Determining the influence of Information Communication Technology in the South African construction project management environment

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ABSTRACT

At the heart of Project Management are time, cost and performance by utilizing the available resources. When analysing the Global Competitiveness index for 2012-2013 it becomes clear that in South Africa labour efficiency is far below what it should be, ranked 113th out of 144. In the same report Business Sophistication is ranked 38th out of 144. It becomes clear that performance, time and cost at the heart of Project Management are hampered by the low labour efficiency.

The adoption of Information Communication Technology (ICT) in the Construction Project Management Environment will raise productivity and will increase the quality and speed of work, financial controls, communication, and access to common data. The effect will be improved communication, an increase in the speed of data transmission, cost savings and fewer occurrences in miscommunication.

The study has been done to set a framework of how ITC can be managed and implemented in the South African Construction Project Management Environment. These enablers and disablers of ICT in Construction Project Management should be determined. The current rate of ICT adoption is verified and the future trends in ICT are researched, characteristics common to quality information should also be verified.

The study determined that the future developments in ITC will be profound and if applied correctly, Project Management through the means of communication will be affected positively.

In the empirical study the characteristics of quality information, the disablers and also the enablers were investigated taking into account the current rate of ICT adoption in the South African Construction Management Environment.

The framework used in the study proposed and confirmed how ITC can be managed and implemented in the South African Construction Project Management Environment. It is set out in the following steps:

Firstly: By determining the common characteristics of quality information, namely accuracy, completeness, consistency, uniqueness, and timeliness. The

implementation of ITC in the Construction Project Management Environment can be controlled.

Secondly: Disablers of ICT adoption in project management exist, namely economic factors (reduction in employment, rising cost, and limited trade), social factors (digital divide, security and lack of education), and other factors (legal, environmental and cognitive). These factors should be managed.

Thirdly: Enablers of ICT adoption in project management exist, namely relative advantage, complexity, compatibility, trial ability and observe ability. These enablers must be focused on and exploited where possible.

Fourthly: Determine the current rate of ICT adoption in Construction Project Management. This was done and it is clear that the digital divide has been crossed by South African Project Managers and that they will embrace future developments in ICT in general.

Finally: Future trends in ICT for the next five to ten years pertaining to Project Management should be analysed and new trends with possible advantages for Project Management must be investigated on a constant basis to see what will be advantageous.

Key terms: Project management, Information Communication Technology, ICT, digital divide, construction

OPSOMMING

Die bepaling van die invloed wat Inligtingskommunikasie Tegnologie het op die konstruksie projekbestuuromgewing in Suid-Afrika

Die kern van Projekbestuur is tyd, koste en prestasie, deur gebruik te maak van die beskikbare hulpbronne. Tydens die ontleding van die Globale Mededingendheidsindeks vir 2012-2013, word dit duidelik dat Suid-Afrikaanse arbeidsdoeltreffendheid baie laer is as wat dit moet wees, ingedeel as 113de uit 144 lande. In dieselfde verslag word “Professionele Besigheid” as 38ste uit 144 geklassifiseer. Hieruit word dit duidelik dat prestasie, tyd en koste wat die kern van Projek Bestuur is, bemoeilik word deur die lae arbeidsdoeltreffendheid.

Die aanneming van Inligtingskommunikasie Tegnologie (IKT) in die Konstruksie Projek Bestuur omgewing sal produktiwiteit verhoog en die kwaliteit en spoed van die werk, finansiële beheermaatreëls, kommunikasie en toegang tot gemeenskaplike data verhoog. Die effek sal verbeterde kommunikasie, 'n toename in die spoed van data-oordrag, kostebesparings en minder misverstande verseker.

Die studie is daarop toegespits om riglyne daar te stel om IKT te bestuur en te implementeer in die Suid-Afrikaanse Konstruksie Projek Bestuur Omgewing. Om dit te bepaal, moet die aanhutsende en beperkende faktore van IKT in die Konstruksie Projek Bestuur bepaal word. Die huidige trant van IKT aanneming is geverifieer en die toekomstige tendense in IKT word nagevors - eienskappe eie aan kwaliteit informasie moet ook nog geverifieer word.

Die studie het bevind dat die effek van toekomstige ontwikkeling in IKT diepgaande is en indien dit korrek toegepas word, dit Projek Bestuur deur die middel van kommunikasie positief sal beïnvloed.

In die studie oor die eienskappe van kwaliteit informasie, is die beperkende asook die aanhutsende faktore ondersoek met inagneming van die huidige trant van IKT aanneming in die Suid-Afrikaanse Konstruksiebestuur Omgewing.

Die raamwerk is voorgestel en bevestig in die studie oor hoe Inligting IKT bestuur in die Suid-Afrikaanse Konstruksie Projek Bestuur omgewing geïmplementeer kan word. Dit word uiteengesit in die volgende stappe:

Eerstens: deur die bepaling van die algemene eienskappe van kwaliteit van inligting, naamlik akkuraatheid, volledigheid, konsekwentheid, uniekheid en tydigheid. Die implementering van IKT in die Konstruksie Projek Bestuur Omgewing kan beheer word.

Tweedens: beperkings van IKT in projekbestuur bestaan naamlik uit: ekonomiese faktore (afname in indiensneming, stygende koste en beperkte handel), sosiale faktore (digitale skeiding, sekuriteit en 'n gebrek aan onderwys), en ander faktore (regs-, omgewings- en kognitiewe faktore). Daar moet op hierdie faktore gefokus en bestuur word.

Derdens: bemagtigers van IKT in Projek Bestuur bestaan naamlik uit: relatiewe voordeel, kompleksiteit, aanpasbaarheid, toets en observasie vermoë. Daar moet op die bemagtigers gefokus word en ten volle benut word waar moontlik.

