operations. It targeted construction professionals such as Contractord, Project Managers, Architects, Quantity Surveyors, Engineers and IT managers working in a contractor organizations in Ghana.

3.4.3 Determining Population and Sample Size

Israel (1992) cited several approaches used in determining the sample size for a study. These, include using a census for small populations, imitating a sample size of similar studies, using published tables, and lastly applying formulas to calculate a sample size. Donkor (2011) revealed that over seventy percent (70%) of Ghanaian contractors tend to operate officially in the Greater Accra and Ashanti Regions and therefore contractors in any of these two areas could be considered for the research. Due to time limitation and financial constraints the study was focused on only contractors in the Greater Accra Region. A list of registered local contractors with the Association of Building and Civil Engineering Contractors of Ghana, Accra, was obtained and used for the research. The list obtained from the Association had a total number of one hundred and twenty-seven (127) contractors in good standing with the Association in the Greater Accra metropolis. Out of this total population, the sample size was calculated using the Yamane formula.

Using Yamane (1967) Formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where;

n = sample size, Unknown

N = Population size, 127

e = level of precision, $\pm 10\%$

$$n = \frac{127}{1 + 127(.10)^2}$$

$$n = \frac{127}{2.27}$$

$$n = 55.94$$

Therefore sample size (n) = 56

Table 3.1: Distribution of Questionnaires

CONTRACTORS	QUESTIONNAIRES:ALLOTTED
D1K1 – D4K4	56
TOTAL	56

Source: Field Survey, 2019.

3.4.4 Pilot Questionnaire

Before the main survey was undertaken, a sample form of the questionnaire was piloted in one of the construction companies in Spintex (Wilkado Construction Works Limited). This pilot study

was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguity and also provide an indication of the time to complete the questionnaire.

Some of the comment and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

3.4.5 Main Questionnaire Administration

The administering of the questionnaire began in the first week of August 2019 and completed in the third week of August 2019. A period of two weeks was given for the administration of the questionnaire. However, all the completed questionnaire were retrieved by the 21st of August, 2019. A total number of fifty-six (56) questionnaires were administered to the various contractors in D1K1 to D4K4 financial class. A total of seven (7) respondents was received from D1K1 contractors, nine (9) respondents from D2K2 contractors, twenty-three (23) respondents from D3K3 and twelve (12) respondents from D4K4 contractors representing 91% of respondents retrieved. The total administered questionnaires and the return rate are shown in Table 3-2.

Table 3.2: Detail of Questionnaires Administered and Returned

NO.OFQUESTIONNAIRE SENT				
56				
No.ofRESPONDENTS	D1/K1	D2/K2	D3/K3	D4/K4
51	7	9	23	12

Source: Field Survey, 2019.

3.5 DATA ANALYSIS TOOLS

Data collected from the questionnaires were analysed using two methods which were the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel.

3.5.1 The Ranking Criteria of One Sample T-Test

The One-sample T-test compares the mean score found in an observed sample (sample mean) to a hypothetically assumed value and establishes whether the sample mean is significantly different from a hypothesized mean. Typically, the hypothetically assumed value is the population mean.

By the central limit theorem, a normal distribution can be assumed when the sample size is more than 30 (Hair et al., 1998). Therefore, with a sample size of 56 it can be assumed that, the underlying suppositions of the central limit theorem were applied and that, the sample size is relatively adequate for use in this statistical inference. Typically, a one sample t-test reports on the mean of the test group, degree of freedom for the test, the t-value (which is an indication of the strength of the test) and the p-values (which is the probability value that the test is significant) (Reymont and Joreskog, 1993; Hair et al., 1998; Field, 2005). With the use of SPSS, a statistical analysis was performed to determine whether the population agreed on a particular factor as a strong reason or not. The t-test analysis is from SPSS usually produces two reports, namely, the one sample statistics and the one sample test showing test significance.

3.5.2 Frequency Analysis

Here, descriptive statistical methods such as tables, bar charts and pie charts were used to analyse the responses from the questionnaire.

3.5.3 Mean Score

This was used to generate ranking of the variables of interest based on the scores assigned by the respondents. The factors are then ranked according to the formula below using Microsoft Excel.

The mean score is calculated as follows:

$$\text{Mean score } (I) = \frac{\sum a_i x_i}{\sum x_i}$$

$$\sum x_i$$

Where I = Mean Score,

a = Rank of event

i and x = frequency of event i

According to (Egbu and Botterill, 2002; McCaffer and Edum Fotwe, 2001) the formula is very common with researchers in the construction management field.

With this formula, the events measured here include: activities Computerized within the firms and their level of usage of ICT applications.

3.6 SUMMARY OF CHAPTER THREE

Indeed, the chapter has comprehensively described the entire research design and the methodology for the study. Following this, the design of the survey instrument including the sampling frame, the sample size, techniques for eliciting the relevant data and how the data will be analyzed have been described.

The next chapter now discusses the analysis of the data and findings from the survey.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents data analysis and findings from the survey. It begins with descriptive analysis of the demographics variables of participating firms and respondents. This is followed by analysis of the firms' ICT infrastructure status and current levels of ICT usage. Finally, the section discusses result from one sample T-test on identified factors hindering the use of digital transformation by Ghanaian contractors. The main statistical methods and tools used were Mean Score and the One Sample T-test on identified factors hindering the use of digital transformation by Ghanaian contractors. The main statistical methods and tools used were Mean Score and the One Sample T-test. Data collected from the questionnaires were tabulated and analysed according to their ranking on relative important index. Bar and pie charts created were appropriate, in support of the descriptive analysis to clarify their status.

4.2 THE SURVEY FINDINGS

4.2.1 Demographic Variables and Respondents Profiles

With the fifty-six (56) questionnaires, which were administered to the contractors in the class of D1K1 to D4K4. A total number of fifty-one (51) were returned constituting 91% of the total response rate. Table 4.1 below shows the breakdown of the number of response received from the selected organizations. Seven (7) questionnaires were received from D1K1 contractors, nine (9) from D2K2, twenty-two (22) from D3K3 and twelve (12) from D4K4 were received respectively.

Table 4.1: Details of Response Rate

CONTRACTORS	RECEIVED
D ₁ K ₁	7
D ₂ K ₂	9
D ₃ K ₃	23
D ₄ K ₄	12
TOTAL	51

Source: Field Survey, 2019.

Regarding the firms' working experience surveyed, Figure 4.1 shows that 12% had worked as contractors in the construction industry for over 20years, 14% between 15 – 20 years, 37% between 10 – 15 years, 24% between 5 – 10 years and 14% between 0 – 5 years. The highest representation of 63% firms with experience of over 10 years is significant to provide some understanding about their ICT challenges over the past periods. Figures rounded over to the nearest digit.