Vierdens: bepaal die huidige koers van IKT aanneming in Konstruksie Projek Bestuur. Dit is gedoen en bevind dat die digitale skeiding deur Suid-Afrikaanse Projek Bestuurders oorbrug is en dat hulle die toekomstige ontwikkelinge in IKT sal navors.

Ten slotte: toekomstige tendense in IKT vir die volgende vyf tot tien jaar met betrekking tot Projek Bestuur, moet geanaliseer word. Nuwe tendense met moontlike voordele vir Projek Bestuur moet op ’n gereelde basis ondersoek word om voordele uit te lig.

Kernbegrippe: Projekbestuur, Inligtingskommunikasie Tegnologie, IKT, digitale skeiding, konstruksie, Informasie Kommunikasie Tegnologie.

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My study leader, Johannes Coetzee

Above all, I want to honour God, who gives me the strength to face anything

-Philippians 4:13-

TABLE OF CONTENTS

CHAPTER 2: LITERATURE REVIEW

CHAPTER 3: RESEARCH FINDINGS AND DISCUSSION

LIST OF FIGURES

Figure Description

LIST OF TABLES

Table Description

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
CI	Construction Industry
CRT	Cathode Ray Tube
DSRC	Dedicated Short Range Communications
GIS	Geographic Information System
GPS	Global Positioning System
HR	Human Resource Management
ICT	Information Communication Technology
IKT	Inligtingskommunikasie Tegnologie
IP	Internet Protocol
IS	Information System
LED	Light Emitting Diode
NWU	North-West University
PM	Project Manager
PMBOK	Project Management Body of Knowledge
Pr.CM	Professional Construction Manager
Pr. CPM	Professional Construction Project Manager
PRINCE2	Projects in Controlled Environments
RFID	Radio Frequency Identification Tags
rho	Rank Correlation Coefficient

Note: *Institution, Organisation, Company and Business are used interchangeably to include any commercial sector entities.*

CHAPTER 1

NATURE AND SCOPE OF THE STUDY

1.1 INTRODUCTION

"Project Management" and "Projects" are not new concepts. Throughout history, vast projects of different magnitudes have been undertaken successfully across generations; examples being the pyramids in Egypt and the Great Wall of China. Officially, Project Management first emerged in the early 1950s on large defence projects and gradually smaller organisations took to adapting the idea. Currently, the smallest construction firms are known to operate Project Management in some form. A great deal of Project Management involves avoiding problems, tackling new ground, managing a group of people and trying to achieve very clear objectives quickly and efficiently (Alshawi & Ingirige, 2003:349; Kerzner, 2009:10).

Today, projects are far more complicated than ever before. They involve larger capital investments, embraces several disciplines, widely disperse project participants, tighter schedules, stringent quality standards, and more. These factors coupled with high-speed developments in Information Communication Technology (ITC), have influenced Project Management practice to take a new turn, taking advantage of newly developed management tools and the latest technology (Alshawi & Ingirige, 2003:349; Kloppenborg, 2009:11).

In a fast changing technological world where the circuits on a silicon chip doubles every 18 to 24 months, also refer to as "Moore's Law" (Taylor, 2000:99; Baltzan & Philips, 2010:81), ITC is positively affected. ICT is responsible for the entire construction process from information being generated, transmitted and interpreted to enabling the project to be built, maintained, reused and eventually re-cycled (Onyegiri *et al.,* 2011:461).

The rapid evolution of ICT offers opportunities to enhance communication between parties in the construction projects and to enable more effective and efficient communication (Adriaanse & Voordijk, 2005:2). This can be used by

South African Construction Project Managers to help to alleviate the poor production figures. Communication can be viewed as a metaphorical 'pipeline' along which information is transferred from one person to another (Emmit & Gorse, 2003:9).

Although communication is an essential value in construction projects, the construction industry is confronted with the importance and use of ITC. As most firms in developed countries have increased and will further increase their investment in ICT, this has raised productivity within the construction industry and resulted in an increase in the quality and speed of work, financial controls, communication, and access to common data. Firms in the developing countries are yet to understand this essential value and its importance to development of their construction sector (Onyegiri *et al.,* 2011:461). This will especially be beneficial in South Africa where we are ranked 113th out of 144 countries on the Global Competitiveness Report 2012-2012 (Schwab *et al.,* 2012:37-38).

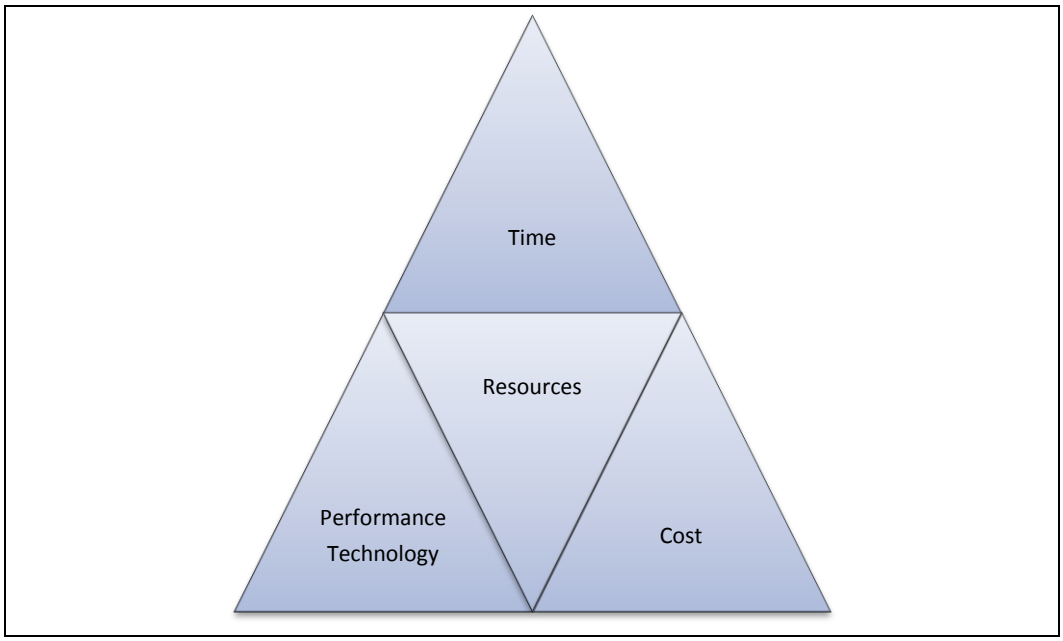
1.2 IMPORTANCE OF THE STUDY

The adoption of ITC in Construction Project Management could improve productivity and increase the quality and speed of work, financial controls, communication, and access to common data (Onyegiri *et al.,* 2011:461).

Successful Project Management can be defined as having achieved the project objectives within the following general adopted constraints:

- Within time;
- Within cost;
- At the desired performance/technology level; and
- While utilizing the assigned resources effectively and efficiently.

Figure 1-1: Overview of Project Management



Source: Kerzner (2009:5).

By incorporating ICT in the Project Management process all elements of the Project Management triangle can be improved, namely Better Productivity, Better Profit and Better Quality (Kerzner, 2009:5).

1.3 PROBLEM STATEMENT

Communication consumes about 75-90% of a Project Manager's time and information therefore needs to be current and available on demand (Scanlin, 2003:6-7). Communication can be modelled as a process that has constant movement. The basis of the model is that an idea travels from Sender through Channel to Receiver. In the communication process, the idea is encoded and decoded into a message in verbal and non-verbal vocabularies. The communicator understands meaning from the message they exchange based on their culture and experience (Beamer & Varner, 2008:158). The interpretation of communication is in most cases the root cause of project failures (Scanlin, 2003:6-7). This is especially prevalent in South Africa with the existence of numerous cultures and different languages.

Although communication is an essential value in construction projects, the construction industry is confronted with the importance and use of ITC. As most firms in developed countries have increased and will further increase their investment in ICT, this has raised productivity within their construction industry and resulted in an increase in the quality and speed of work, financial controls, communication, and access to common data. Firms in the Third World countries are yet to understand this essential value and its importance to development of their construction sector (Onyegiri *et al*., 2011:461).

The problem, however, is that the construction industry is faced with the on-going challenge of changing and improving current work practice in order to become more client-orientated, more competitive as well as productive through adoption of ICT as an integrated part of the construction process (Weippert *et al.,* 2003:328).

The construction industry is fragmented due to the many stakeholders and phases involved in a construction project. This fragmentation has led to well documented problems within communication and information processing and has contributed to the proliferation of adversarial relationships between the parties involved in a project. However, the benefits of ICT come at a cost because of the complexity of work, the administrative needs, the cost of doing business, the continual demand for upgrading and the greater know-how required (Nitithamyong & Skibniewski, 2004:491).

At the heart of Project Management are time, cost and performance by utilizing the available resources (Kerzner, 2009:5). When analysing the Global Competitiveness index for 2012-2013, it becomes clear that in South Africa labour efficiency is far below what it should be, ranked 113th out of 144. In the same report Business Sophistication are ranked 38th out of 144 (Schwab *et al.,* 2012:37-38). It becomes clear that performance, time and cost at the heart of Project Management are hampered by the low labour efficiency.

1.4 OBJECTIVES OF THE STUDY

1.4.1 Primary objective

To create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment.

1.4.2 Secondary objectives

In order to achieve the objective stated above, the following sub-objectives will be pursued:

- Common characteristics of quality information in Project Management;
- Disablers of Information Communication Technology in Project Management;
- Enablers of Information Communication Technology in Project Management;
- The current rate of Information Communication Technology adoption in Construction Project Management; and
- Future trends in Information Communication Technology for the next five to ten years pertaining to Project Management.

1.5 SCOPE OF THE STUDY

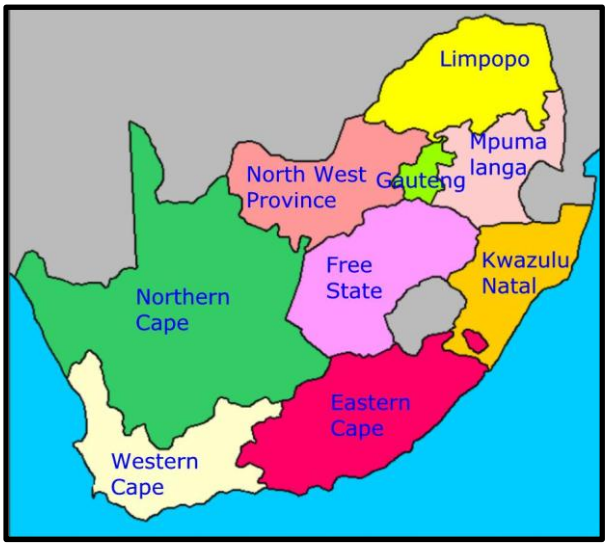
1.5.1 Geography

The study's geography includes Construction Project Managers within the borders of South Africa registered as professionals with the South African Council for the Project and Construction Management Professionals (SACPCMP). This is in accordance with the Project and Construction Management Act (Act No 48 of 2000). There are 1200 registered members. Only persons registered with above council can be classified as Professional Construction Project Managers in South Africa (SACPCMP, 2012).

Five classifications exist that will be included in the study:

- Professional Construction Project Manager (Pr. CPM);
- Professional Construction Manager (Pr. CM);
- Mentor;
- Candidate;
- Other.