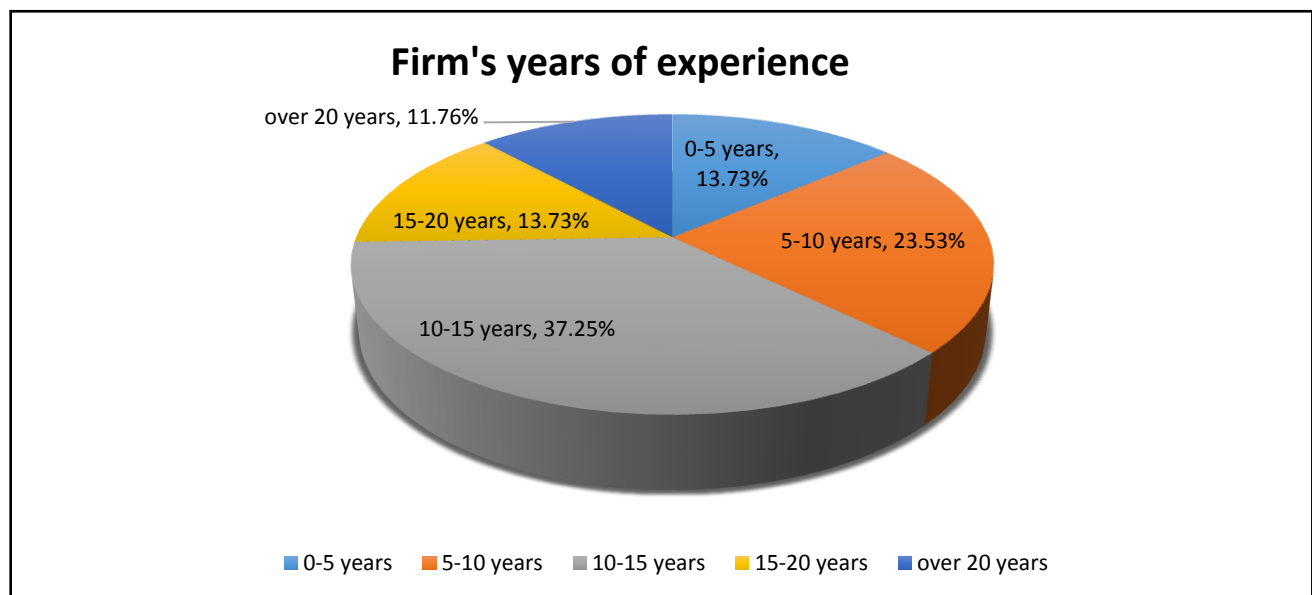


Figure 4.1: Company experience

Source: Field Survey, 2019

Again, the data analysis revealed that varied professional backgrounds in the contractor's organizations were represented in the survey. According to Table 4.2, the backgrounds of respondents comprised of 12 Contractors (23.53%), 6 Project Managers (11.76%), 1 IT Manager (1.96%), 5 Architects (9.80%), 15 Engineers (29.41%), 6 Quantity Surveyors (11.76%), 5 Site Supervisors (9.80%) and 1 Project Coordinator and Administrator (1.96%). The high representation of Contractors, project managers, Engineers and Quantity Surveyors was inevitable as these are the very key professionals usually engaged by contractor organizations in Ghana. Of them, Fig. 4.1 indicated that, the majority of 52.94% had experience of between 5 – 10 years in the construction industry, Over 25% also indicated that they have experience less than 5 years, while about 9.80% had professional experience between 10 – 15 years and other 7.84% had experience over 15 years.

Table 4.2: Respondents' professional background

Professional Background	Percentage of Respondents
Project Coordinator & Administrator	1.96%
Site Supervisors	9.80%
Contractors	23.53%
Project Managers	11.76%
IT Managers	1.96%
Architects	9.80
Engineers	29.41%
Quantity Surveyors	11.78%

Source: Field Survey, 2019

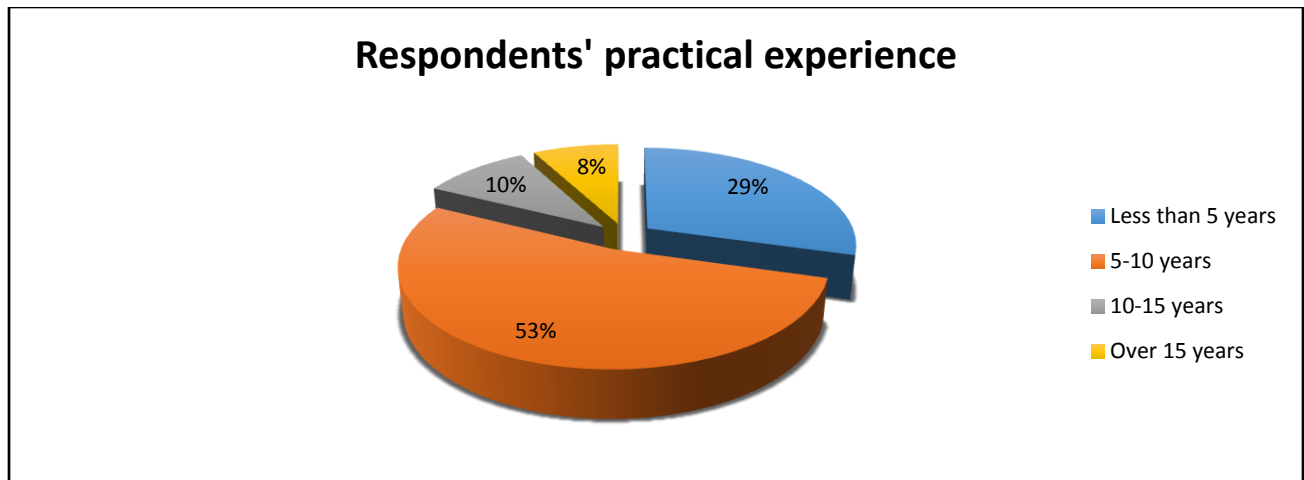


Figure 4.2: Respondents' practical experience

Source: Field Survey, 2019.

Respondents from the survey shows that 58.82% of the firms are Private Limited Companied, 13.73% respondents firms are Partnership, 25.49% are Sole proprietorships and 1.96% a Public Limited Company.

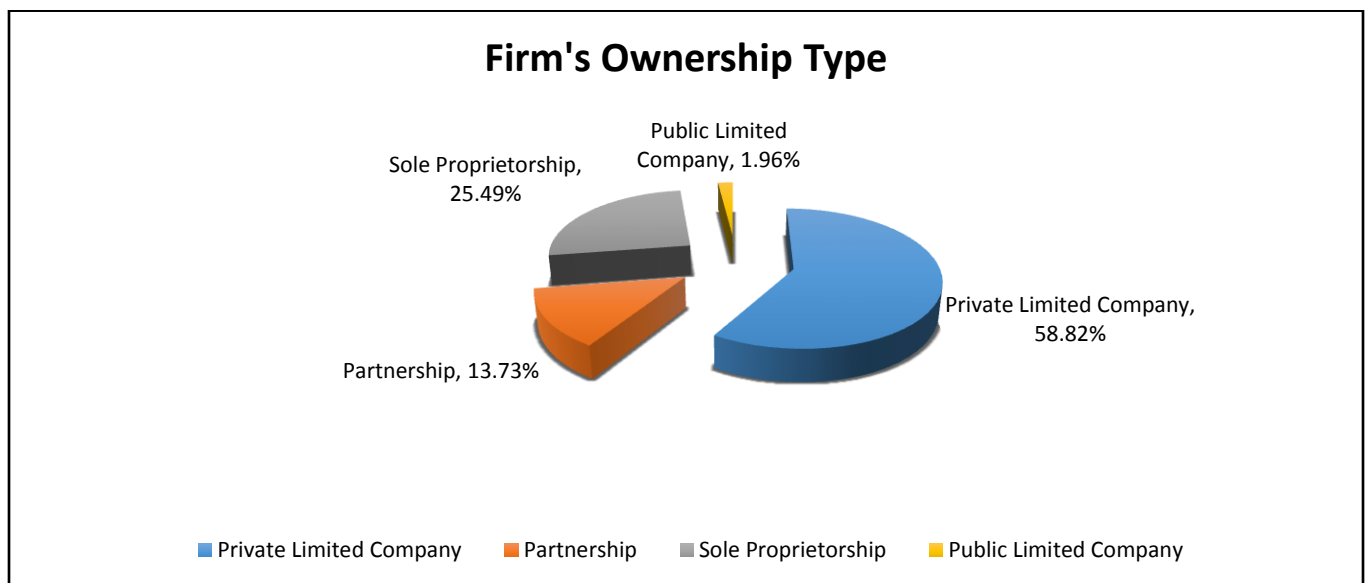


Figure 4.3: Firm's ownership type

Source: Field Survey, 2019.

4.2.2 To Assess The Current Use of Digital Transformation Tool in the Construction Firms in Ghana.

Part of the questionnaire sought respondents' perception on the concept of digital transformation in their firms. From Fig. 4.4 below, it can be deduced that the contractor's knowledge on the concept of digital transformation was high (Schallmo et al., 2017). The majority of the firms (86%) have an idea about the concept of digital transformation whereas (14%) which represents the minority have no knowledge on the concept.