Figure 1-2: Map of South Africa



Source: South Africa (2012)

The study only focuses on Construction Project Managers within the borders of South Africa.

1.6 RESEARCH METHODOLOGY

The research conducted in this study, consisted of two phases, namely a literature review and an empirical study.

1.6.1 Literature review

The main purpose of the literature review is to create a framework for improvement and better flow of Information by means of ITC in the South African

Construction Project Management Environment. To achieve the outcome the following areas will be reviewed:

- Project Management Methodology;
- Project Management in general;
- Project Management in the Construction Environment;
- The common characteristics of Quality Information (IQ);
- ITC clarified;
- The disablers of ICT adoption in Project Management;
- The enablers of ICT adoption in Project Management.
- A future projection of ICT based on the next five to ten years pertaining to Project Management.

1.6.2 Empirical study

In order to practice an investigation on the current rate of ICT adoption in Construction Project Management, a structured questionnaire covering the use of ITC in the South African Construction Project Management Environment, was formulated. The characteristics of quality information, the disablers as well as the enablers were used in the design of the questionnaire.

The study was based on quantitative research. The data based on the empirical study has been analysed by North-West University Statistical Consultation Services (Potchefstroom campus). The data collected was statistically analysed, by the use of Statistica (Statsoft, 2008) and SPSS (SPSS, 2008). The knowledge gained in the literature review has been used to formulate a questionnaire.

1.7 LIMITATIONS TO THE STUDY

The study's geography only focuses on registered professional Construction Project Managers registered with the South African Council for the Project and Construction Management Professionals (SACPCMP). This is in accordance with

the Project and Construction Management Act (Act No 48 of 2000) (SA, 2000). There are 1200 registered professionals.

1.8 LAYOUT OF THE STUDY

Chapter one contains the problem statement of the study. It explains the nature and the scope and displays all objectives. The layout of the study is set out in this chapter and explained. The research methodology and limitations of this study are also identified and discussed.

Figure1-3: Layout of the study

Chapter 1	Chapter 2	Chapter 3	Chapter 4
Introduction	Introduction	Introduction	Introduction
Importance of Study	Project Management Methodology	Gathering of Data	Conclusion
Problem Statement	Project Management	Response to the Survey	Demographic Information
Objectives	Project Management in Construction	Demographic Information	Construction Projects in General
Scope	Information Communication Technology	Construction Projects in General	Reliability of Questionnaire
Research Methodology	Quality Information	Sample Responses	Recommendations & Framework
Limitation of Study	What Disables (ICT)	Correlation Between Demographic and Other	Achievement of Objectives
Layout of Study	What Enables (ICT)	Chapter Summary	Suggestion for Further Research
Chapter Summary	Future Projection of (ICT)		Chapter Summary
	Chapter Summary		

Chapter two is a literature review based on previous research and existing knowledge. This section firstly clarifies definitions of Project Management Methodology, Project Management, Construction Project Management and ITC. Then common characteristics of quality Information under the headings Accuracy,

Completeness, Consistency, Uniqueness and Timeliness are done. Disablers and enablers of ICT adoption in Project Management have been researched next. Lastly a future study of ICT with a five to ten year projection has been done.

Chapter three consists of an empirical study based on a questionnaire designed from the literature study in chapter two - the data that were collected during the study, the measurement tools used the identification of the study population, the method of data collection as well as the analysis of the data. The results of the empirical study are also presented and discussed.

Chapter four concludes the study with the conclusions and recommendations. The achievement of the objectives and suggestions for further research are indicated.

1.9 CONCLUSION

The aim of this study was to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment. The study focusses on the importance of communication in all phases of Construction Project Management from planning, testing, implementation to closure (Kerzner, 2009:70). It becomes clear that performance, time and cost at the heart of Project Management are hampered by low labour efficiency.

1.10 CHAPTER SUMMARY

At the heart of Project Management are performance, time and cost by utilizing the available resources (Kerzner, 2009:5). When analysing the Global Competitiveness index for 2012-2013 it becomes clear that in South Africa labour efficiency is far below what it should be, ranked 113th out of 144 countries. In the same report Business Sophistication are ranked 38th out of 144 (Schwab *et al.,* 2012:21-22). It becomes clear that performance, time and cost at the heart of Project Management are hampered by low labour efficiency.

A framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment is required.

In the next chapter a literature review will be conducted. The results obtained from this is presented and defined in chapter two. The primary objective is to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review aims to create a framework from the current body of knowledge for the improvement and flow of communication by means of ITC in general and in particular in the South African Construction Project Management Environment. Focus is also placed on the importance of communication in all phases of Project Management from planning, testing, implementation and closure (Kerzner, 2009:70).

Clarification is given to the term Project Management methodology and then to Project Management by focusing on time, resources, cost and performance/technology. Secondly construction Project Management is explained in terms of its importance to the construction industry. Thirdly ITC is clarified. The common characteristics of quality information are clarified, namely Accuracy, Completeness, Consistency, Uniqueness and Timeliness. The enablers and disablers of ICT in Project Management are analysed. Lastly a five to ten year futuristic study on ICT is performed taking into account the latest developments in the field with specific focus on the theory and developments of Project Management.

2.2 PROJECT MANAGEMENT METHODOLOGY

A methodology is a structured approach for delivering a project, and consists of a set of processes, with each process having clearly defined resources and activities, it is also used to determine both project success and failure (Kloppenborg, 2009:10; Turner, 2000:139).

A Project Management methodology will set out what an organisation regards as best practice; improve inter-organisational communication; and minimise

duplication of efforts by having common resources, documentation and training (Clarke, 1999:142; Kerzner, 2009:2-3).