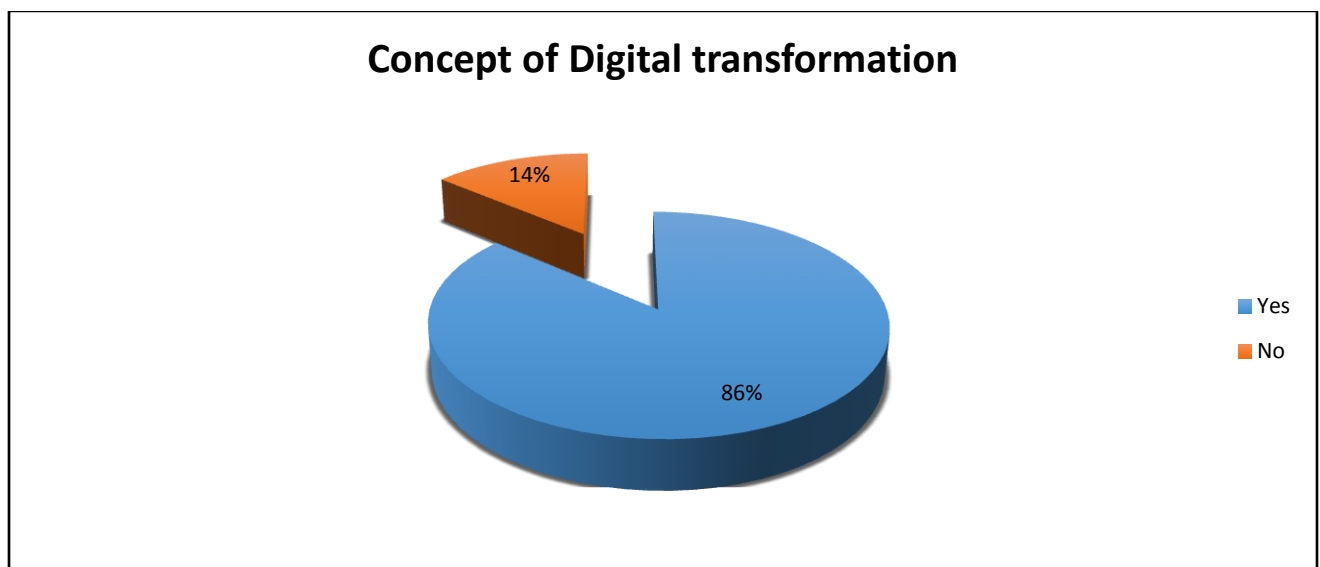


Figure 4.4: Respondents' concept of digital transformation

Source: Field Survey, 2019.

On the issue of respondents' viewpoint on the extent of current usage of digital transformation in their firms, Table 4.3 shows a high percentage of (57.14%) respondents who believe their current usage of ICT is average which 19.64% consider their ICT usage as low. Only (23.21%) thought they are using ICT to a high extent in their firms. Given the perception of the respondents, there is some level of recognition that their current ICT usage appears ordinary suggesting some aspects for improvement.

Table 4.3: Respondents' view on the extent of ICT usage in their firms

	No. of Respondents	High	Medium	Low	Total
Contractors	51	21.57%	56.86%	21.57%	100.00%

Source: Field Survey, 2019.

In addition, a portion of the questionnaire required respondents' perception on the role of digital transformation in their firms. From Fig. 4.5 below, it can be realized that the contractors' perceived role of digital transformation in their firms were varied. It is however surprising to note that, the majority of the firms (50.98%) see the role of digital transformation as supporting compared to a more strategic roles of values adding (27.45%) and critical (21.57%) (Isigdad et al., 2007).

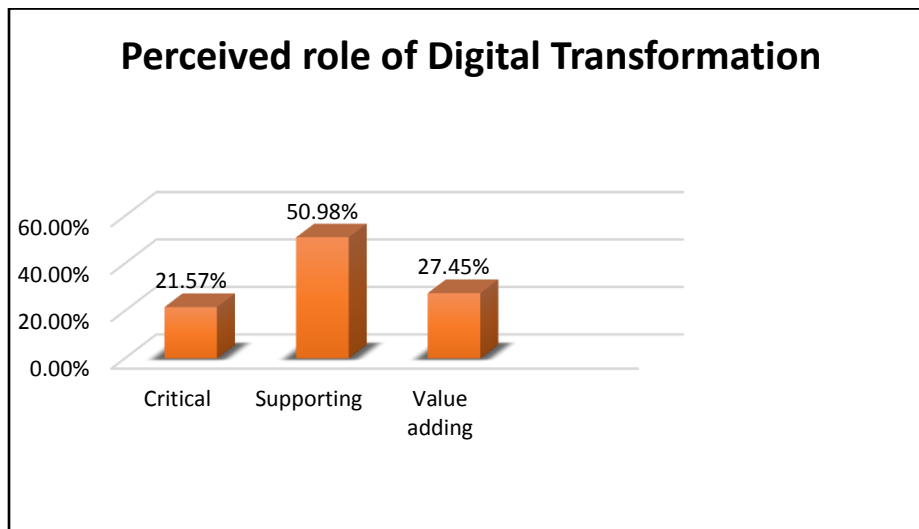


Figure 4.5: Perceived role of digital transformation

Source: Field Survey, 2019

4.3 FIRMS ICT INFRASTRUCTURE PLATFORMS

In this part, respondents answered questions on the types of ICT hardware infrastructure, operating systems, communications and network infrastructure, ICT workforce and the average staff ratio in their organizations.

4.3.1 Firms ICT Hardware Status

Referring to Table 4.4 below, all the contractors surveyed 100% use both desktop PC and mobile phones in their firms. Also over a third of the companies 79.27% indicated that, they use Laptops in their organizations and 60.50% of the contractors use digital cameras respectively. Mobile ICT hardware's such as Personal Digital Assistance (PDAs) and Tablet PCs are used by 18.60% and 39.50% of the respondents respectively. Additionally, multimedia projectors are used by 44.20% of the contractors. Drones seem not to be popular and covered only 2.3% of the total respondents from D1K1class.

Table 4.4: Types of ICT hardware infrastructure in use

	No. of Respondent	Desktops	Laptops	PDAs	Tablets PCs	Mobile Phones	Digital Cameras	Multimedia Projectors	Drones
Contractors	51	100%	79.27%	18.60%	39.50%	100%	60.50%	44.20%	2.3%

Source: Field Survey, 2019.

Moreover, result from the data analysis also shows that, the three most common windows operating system in use are Microsoft windows, Google Android Operating System and Apple Operating System. Majority of the firms were using Microsoft windows 52.6% while Google android OS and Apple OS were used by 28.8% and 18.6% respectively.

Questions were also included to assess why the choice of the particular operating system. Data analysis showed that, respondents' use of these operating systems was based on preference. As indicated in Table 4.5, about 50.98% of the contractors choose their operating system were based on availability in the market, while 33.33% were based on familiarity, how conversant contractors are with the operating system. Other considerations for the choice of windows operating systems as identified by the respondents were in terms of cost, which is 15.69%.

Table 4.5: Reasons for choice of particular operating system

	No. of Respondents	Availability	Cost	Familiarity	Total
Contractor	51	50.98%	15.69%	33.33	100%

Source: Field Survey, 2019.

4.3.2 Communication and Network Platforms

The ability to exchange data between the project team in a building project both within and outside depends on the organisations communication platforms. The study wanted to know the contractors current network platforms as the basis of their ability to communicate electronically within their firms and externally. In general, the survey revealed an impressive response of computer networking within the contractor organizations. As shown in Table 4.6 below, 74.51% of the firms have networked the computers in their companies. This shows that, only 25.49% of the computers in the respondent's organisations are networked (Oesterreich and Teuteberg, 2016).

Table 4.6: Network of computers (LAN/WAN) in firms

	No of Respondents	Yes	No	Total
Contractors	51	74.51%	25.49%	100%

Source: Field Survey, 2019.

The use of electronic mail and access to the internet in the contractor organizations was found to be quite high. This tends to support earlier reports that the internet connectivity and the general use of email and World Wide Web is viewed as being substantially high in the construction industry (Becerik, 2004)

The electronic mail and the internet represent the basic technologies required for accessing the World Wide Web and electronic communication between businesses and customers. On an average, e-mail usage for official communication by the contractors is about 84.06%, while social networking tools are used by 50.72%. Only 21.74% and 8.70% of the respondents use video and conferencing tools and collaborative tools for their daily businesses communication. Again, access to the internet used by the firms was very predominant as 97% of contractors have access to internet and the remaining (3%) do not use internet in their organization (Rivard, 2000).

Table 4.7: Communication tools used

ⁱ	No. of Respondents	Emails	Video and web conferencing	Social Networking tools	Collaboration tools
Contractors	51	84.06%	21.74%	50.72%	8.70%

Source: Field Survey, 2019.

Table 4.8: Internet used

	No. of Respondents	Yes	No	Total
Contractors	51	97%	3%	100%

Source: Field Survey, 2019.