If a methodology is not followed, projects are normally managed according to the experience of the Project Manager who is specifically appointed for this task. These practices lead to large variations in management practices and thus can create a significant impact on the capability of coordinating and controlling project information. Communication is also affected by this as no standard protocol is followed (Hunt, 1995:158; Jacobs *et al.,* 2009:59).

It has been shown that Project Management practices can vary significantly from one project to another (Payne & Turner, 1999:57). The best way to increase the likelihood of an organisation having a continuous stream of successfully managed projects is to develop a good Project Management methodology in-house that is flexible enough to support all projects (Kerzner, 2009:2). The best way is to adapt Project Management methodology from external standards such as Project Management Body of Knowledge (PMBoK), as project life cycles and management structures are different in every organisation (Kloppenborg, 2009:10; Zielinski, 2005: 20).

The amount of time and effort needed to develop a methodology will vary from company to company, depending on factors such as the size and nature of projects, competitive pressure and the number of functional boundaries to be crossed (Kerzner, 2009:72). The increase in size and time span of projects increases the need for a well divined methodology as project complexity increases.

For those that do not wish to develop their own methodology, there are internationally-recognised Project Management methodologies available which are supported by accreditation: Firstly the Project Management Body of Knowledge (PMBoK), developed by the Project Management Institute (PMI, 2012:21); Secondly Projects in Controlled Environments (PRINCE2) developed by the Office of Government Commerce in the UK (McManus & Wood-Harper, 2002:34). There are also numerous non accredited methodologies such as Agile, Waterfall, Total Quality Management and Six Sigma available for specialised

project applications (Elzas, 2010:1). In South Africa PMBoK is prevalent under Construction Project Managers that are registered with the South African Council for the Project and Construction Management Professionals (SACPCMP, 2012).

What is clear in all methodologies is that communication form a very important part - in PMBoK it is called Communication Management and the same also applies to PRINCE2 (Kloppenborg, 2009:10). Communication must form part of any successful methodology to ensure success.

2.3 PROJECT MANAGEMENT

In order to understand Project Management, one must begin with the definition of a project (Kerzner, 2009:2):

A project can be considered to be any series of activities and task that:

- Have a specific objective to be completed within certain specifications;
- Have defined start and end dates;
- Have funding limits (if applicable);
- Consume resources (money, people, and equipment); and
- Are multifunctional (cut across several functional lines).

Project Management, on the other hand, involves project planning and project monitoring, and include items such as:

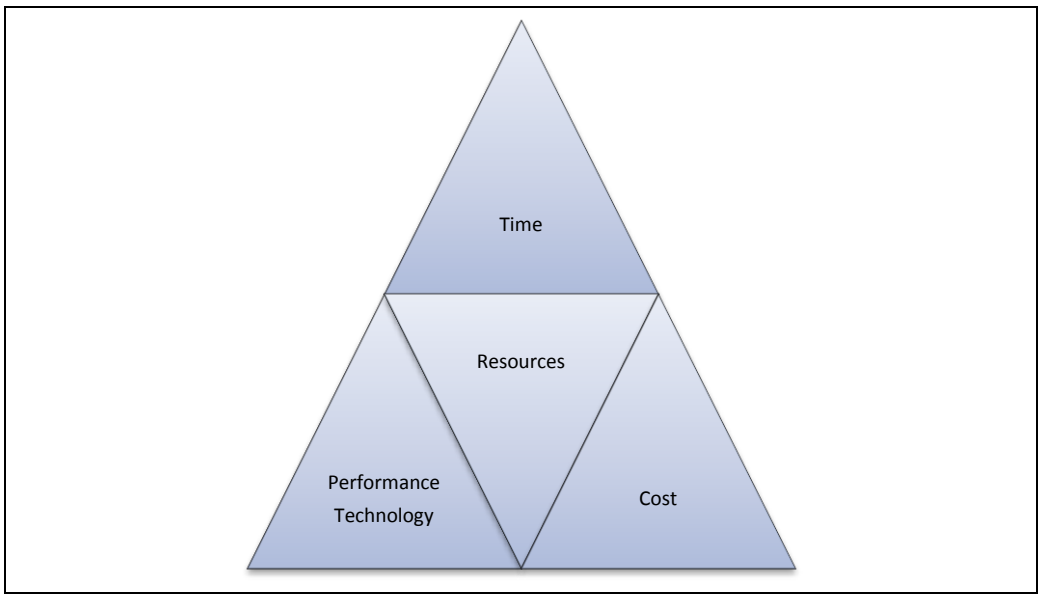
- Project planning
    - Definition of work requirements;
    - Definition of quality and quality work; and
    - Definition of resources needed.
- Project monitoring
    - Tracking progress;
    - Compare actual outcome to predicted outcome;
    - Analysing impact; and
    - Making adjustments.

Successful Project Management can then be defined as having achieved the project objectives:

- Within time;
- Within cost;
- At the desired performance/technology level;
- While utilizing the assigned resources effectively and efficiently; and
- Accepted by the customer.

Project Management is designed to manage or control company resources on a given activity, within time, within cost, and within performance as seen in Fig 2-1. Time, cost, and performance are the triple constraints on the project; if one of these is not achieved the project is classified as a failure (Kerzner, 2009:5).

Figure 2-1: Overview of Project Management



Source: Kerzner (2009:5).

Project Management is the planning, organising, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives. Furthermore, Project Management utilizes the systems approach to management by having functional personnel (the vertical hierarchy) assigned to a specific project (the horizontal hierarchy) - together they are responsible for the success of the project (Kerzner, 2009:5).

Project Management is the art and science of managing relatively short-term efforts having finite beginning and ending points, usually with a specific budget, and with customer-specified performance criteria. “Short-term” in the context of project duration, is depended upon the industry. For example, in the construction

industry, a house might be built in eight months while a hospital might take two years. In the aerospace industry, a new airplane might take eight to ten years to design and build. The longer and more complex a project is, the more it will benefit from the application of Project Management tools (Taylor, 2006:4).