With regard to where is accessed by the companys staff, the study revealed that (29.41%) of the firms have access to internet at their offices only, while 60.78% indicated they have access to the internet at both their offices and project sites through wireless networks only (9.80%) have internet only at their project sites. On the issue of the companies with a page on the World Wide Web (WWW), the study also shows that more than half (70%) of the firms have company websites address for external links with the rest of the world. From the above, it can be concluded that, firms integration through internal network of computers (LAN) in the individual companies is very high, usage of the internet and email for official communication and collaboration with external partners also appear very high (Schallmo et al., 2017).

Table 4.9: Access to internet in the organisation

	No. of Respondents	Company Offices only	Project sites only	Both in offices And project sites	Total
Contractors	51	29.41%	9.80%	60.78%	100%

Source: Field Survey, 2019.

Table 4.10: Company page with World Wide Web

	No. of Respondents	Yes	No	Total
Contractors	51	80.39%	19.61%	100%

Source: Field Survey, 2019.

4.3.3 Personnel Handling ICT in the Firms

The section identified personnel handling ICT related works within the contractor's organizations. The average computer to employee ratio and types of ICT services provided in-house and those services out-sourced were also identified. According to the survey, ICT related works in the organizations were mainly handled by the technical staff at the company offices and project sites. Table 4.11 concluded that, the average number of computer to staff ratio within the firms is about one computer to one employee (1:1) and a majority of 76.4% of the respondents confirmed this. Only (11.76.4%) were using computer at a ratio of two employees to one computer (2:1) and three employees to one computer (3:1)

Table 4.11: Current average staff to computer ratio

	No. of Respondents	1:1	2:1	3:1	Total
Contractors	51	76.47%	11.76%	11.76%	100.00%

Source: Field Survey, 2019.

The study further revealed that (Fig 4.6), about (80%) of the companies have separate IT division in their organization. A separate IT division within the organization provides an indication of the extent

of use of information and communications technology for the day-to-day activities of those organizations.

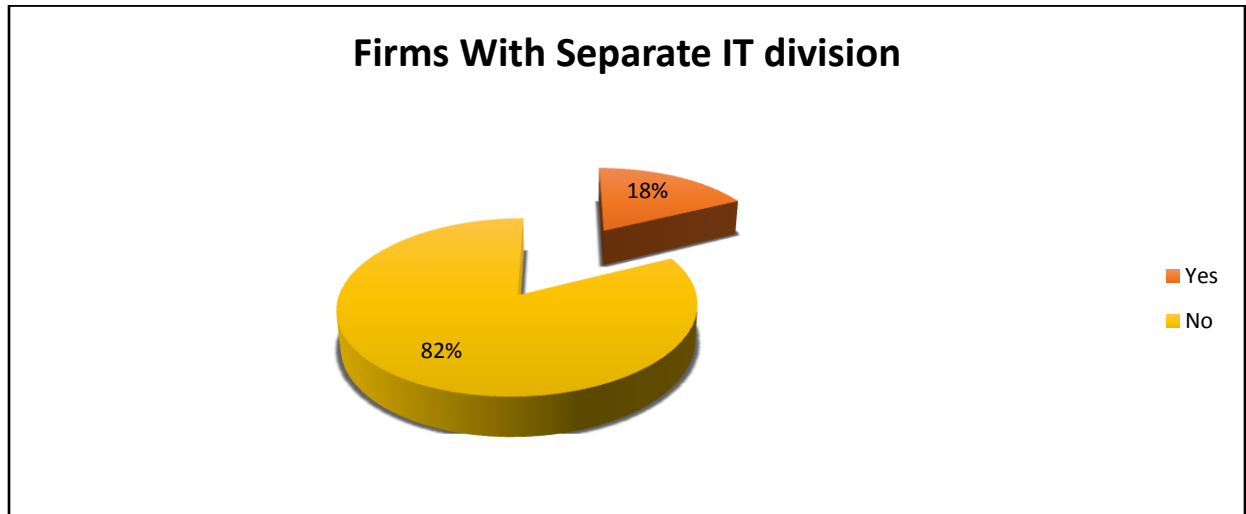


Figure 4.6: Firms with separate IT Division

Source: Field Survey, 2019.

Fig4.7 below shows the extent of IT support services provided in-house and those outsourced.

The respondents indicated that their firms obtain technical support services from the IT division within the organization while some IT services are outsourced to companies specializing in these services. Of those with separate IT division, the main services provided are internet and e-mail support (78.21%) followed by Networking which constitutes (18.91%) of the total respondents.

On the other hand, services generally out-sourced include internet and e-mail support 46.08%, software maintenance (41.90%) and Database maintenance (23.60%).

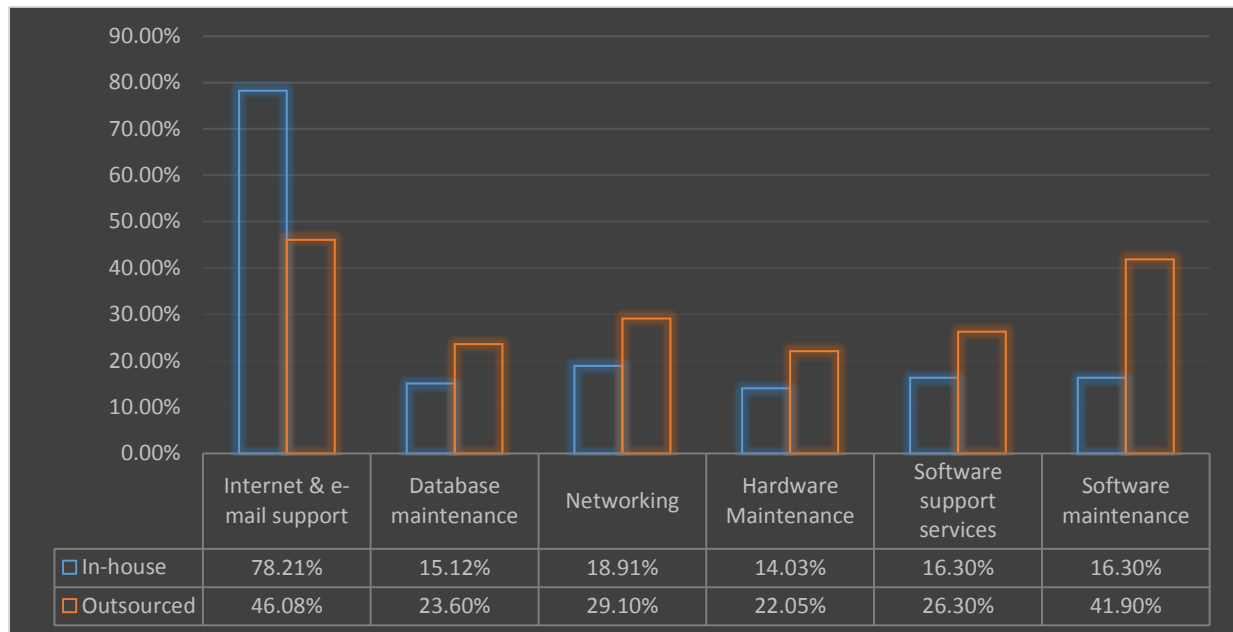


Figure 4.7: Services provided in-house and those out-sourced

Source: Field Survey, 2019.

From the results above, it can be concluded that internet and e-mail support are the main services provided by the in-house IT divisions, while other specialized services such as database maintenance, networking, hardware maintenance and software support services are mainly outsourced.

4.4 ANALYSIS OF FIRMS LEVEL OF USAGE OF ICT

This section analyzed the level of computerization of the contractor's operations/activities including extent of usage of some advance ICT tools and applications. The statistical analysis employed in this situation is the mean index score. In order to determine the degree usage of ICT for the contractor's operations, the following classification of the ratings on the Likert scaling as were used (Majid, 1997; Aminudin, 2006) where,

Never Computerized/Used:	$1.00 \leq \text{mean score} \leq 1.80$
Not always Computerized/Used:	$1.81 \leq \text{mean score} \leq 2.60$
Average Computerized/Used:	$2.61 \leq \text{mean score} \leq 3.40$
Quite Always Computerized/Used:	$3.41 \leq \text{mean score} \leq 4.20$
Always Computerized/Used:	$4.21 \leq \text{mean score} \leq 5.00$

Table 4.12: Activities computerized

Activities	Mean	Std.Deviation	Ranking
Technical calculations	5.0000*	0.9716	1
Project drawings	4.6181*	0.6523	2
Project (costing/budgeting/estimating)	4.1818*	0.8626	3
Project records	4.0892*	0.9775	4
Distribution of project document	3.9090*	1.2907	5
Scheduling and works planning	3.9024*	1.1576	6
Communication with project sites and external)	3.7500*	1.3760	7
Subcontractors and supplier's information	3.5208*	1.3044	8
Purchases and invoicing (Supply chain)	3.4791*	1.2880	9
Resources management	3.3043*	1.3311	10
(labour/materials and equipment)			
Site management and security	2.9791*	1.4065	11
Average mean:	3.8849***		

Source: Field Survey, 2019.