A project may be defined as a series of related jobs usually directed toward some major output and requiring a significant period of time to perform. Project Management can be defined as planning, directing, and controlling resources (people, equipment, material) to meet the technical, cost, and time constraints of the project (Jacobs *et al.,* 2009:59).

Project Management offers a strategic framework for coordinating the numerous activities associated with organisational projects. It is the science of making intelligent trade-offs among time, cost and scope. All three of the factors combined to determine a project's quality (Baltzan & Phillips, 2010:259).

Project Management is "the application of knowledge, skills, tools and techniques to project activities to meet project requirements." This includes work processes that initiate, plan, execute, control, and close work. During these processes, trade-offs must be made among the:

- Scope (size);
- Quality (acceptability of the results);
- Cost; and
- Schedule.

When Project Managers successfully make these trade-offs, the project results meet the agreed upon requirements, are useful to the customers, and promote the organisation. Project Management includes both administrative task for planning, documenting, and controlling work and leadership task for visioning, motivating, and promoting work associates. Project Management knowledge, skills, and methods can be applied and modified for most projects regardless of size or application (Kloppenborg, 2009:5).

The Project Management Institute (PMI) in the Unites States defines a project as a temporary endeavour undertaken to create a unique product, services, or result. Project Management is the application of knowledge, skills, tools, and techniques

to project activities to meet project requirements (Baltzan & Phillips, 2010:260; PMI, 2012:23).

Although new techniques of Project Management evolved, it took time before people realised that communication plays a vital role in project success (Alshawi & Ingirige, 2003:352).

In Project Management communication is of utmost importance through all phases of the life cycle of a project from conceptual phase, planning phase, testing phase, implementation phase and closure phase (Kerzner, 2009:70). Communication has been listed as the root cause of most project failures (Biggs, 1997:190) as shown in this earlier study.

Where the emphasis has traditionally been on the need to manage the interface between the project and the client's organisation, it is now shifting towards the need to manage the flow of activities across the supply chain, concentrating on those activities that actually add value. This has increased the importance of communication at all stages in the Project Management process (Alshawi & Ingirige, 2003:361).

2.4 PROJECT MANAGEMENT IN THE CONSTRUCTION ENVIROMENT

In construction, Project Management is one of the most crucial elements of the entire construction process. Without effective Project Management, the best-conceived projects risk failure; but when professional Project Management skills are applied, even marginal or faltering projects may be saved from disaster. The role of the Project Manager is not only confined to those skills associated with an engineering background. The construction industry is a business, albeit an engineering-driven one, and the qualities of a top flight Project Manager include good business management skills, and most important, an ability to work harmoniously with others - and to get them to work for you (Levy, 2007:6).

Construction Project Management to a large degree involves avoiding problems, tackling new ground, managing a group of people and trying to achieve very clear objectives quickly and efficiently (Alshawi & Ingirige, 2003:349).

Construction Project Management involves multiple parties and includes construction progress, quality, safety, technology, contracts, funds and equipment, and others. Procedural and standardised management are implemented to improve project performance and success (Jiaqing & Jingying, 2010:20).

Construction Project Management is a new mode of Project Management, which is consistent to the objective of construction engineering. It is a mode taking the project at the start, the centre and the ending. The modern construction project is the process of which under the restrictions of the factors such as society, economy and time, people take good use of modern scientific knowledge and technology to create new materials to meet the demand of a specific project (Zhang & Yuan, 2007:2-3).

The role of the construction Project Manager is as follows:

- Construction engineering: The proper technique of assembling material, components, equipment, and systems, and the selection and utilization of the best construction technology in doing so.
- Management of the construction process: Establishing the best way to implement the construction process, including appropriate scheduling and coordination and the control of the flow of labour, materials, and equipment to the jobsite.
- Human resource management: Since labour productivity and a harmonious working environment are essential elements of a successful project, control over human resources becomes important - more so than ever these days, while there are shortages of both skilled workers and experienced managers.
- Financial management: Construction is a high-risk business with historically low profit margins. Control over cost, cash flow, and project funding is critical to the success of any business endeavour, and construction is certainly no exception (Levy, 2007:9).

The seven criteria that are essential for the successful completion of a construction project (Levy, 2007:8), are:

1. The project was completed on time;
2. The completed project remained within budget;

3. The quality levels expected were achieved;
4. The project was completed with no unresolved disputes and no outstanding claims;
5. The contractor maintained a professional relationship with the designers, architect and engineer;
6. The contractor maintained a mutually beneficial relationship with all subcontractors and vendors; and
7. The contractor-client relationship was a good one.

The importance of communication in Construction Project Management was not always realised, but the situation is changing; as more and more firms in the construction industry started to realise the benefits of improving communication between the projects' participants which can lead to improved efficiency, better quality and competitive advantage (Alshawi & Ingirige, 2003:353; Zhang & Yuan, 2007:4).

The constant factor in Construction Project Management is that the project manager remains in orchestration, guidance, and control of the construction process from beginning to end. Construction Project Management means managing the construction project. This is achieved by means of communication (Levy, 2007:9). Current Project Management practices are often isolated and are concerned with managing problems related to individual stages of the project. This must chance to where communication are the driver of all stages of Construction Project Management in an integrated method (Alshawi & Ingirige, 2003:351).

Where the emphasis has traditionally been on the need to manage the interface between the project and the client's organisation, it is now shifting towards the need to manage the flow of activities across the supply chain, concentrating on those activities that actually add value. This has increased the importance of communication at all stages in the Construction Project Management process (Alshawi & Ingirige, 2003:361; Levy, 2007:12).