From the table (4.12) above, it is apparent that the mean response rating for most of the contractor's main operations was above average with an overall average mean score of about 3.88. Of the 11 activities stated above, more than half (7) had a standard deviation greater than 1.0.

This is an indication that, more than half of the respondents, had variations in the rating of their level of computerization of their activities while the remaining (4) had a standard deviation less than 1.0 indicating some level of agreement among the respondent's rating.

According to the survey, the most prominent activities highly computerized/digitize in the respondent's organizations are Technical calculations with a mean (5.00*), Project drawing mean (4.62*) and Project (costing/budgeting/estimating) mean (4.12*).

The trend further shows that, computerization of activities such as Project records (mean=4.10*), distribution of project drawings (mean=4.00*) and scheduling and works planning (mean=4.00*) are all above the average value of 3.88. The moderately computerized activities identified by the contractors are Communication with project site and external (mean= 3.75*), subcontractors and suppliers information (mean – 3.52*), and purchasing and invoicing (mean – 3.50*), while operations and activities such as resources management such as labour/materials and equipment has a (mean = 2.98*), were the least rated.

Based on the findings presented above, it is rational to infer that, digitization of the contractor's main business activities in a developing country like Ghana appears quite high (Molla and Heeks, 2007).

4.4.1 Level of Usage of Advanced ICT Tools and Applications

Table 4.12 below provides a range of ICT tools and application and the mean index score Of the contractor's level usage. Mean ratings on the level of usage were calculated based on a Scale of 1-5 (from "Never" to "Always").

Table 4.13: Usage of advanced ICT tools and application

ICT application	Mean	Std. Deviat	Ranking
Email & Short Message Service (SMS)	3.3818*	2.1472	1
Mobile Internet	2.9090*	2.0391	2
Modeling and visualization Technologies (eg.3D-Cad)	2.7818*	2.1229	3
Building Information Modeling (BIM)	2.2857*	1.9420	4
Electronic Document Management System (EDMS)	2.2363*	1.9241	5
Site Surveillance Technologies (eg. CCTV)	2.1607*	1.4113	6
Project specific website/Extranet	2.0727*	1.5617	7
Electronic Purchasing (E-purchasing)	2.0714*	1.3053	8
Electronic Tendering	1.8545*	1.5446	9
Integrated software (Enterprise Resource Planning)	1.6607*	1.4805	10
*Average Mean	2.3414** *		

Source: Field Survey, 2019.

By considering usage the range of emerging digital transformation tools, the study revealed that current level of usage by the firms largely below average (average mean of 2.34*). According to the data, the most prominent ICT application tool used was Email and Short Message Service (SMS) mean =3.40* and mobile internet (mean = 3.00*). Apart from these technological tools, which were significantly above average, data analysis revealed that the contractor's usage of the other ICT tools and applications are generally deficient.

For instance, usage of applications such as Modeling and visualization technologies, eg. 3D-CAD, mean=2.78), Building Information Modelling (BIM) mean = 2.28*, Electronic Document Management System (EDMS) (mean = 2.23*), Site Surveillance Technologies (CCTV) (mean=2.16*), Electronic Purchasing (mean = 2.23*), Project Specific Website/Extranet (mean = 2.07), were found to be very inadequate. Besides, other tools and applications such as Electronic Tendering (mean = 1.85) and Integrated Software (Enterprise Resource Planning) (mean = 1.66*) were basically not used.

Data from the results shows that, it is acceptable to conclude that more advanced and newer technologies are poorly utilized by contractors in Ghana, The findings suggest that, while there is some level of awareness about these technologies, the motivation for usage is lacking due to both internal and external constraints.

4.4.2 Construction Softwares in Usage

The survey examined the contractor's usage of commercially available software applications including those softwares designed specially for use in-house. According to table 4.14, the survey results clearly show that, the highest construction software that contractors use in the Autodesk BIM 360 (33.33%), almost (21.57%) of contractors do not use any of the softwares listed above. Aside Coconstruct, PlanGrid e-builder, which was used by 9.8%, 7.84% and 5.88% of the respondents, the remaininig softwares are less in use.

Obtaining from the above results, it is possible to conclude that more advanced and newer construction softwares are poorly utilized by contractors in Ghana (Sekou, 2012). The findings suggest that, while there is some level of awareness especially with the Autodesk BIM360, the remaining softwares have low publicity and the motivation for usage is lacking due to both internal and external constraints.

Table 4.14: Usage of construction software

Construction Software	Percent usage by respondents
Autodesk BIM 360	33%
Procore	4%
E-builder	6%
Corecon	4%
Coconstruct	10%
STACK	6%
PlanGrid	8%
Wrike	8%
None	21%

Source: Field Survey, 2019.

4.5 Analysis of Factors Hindering Use of ICT by the Contractors

As indicated earlier, the one sample t-test was employed in the analysis of this data. This statistical tool was employed basically to ascertain the significant and most important reason hindering ICT usage by contractors. With reference to the 5-point Likert rating scale adopted, ratings of 4 and 5 representing strongly strong reasons respectively. By that, the population mean μ_0 was set at an appropriate level of 3.0 (Oyediran, 2006) and the significant level was also set at 90% in accordance with expected risk levels (Cohen, 1992)

Therefore, based on the five-point Likert rating scale, a factor was considered critical if it had a mean of 3.0 or more. Where two or more criteria have the same mean, the one with the lowest standard deviation was assigned the highest importance ranking (Field, 2005). The standard error is the standard deviation of sample means and is a measure of how representative a sample is likely to be to the population.

A large standard error suggests that there is a lot of variability between means of different sample. A small standard error suggests that most sample means are similar to the population mean and so the

sample is likely to be an accurate reflection of the population. Clearly, the standard error for all the means is in the close of Zero which indicates that the sample chosen is an accurate reflection of the population (Table 4.15)

Table 4.15: Results of T-Test showing one-sample statistics

FACTORS HINDERING THE USE OF DIGITAL TRANSFORMATION	N	Mean	Std. Deviation	Std. Error Mean
Management Constraint	51	3.5294*	1.34689	.18860
Financial Constraint	51	3.6078*	1.21784	.17053
Human Resource Constraint	51	3.3333*	1.33666	.18717
Technical Constraints and support	51	3.4902*	1.22266	.17121
Legal constraints towards ICT investment	51	2.2941*	.98578	.13804
*Mean > 3.0 (Population mean)				

Source: Field Survey, 2019.

From the results in table 4.15 above, it can be observed that almost all variables had standard deviation values of more than 1.0. This provides the indication that, the respondents had different interpretations for the factors. Nevertheless, only one (1) of the factors had its standard deviation value less than 1.0, suggesting some level of agreement among respondents in how those were interpreted.

Table 4.14 below displays the significance (i.e. p-value) of each factor. This test (P-value) was conducted on each factor to identify significant factors hindering usage of ICT by the contractors.

This then provides a basis for a statistical decision to be made as to whether or not the population mean and sample mean are equal. The significance values (p-value) provided in Table 4.14 for a two-

tailed test. Since our interest is for one-tailed test, where we look for only sample mean greater than the population mean (i.e. $U > U_0$), the significant value (“Sig”) in Table 4. Has been divided by two and the results displayed in table 4.15.

Table 4.16: Results of one sample test showing test significance

	Test value=3.0					
FACTORS HINDERING THE USE OF DIGITAL TRANSFORMATION	t	N	Sig. (2-tailed)	Mean Difference	90% Confidence Interval of the differ	
					Lower	Upper
Management Constraint	2.807	50	.007	.52941	.1506	.9082
Financial Constraint	3.564	50	.001	.60784	.2653	.9504
Human Resource Constraint	1.781	50	.081	.33333	-.0426	.7093
Technical Constraints and support	2.863	50	.006	.49020	.1463	.8341
Legal constraints towards ICT investment	-5.114	50	.000	-.70588	-.9831	-.4286
*Mean > 3.0 (Population mean)						

Source: Field Survey, 2019.

Table 4.17: Results of one sample test showing test significance

	Test value=3.0					
FACTORS HINDERING THE USE OF DIGITAL TRANSFORMATION	t	N	Sig. (1-tailed)	Mean Difference	90% Confidence Interval of the difference	
					Lower	Upper
Management Constraint	2.807	50	.0035	.52941	.1506	.9082
Financial Constraint	3.564	50	.0005	.60784	.2653	.9504
Human Resource Constraint	1.781	50	.045	.33333	-.0426	.7093
Technical Constraints and support	2.863	50	.003	.49020	.1463	.8341
Legal constraints towards ICT investment	-5.114	50	.000	-.70588	-.9831	-.4286
*Mean > 3.0 (Population mean)						

Source: Field Survey, 2019.

4.5.1 Interpretation of Results

Referring to the summary of results in Table 4.17 above, it can be gathered that the most important factors from the study are: Financial constraints for the use of digital transformation investments (Mean =3.5294), Technical constraint towards digital transformation (Mean -3.4902), Human resource constraint towards digital transformation content of construction education (Mean = 3.3333), and Legal constraint towards digital transformation (mean =2.2941).

However, despite the importance of these factors, Table 4.17 revealed that the most significant ones among them as reasons hindering the use of digital transformation by the contractors are:

1. Financial constraint
2. Management constraint
3. Technical constraint
4. Human Resource constraint
5. Legal constraint

It is important to note that, whereas Budget Constraints for ICT investments by firms (mean = 3.6078, P=0005) came out as the highest ranked factor, issues of Legal Constraints in digital technology investment (mean=2.2941, P=0.00000) was ranked the lowest in terms of the factors hindering ICT usage by the respondents.

This suggests that although workers resistance to ICT usage within the contractor organizations may appear significant, it was largely perceived by the respondents as not an important barrier to ICT usage.

The perception of the respondents also suggests that, their principal concern was budget constraint for ICT investments. This basically agrees with the growing challenge of inadequate funding for major investment activities by contractors in Ghana (Laryea, 2010). Generally, the cost of implementing ICT is a huge venture and involves both the cost of investments of ICT tools and at the same time the maintenance cost of tools.

By that, firms annual turnover and hence Project/Organisation budget have a great influence on the firms ICT status. Nevertheless, inspite of this difficulty in predicting cash flows by contractors due to

payment delays, high cost of capital and general lack of funding continue to be a major challenge to contractors in the Ghanaian construction industry (Laryea 2010).

Further reference to Table 4.17 shows that apart from the issue of financial constraints, management constraints towards digital transformation (mean = 3.5294, $P = 0.0035$). In addition, technical constraint support for digital transformation (mean = 3.4902, $P=0.0030$), human resource constraint (mean = 3.3333, $P=0.04$), and the legal constraint in ICT base (mean = 2.2941, $P=0.000$) were ranked 2nd, 3rd, 4th and 5th significant factors respectively.

The lack of commitment by firm's management towards digital transformation was ranked second at a significance of ($P=0.0035$). This brings to the realisation the need to recognize that, effective digital transformation tools will require management focus and leaderships commitment on both the technical and organisational aspects for its implementation and use. As a result, the focus on management support for digital transformation use in an organisation is therefore quite critical.

This may require the use of corporate power and motivational strategies to create an enabling environment for workforce to be committed to the organizational objectives in implementing and using ICT systems. By ranking the technical constraint for digital transformation as the third most significant factor ($P= 0.0030$), by and large agrees with studies such as (Songer et al. 2001; Weippert et al., 2002b). These studies found lack of training as a key barrier to adopting and using IT/ICT applications. Traditionally, the emergent problems in learning and training in the construction sectors are quite significant. This is due not only to the nature of the industry but also to a lack of familiarity with new methods of working. Since training in construction is of strategic importance, the creation of not merely learning organizations, but a "learning sector" is required. Beyond that, the result also confirms that, it is necessary to provide technical support for solving problems when using IT/ICT

applications in construction. It is therefore notable to justify training as an essential fact or for success of ICT implementation and usage.

4.6 SUMMARY OF CHAPTER FOUR

This chapter has presented the analysis of the data from the survey. The analysis is undertaken included descriptive on the demographic data, average index analysis on their level of ICT usage and one sample t-test on factors hindering their ICT usage. Findings suggest though there appears to be high level of awareness among respondents on ICT usage. Findings suggest though there appears to be high level of awareness among respondents on ICT generally, overall level of usage is still inadequate. Reports from the one sample T-test suggest that ICT usage is constraint to some extent by both internal and external factors. Following this analysis, results are hereafter presented with conclusions and recommendations in the next chapter.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 INTRODUCTION

This chapter summarizes the results from the research and draws conclusions from the collated data. It begins by summing up all the core issues discussed earlier in previous chapters including a recap of the key research questions. Afterward, a review of how the key objectives were satisfied and a summary of the results are described. Finally, conclusions are drawn and recommendations for action are also included.

5.2 SUMMARY OF THE RESEARCH

The research so far has presented the aim, objectives and the background problems that induced the formation of the theoretical framework as well as the research questions. Following this, a research methodology was consecutively adopted to answer the key objectives of the study as presented in the research analysis and findings. In addressing the aim and the objectives of the research, the main approach used was to review the readiness of contractors towards digital transformation literature. This was then followed by investigating the use and relevance of these findings in the Greater Accra metropolis of contractor organisations in Ghana through survey questionnaire. At the end of the empirical study, the level of the firms ICT infrastructure status, the extent of usage of digital technological tools and a set of reasons hindering the use of digital transformation reflecting the different perspectives of the contractors were appropriately established. The research came out with key findings some of which addressed the main aim and objectives.

As mentioned earlier in chapter one, this research was set out to identify the factors hindering the readiness of digital transformation by D1K1 to D4K4 contractors in Ghana. To achieve this, three research objectives were adopted in order to collectively satisfy this aim.

5.3 SUMMARY OF THE RESEARCH FINDINGS

The study produced some significant findings that are summarized below.

5.3.1 To Assess The Current Use of Digital Transformation Tool in the Construction Firms in Ghana.

Based on the review of data from literature, this aspect itemized 11 activities/operations of contractor organisations and 10 advanced ICT tools and applications. It analysed the level of computerization or digitization of these operations/activities and also the extent of usage of the advanced digital transformational tools and application using mean score. The findings have indicated a high ranking level of computerization/digitization of most activities and operations identified in this study. It revealed that activities related to Technical calculations, Project Drawings, Project costing/budgeting/estimating were rated as major activities performed digitally. Also the findings suggest that, computerization of activities such as Project records, Distribution of project documents scheduling and works planning, etc. were moderately high (see chapter 4, table 4-11).

Again, the findings have revealed that certain activities were not fully computerized in the contractors' organisations. These include activities such as Site management and security, Resources management (Labour/materials and equipment), Purchase and invoicing (Supply chain) were the least rated. Concerning the extent of usage of advanced ICT tools and applications by the contractors, the findings suggest that the contractors were quite deficient in their use of more advanced and emerging ICT tools and applications. Apart from the use of mobile internet and short message Service (SMS) which were sufficiently represented, exploitation of ICT tools

and applications such as Electronic Purchasing, Modeling and visualization (eg. 3D-CAD), Site Surveillance Technologies (e.g. CCTV), Electronic Tendering Electronic Document management systems (EDMS), were found lacking in the firms.

5.3.2 Objective 2: To Assess Information and Communication Technology Infrastructure of Local Construction Firms in the Financial Class in Ghana

As indicated previously, this research objective was achieved by a research framework drawn from the IT barometer surveys, 1999-2010 to cover firms ICT hardware, operating systems, software in use, communication, networks status and ICT workforce. Indeed, this objective was primarily pursued to assess the availability of these components as the foundation for effective implementation and use of ICT by the firms.