2.5 COMMON CHARACTERISTICS OF QUALITY INFORMATION

Information is everywhere in an organisation. When addressing a significant business issue, employees must be able to obtain and analyse all the relevant

information in order to make the best decision possible. The business decisions made are only as good as the quality of the information used to make the decision.

Quality of information serves as the background for all steps in the communication process in the modern enterprise: establishing, opening and strengthening of communication channels. Relatively small businesses, which operate locally, have limited ability to access and utilize the large amount of information. In such cases, managers can mainly operate their business by relying mostly on their own experience. Large businesses, operating on national and global scales, need a well-established information system as a basis for effective communication among various subjects involved in a business process (Michnik & Lo, 2009:851).

Quality of information results from an Information System (IS) which covers the organisational processes, procedures, and roles employed in collecting, processing, distributing, and using data. Companies need to treat information as a product that ultimately serves as a tool to satisfy consumer needs (Michnik & Lo, 2009:853).

When better operational information is available, organisations benefit in terms of reducing labour cost, reducing waste, better utilizing machinery, and lowering inventory cost. Thus, high information content (i.e., accurate, complete, and relevant information) leads to better product cost control and increased organisational efficiency (i.e., increased profit margin, increased decision-making efficiency). Data quality is at the heart of information quality and can result in poor information quality. Poor data quality, and hence poor information quality, has adverse effects on organisational, tactical, and strategic level (Gorla *et al.,* 2010:209).

At the operational level, customers may be dissatisfied and employees will lack job satisfaction because of inaccurate or incomplete information. At the tactical level, the quality of decision making may be adversely affected by irrelevant information. Selection and execution of a sound business strategy may become difficult because of inaccurate or delayed information. On the other hand, high information quality in terms of information content (i.e., accuracy, completeness,

relevance to decision making) may lead to high organisational impact in terms of market information support (i.e., anticipating customer needs) and internal organisational efficiency (i.e., high-quality decision making) (Gorla *et al.,* 2010:209).

The five characteristics common to high quality information are accuracy, completeness, consistency, uniqueness and timeliness (Baltzan & Philips, 2010:81). They are:

- Accuracy: Are all the values correct? For example, is the name spelled correctly? Is the rand amount recorded properly?
- Completeness: Are any of the values missing? For example, is the address complete including street, city, state, and area code?
- Consistency: Is aggregate or summary information in agreement with detailed information? For example, do all total fields equal the true total of the individual fields?
- Uniqueness: Is each transaction, entity, and event represented only once in the information? For example, are there any duplicate customers?
- Timeliness: Is the information current with respect to the business requirement? For example, is information updated weekly, daily, or hourly?

High quality information can significantly improve the chances of making a good decision and directly increase an organisation's bottom line. High quality information does not automatically guarantee that every decision made is going to be a good one, since people ultimately make the decisions. But such information ensures that the basis of the decision is accurate. The success of the organisation depends on appreciating and leveraging the true value of timely and high quality information (Baltzan & Phillips, 2010:82).

Nelson *et al.* (2005:225) have used the constructs of accuracy, completeness, currency, and format for information quality. The addition of "format" by the authors is related to the presentation layout of information outputs.

Rai *et al.* (2002:59) worked on three constructs namely content, accuracy and format.

The well-accepted end user computing satisfaction (EUCS) instrument developed in the 1990s and still in use today, has five constructs, comprising information quality: content, accuracy, format, ease of use, and timeliness (Doll *et al.,* 1994:453).

The field of information quality was first studied in the 1990s when conventional information quality has been described as how accurate the information is. Wang and Strong (1996:12) identified information quality as encompassing multiple dimensions, managing the information as a product, capitalizing the knowledge as assets, and then to survive and prosper in the digital economy. Although some of the dimensions are objective while others subjective, some are context independent and others context dependent. Gardyn (1997:281) focused on attributes of information quality that were important to users, including correctness, completeness, consistency, currency and accessibility.

A model was proposed that consolidates the dimensions into four quadrants: sound, useful, usable and dependable information (Lee *et al., 2002:141*).

DeLone and McLean (2003:19) used five elements to measure information quality: accuracy, timeliness, completeness, relevance, and consistency. These are very closely linked to the six element instrument developed and validated by Sedera and Gable (2004:449) where they had also included format to the other five elements proposed by DeLone and McLean:

- Accuracy: Freedom from mistake or error; conformity to truth or to a standard or model; degree of conformity of a measure to a standard or a true value;
- Timeliness*:* Coming early or at the right time; appropriate or adapted to the time or the occasion;
- Completeness: Having all the necessary parts, elements, or steps;
- Relevance: Having significant and demonstrable bearing on the matter at hand; affording evidence tending to prove or disprove the matter at issue or under discussion; means relating to or bearing upon the matter in hand; implies a traceable, significant, logical connection;
- Consistency: The same on an on-going basis; on numerous occasions the result is closely correlated to previous results;

- Format: The language of an item; it will be done in the same way to prevent misunderstanding or errors.

Information is everywhere in an organisation. When addressing a significant business issue, employees must be able to obtain and analyse all the relevant information so that they can make the best decision possible. The business decisions made are only as good as the quality of the information used to make the decision.

For this study, five characteristics common to high quality information is defined, namely information quality: accuracy, completeness, consistency, uniqueness and timeliness (Baltzan & Philips, 2010:81).

High quality information can significantly improve the chances of making a good decision and directly increases an organisation's bottom line (Baltzan & Phillips, 2010:82). High quality information will directly influence the quality of communication.

2.6 INFORMATION COMMUNICATION TECHNOLOGY

By analysing literature, it becomes clear that there is no fixed definition of ITC. It also becomes apparent that the words on their own - information, communication and technology - also can be interpreted differently.