The findings have shown that, majority of the contractors in the survey use ICT and this reflected in the responds on their ICT infrastructure levels. Results from the investigation also identified a high usage of ICT hardware such as Desktop PC, Laptops, digital cameras and mobile phone among the contractors. However, most portable mobile ICT hardware such as Personal Digital assistance (PDAs) and Tablets PCs were found unpopular. With regards to the windows operating systems in use, Microsoft Windows, Google Android Operating System and Apple Operating System were the most accepted. Amongst them, Microsoft Windows was rated high followed by Android OS and iOS respectively. Interestingly, choice of these operating systems by the firms were mainly based on availability followed by its familiarity and then cost.

With regards to software application status, Autodesk BIM 360 was the most popular while other such as Conconstruct, PlanGrid etc. Surprisingly, the result also revealed that most of the firms do not benefit from the usage of computer aided cost estimating and quantity surveying software. The few software identified here were mainly based on self-developed excel spreadsheet applications.

On the issue of firms communication and network status, the study has found that usage of Local Area Network and Wide Area Network (LAN/WAN) for internal communication and data exchanges was very minimal. Internet access and e-mail usage by the firms was however found to be very prevalent through the use of wireless network connections and individual mobile. Most of the firms use internet at their company head offices and project sites through wireless networks. In addition more than half of the firms surveyed also have a page on the World Wide Web (WWW).

The study also revealed that, personnel handling ICT related works within the contractor organisations were mainly technical and administrative staff both the company offices and project sites. Most of the firms outsource their IT related services while about a third of the firms have separate IT division.

5.3.3 To Identify the Factors Hindering the Use of Digital Transformation by Contractors in Ghana

In fulfilling this objective, five (5) major factors affecting the use of digital transformation were drawn from literature. These factors were first tested among some professionals in the building construction firms in a preliminary survey to ascertain their relevance locally. The factors were then ranked by the survey respondents (building contractors) as per the ranking scale implemented for this study.

The results point to a number of key factors that prevent the extensive use of digital transformation by the contractors. These include: Financial constraints for digital transformation use (Mean = 3.6078), Management constraint towards the use of digital transformation (Mean = 3.5294). In addition, Technical constraint towards the use of digital transformation (Mean = 3.4902), human resource constraint (Mean = 3.33333) and Legal constraint (Mean = 2.2941) (chapter 4, Table 4-13).

Finally, a test for significance (see chapter 4, table 4-15) on the results has revealed that, the five most significant reasons hindering the use of ICT by building contractors in the Ghana include:

1. Financial constraint
2. Management constraint
3. Technical constraint

5.4 CONCLUSION

The following conclusions can be drawn from the study:

1. Despite the many challenges of the Ghana construction industry, Digital Transformation is well recognized by building contractors in Ghana as a significant technological spotlight that can help increase the effectiveness of communication and data during the construction process. The study has indeed revealed that, there is a significant level of awareness among the contractors about the potential benefits of digital technologies could offer to their operations. While the use of some selected ICT hardware, notably Desktop PCs, Laptops, digital cameras and mobile phones appears high, more advanced and portable mobile ICT hardware such as Personal Digital assistance (PDA) and Tablet PCs were found deficient.

In addition, general attitude by the firms towards ICT is positive and this approach may have influenced their confidence to use the technology to various extents. However, current level of ICT usage in general appears to be at a more elementary stage consisting of basic hardware and software applications. Though more advanced technical applications of ICT seem to be lacking most of the firms perceived their current usage of ICT as average.

2. Overall usage of commercially available software applications for specific work tasks are encouraging and well recognized within current practice. Most common software application in use included Autodesk BIM 360. Surprisingly, commercially available software for project cost estimating and quantity surveying works are not adequately developed. Most software in use for estimating are self developed and mostly based on Microsoft excel spreadsheets. Altogether respondents were not aware of any industry specific software developers locally, most firms appear very confident to support such ventures in the future.
3. The use of Network infrastructure such as Local and Wide Area Network (LAN/WAN) by the firms for internal and external communication and data exchanges is generally a less mature field. However, internet access and use of computer-supported communications such as e-mail and web is very prevalent through the use of wireless network connections and individual modem. Most ICT related works within the contractors' organisations are handled by technical and administrative staff at both the company offices and project sites.
4. Digitization of business activities associated with resource planning and scheduling, communication and distribution of documents (e-mail), technical calculations, Costing and Budgeting; Resource management (labour, plant and materials), project cost control by the building contractors were very encouraging. Though majority of firms were deficient in the use of most advanced ICT tools and applications, the trend is that mobile internet applications and Short Messages Services (SMS) through the use of mobile phones were significantly gaining adequate level of usage. As a whole, there appears to be a high level of optimism among the firms that more advanced ICT applications such as Electronic Purchasing, Modeling and visualization (e.g. 3D-CAD), Project Specific Websites,

Electronic Tendering, Videoconferencing and intranets applications could gain some patronage in the near future if the necessary awareness is created.

5. Finally, it is notable to recognise from this survey that, the most significant factors affecting the use of digital transformation by building contractors are: Financial constraints for digital transformation investments, Lack of management commitment towards digital transformation, inadequate digital transformational content of construction education (Human resource constraint) and the legal constraint in firms digital transformation base.

These factors should explain the main reason behind current level of ICT usage among building contractors in Ghana. It is therefore possible to acknowledge that, whilst the posture and interest towards digital transformation by building contractors in Ghana seems promising, these factors continue to be a major issue that stakeholders and individual organisations need to address in order to increase usage and derive the full benefit of digital transformation.

5.5 RECOMMENDATIONS

On the basis of findings and conclusions drawn from the study, the following recommendations are proposed.

5.5.1 Financial Support for Digital Transformation Investment in Construction

Investing in digital transformation is no longer primarily buying a piece of hardware or software. It is now more of a potential long-term investment in the process of change itself (Cleveland 1999). Due to obvious tight margins for funding digital transformation within most construction firms as revealed in this study, there is the need for some internal policies towards ICT investments in the Ghanaian construction industry. It is therefore recommended that construction firms should be motivated by the direct benefits of digital transformation and draw deliberate

policies that provide some proportion of their internal budget for this investments. This will aim to improve both productivity and profitability for their benefit. Again, based on the understanding on the returns on digital transformation investment, financial institutions can assist contractors in Ghana to finance their ICT investment by offering flexible credit facilities to firms seeking to invest in digital transformation. This will support their operations to improve efficiency and payback the facility.

5.5.2 Training and Management Support for Digital Transformation Investment in Construction Firms.

As observed from the study, the management of construction activities is gradually moving from traditional paper based format to more digital processes. It is therefore recommended that adequate ICT training and technical support for professionals in building construction firms should be vigorously promoted by employers and other stakeholders such as various professional bodies and associations of the industry in Ghana, This should aim at providing the necessary awareness and build capacity to meet future challenges in this marketplace. Again, there should be a closer cooperation between Ghanaian ICT technology developers and contractors to train professional and also develop ICT systems that will address the specific operational needs of Ghanaian contractors.

5.5.3 Increase Digital Transformation Content in Construction Education At All Level

As explained by Foresight 2000, the advent of computer and ICT integration in the construction process creates the need for cross disciplinary education. By recognizing the importance of digital transformation education in construction, it is recommended that a robust content of ICT education which will generate adequate construction. ICT skill acquisition should be incorporated in construction courses as a supplement to technical knowledge and expertise in various fields of construction study. A re-think in this respect will help deliver the require ICT skills for the

Ghanaian construction industry. This will also be significant to develop and support the understanding of how digital transformation could be used to support construction process at all levels to facilitate the necessary change and innovation.

5.6 FURTHER RESEARCH WORK

Although, this study has proposed recommendations for promoting the use of digital transformation in the Ghanaian construction industry, these results reflect only the views of contractor organization in financial class D1K1 to D4K4. It is therefore recommended that further research be undertaken to ascertain the situation in large scale contractor (D1K1 – D2K). Again, there is the need to repeat the research for all financial classes (D1K1 – D4K4) and the study expanded to cover construction consultants, clients and academia to give an objective view of the whole construction industry in Ghana.

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APPENDICES

To whom it may concern

Dear Sir/Madam,

Invitation to participate in a research into state of readiness of Ghanaian construction industry towards digital transformation: effects of communication on the success of construction projects in Ghana

I write to request your assistance as an experienced professional with substantial knowledge in digital transformation to complete the attached questionnaire. Currently, I am undertaking a Master of Science (MSc.) degree in the Department of Building Technology of the Kwame Nkrumah University of Science and Technology under the supervision of Dr. Barbara Simons. This research is entitled **“State of readiness of Ghanaian construction industry towards digital information: effects of communication on the success of construction projects in Ghana”**.

This research aims to assess the readiness of Contractors in the promotion of digital transformation in Ghana. Hence, your expert knowledge and experience will be extremely useful for this research in determining how construction process can promote digital transformation on the success of their projects. The questionnaire will take 10 to 15 minutes. All your responses will be treated with strict confidentiality and used only for academic purpose. Your views are valuable for the success of this research. After the research, we are willing to share a summary of the outcomes with practitioners in Ghana and anyone who shows interest. For any enquiries, please contact Dogbey, Selase Yao (Tel.: **0246828332**; & email: selasedogbey@gmail.com)

Sincerely,

Dogbey, Selase Yao, MSc. Student

Dr. Barbara Simons, Project Supervisor

Department of Building Technology

Kwame Nkrumah University of Science and Technology, Ghana

“The state of readiness of Ghanaian Construction industry towards digital transformation: effects of communication on the success of construction projects in the Greater Accra Region of Ghana”

Questionnaire Survey

Important Instructions:

1. Please duly fill this questionnaire with reference to your latest experience about Contractors readiness towards digital transformation and the effects of communication on the success of project.

2. Please answer the questions by ticking {such as “✓”} or checking {such as “☒”}.
3. If you wish to have a copy of the report on research findings, please provide your email address:
Click or tap here to enter text.

Section A: Background of Respondent

Q1. Please indicate the Financial Class of your Company.

☐ D1K1 ☐ D2K2 ☐ D3K3 ☐ D4K4

Q2. How many years of experience does your Company have in the construction industry?

☐ 0-5 ☐ 5-10 ☐ 10-15 ☐ 15-20 ☐ Over 20 years

Q3. Please indicate your position in this company

☐ Project Manager ☐ IT Manager ☐ Site Supervisor ☐ Architect ☐ General
Foreman ☐ Engineer ☐ Quantity Surveyor ☐ Contractor ☐ Other

Q4. What is your educational qualification?

☐ HND ☐ BSc. ☐ MSc/Mphil ☐ PhD ☐ Other

Q5. Please indicate how long you have been involved in the construction industry?

☐ less than 5 years ☐ 5-10 ☐ 10-15 ☐ Over 15 years

Q6. What form of ownership is your firm?

☐ Private Limited Company ☐ Partnership ☐ Sole Proprietorship ☐ Public Limited
Company

Section B: Background Knowledge

Q7. What type of construction projects does your firm undertakes? (You can tick more than 1 in the list)

- ☐ Residential ☐ Building ☐ Commercial & Institutional ☐ Industry ☐ Heavy
☐ Highway

Q8. Are you aware of the concept digital transformation?

- ☐ Yes ☐ No

Q9. If yes, which of the following best describes digital transformation?

☐ **Digital transformation is the integration of digital technology into all areas of a business, fundamentally changing how you operate and deliver value to customers.**

☐ **Digital transformation is a cultural change that requires organizations to continually challenge the status quo, experiment, and get comfortable with failure.**

☐ Digital transformation is a thorough reconsidering of how organizations uses technology, people and processes to fundamentally change business performance.

☐ Digital transformation, is a managerial decision which requires cross-departmental collaboration in pairing business-focused philosophies with rapid application development models

Q10. To what extent is digital transformation currently being applied in your organization?

- ☐ High ☐ Medium ☐ Low

Q11. How do you perceive the role of digital transformation with respect to the overall business strategy of your organization?

- ☐ Critical ☐ Supporting ☐ Value adding

Section C: Firms ICT Infrastructure Status

ICT General Information

Q12. Does your firm own and use ICT devices in its operations?

- ☐ Yes ☐ No

Q13. If yes, please state where it can be found in the organization?

☐ Company office/s only
site/s

☐ Project site/s only

☐ Both office/s and Project
site/s

Hardware Infrastructure

Q14. Please indicate usage of the following ICT hardware devices in your organization (Please Tick all that apply)

☐ Desktop computers

☐ Laptops

☐ Personal Digital Assistants (PDAs)

☐ Handheld computers/Tablets PCs

☐ Mobile phones

☐ Digital Cameras

☐ Multimedia projectors

Operating systems in use

Q15. Please indicate the type of Operating System currently being used in your organization.

☐ Microsoft windows

☐ IOS

☐ Google Android OS

☐ Linus

☐ Other

Q16. Please state why the choice of Operating System indicated above?

☐ Availability

☐ Cost

☐ Familiarity

Communication and Network Infrastructure

Q17. Are ICT devices in your organization Networked?

☐ Yes

☐ No

Q18. Which of the following communication tools does your organization use for both internal and external interactions?

☐Emails tools ☐Video and web conferencing ☐Social Networking ☐Collaboration tools

Q19. How effective is ICT with regards to effective communication on project success?

☐Extremely effective effective at all ☐ Very effective ☐Somehow effective ☐Not

Q20. Do you use internet in your organization?

☐Yes ☐No

Q21. Please indicate where internet can be accessed in your organization?

☐Company office/s only ☐ Project site/s only ☐Both office/s and Project site/s

Q22. Does your company have a page on the World Wide Web (www)

☐Yes ☐ No

ICT Workforce

Q23. Do you have a Separate IT Division?

☐Yes ☐No (If No, please skip to Q25)

Q24. If yes, please indicate which of the following services your in-house IT Division provides

☐01. Internet & e-Mail support

☐02. Database Maintenance

☐03. Networking

☐04. Hardware Maintenance

☐05. Software Support Services

☐06. Software Maintenance

☐07. None

Q25. Please indicate, which of the following services are outsourced (Pls. tick relevant box/es)

- ☐ Internet & e-Mail support
- ☐ Database Maintenance
- ☐ Networking
- ☐ Hardware Maintenance
- ☐ Software Support Services
- ☐ Software Maintenance
- ☐ None

Q26. What is the current average staff to computer ratio in your organization? (NOTE: **Ratio= No. of staff ÷ No of Computers**)

- ☐ 1:1
- ☐ 2:1
- ☐ 3:1
- ☐ 4:1
- ☐ 5:1

Section D: Level of usage of Information and Communication Technology

Q27. Please indicate the extent of usage of computer software for the following activities in your organization. (Note: 1= Never, 2=Not always, 3=Average, 4 Quiet Always, 5=Always). Please write the number in the box.

- ☐ Project Drawings
- ☐ Purchases and Invoicing (Supply chain)
- ☐ Technical Calculations
- ☐ Project Costing /budgeting/Estimating
- ☐ Resources Management (Labour, Material and Equipment)
- ☐ Scheduling and works planning
- ☐ Project Records
- ☐ Site management and Security
- ☐ Subcontractors and suppliers information
- ☐ Communication (with project sites and external parties)
- ☐ Distribution of project Documents.

ICT Application

Q28. Please indicate the extent of usage or application of the following digital transformation tools in your company. (Note: 1= Never, 2=Not always, 3=Average, 4 Quiet Always, 5=Always)

- ☐ E-mail and Short Message Services (SMS)
- ☐ Mobile internet
- ☐ Electronic Purchasing (E-purchasing)
- ☐ Project specific websites (Extranets)
- ☐ Site surveillance Technologies (e.g. CCTV etc.)
- ☐ Electronic tendering (E-tendering)
- ☐ Modeling and Visualization (e.g. 3D-CAD,4D-CAD etc.)
- ☐ Electronic document management systems (EDMS)
- ☐ Integrated software (e.g. Enterprise Resource Planning, ERP)
- ☐ Building Information Modeling (BIM)

Q29. As contractors, does your organization use ICT software for its operations?

☐Yes ☐No

Q30. Please indicate usage of the following construction software available in your organization.

☐Autodesk BIM 360 ☐Procore ☐e-Builder
☐Aconex
☐Acculynx ☐Corecon ☐CoConstruct
☐STACK
☐PlanGrid ☐Wrike ☐None

Q31. Does your firm have proprietary or in-house software designs for your own business use?

☐Yes ☐No

SECTION E: Reason Hindering the Use of Digital Transformation in Your Organization

Q32. Which of the following statements in your opinion, best describe reasons hindering the use of ICT in your organization.

☐Financial Reasons ☐Managerial Reasons ☐Human Reasons ☐Technical Reasons
☐Legal

Q33. Is your organization ready for digital transformation?

☐Yes ☐No