ITC in construction can be broken down into different segments for its better understanding and its role in construction. The words information, communication and technology can be understood from different perspectives as well as towards an ICT view, as a whole new meaning of its own (Onyegiri *et al.,* 2011:462).

From the functionalist (positivistic, 'scientific') perspective "ICT is a neutral provider of input for decision making". From this point of view communication is no more than distribution of information. ICT may be adopted by specific groups of users within an organisation, for example, use of estimating software by engineers and Project Managers (Adriaanse & Voordijk, 2005:163).

Communication between construction industry participants and organisations are concerned with information exchange, dealings with drawings, specifications, cost data, programmes plus other design and management information. Conclusively, ICT can be the intersection of meaning to reach a mutual understanding between sender and a receiver via technology (Emmit & Gorse, 2003:23).

Communication can be viewed as a metaphorical 'pipeline' along which information is transferred from one person to another. Nonetheless, defining 'communication' is difficult as it is multidimensional and indefinable. It could have a variety of different meanings, contexts, forms and impacts and thus could mean different things to different people in different situations. Certainly the case within the construction industry is a situation where excess of diverse communication occurs simultaneously as teams in different sectors of construction undertake tasks, activities and are constantly involved in communication. Communication may include conversations, listening, networking, data and information collections, mails and using different mediums ranging from electronic to manual means to get those done (Dainty *et al.,* 2006:40).

During the 1990s the international construction industry started using ICT with increased confidence. The use of e-mail became usual and web-sites were established for marketing purposes and then for one-way, followed by two-way, communication. Intranets and extranets were established to facilitate communication within companies and through their branches (Murray *et al.,* 2001:39).

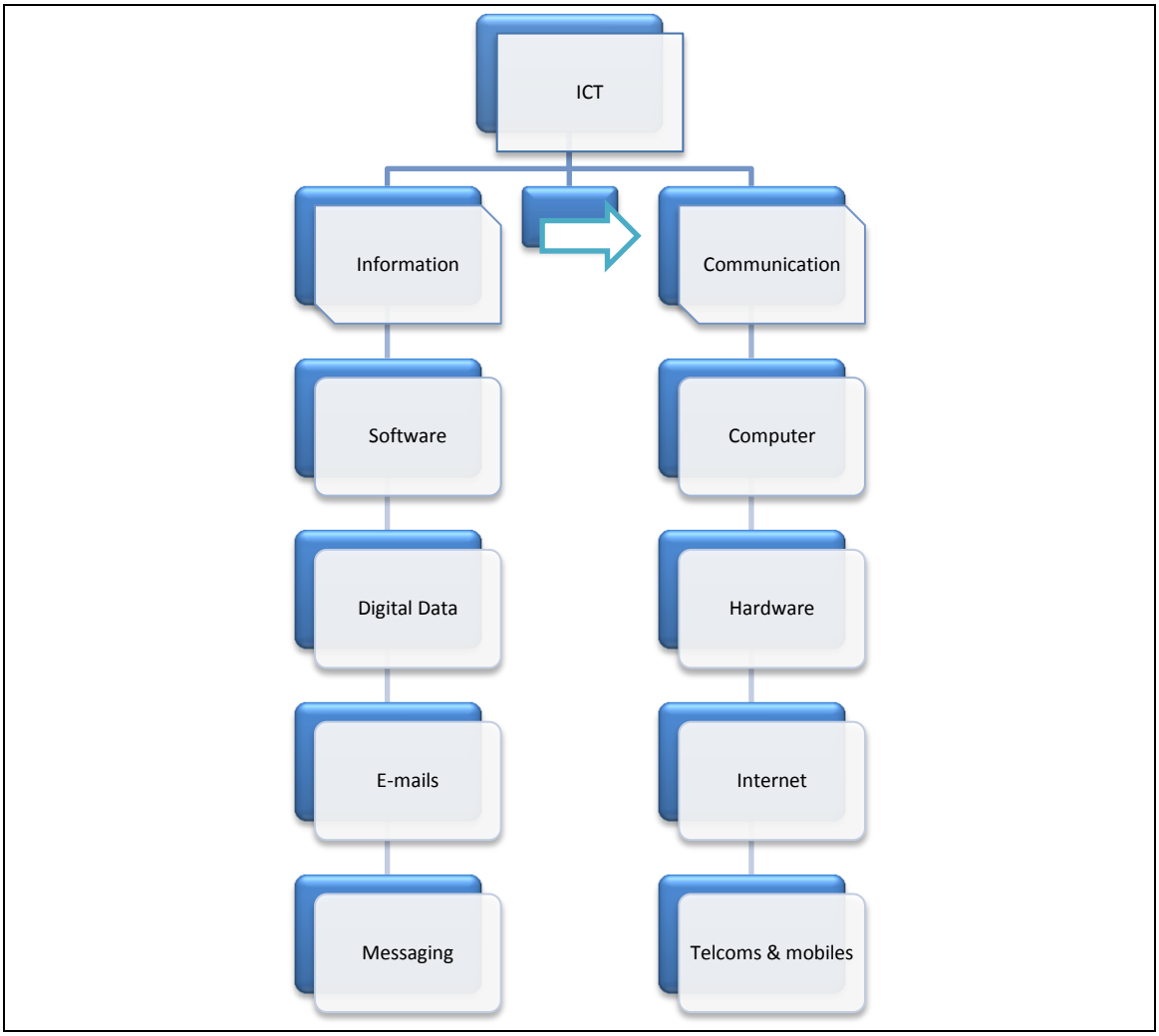
In the year 2012 ICT turned out to be responsible for the entire construction process from information being generated, transmitted and interpreted to enabling the project to be built, maintained, reused and eventually recycled. The everyday life of individuals is increasingly reliant upon information technology and communication. This has totally transformed individuals and organisations to its widespread use (Onyegiri *et al*., 2011:461).

In recent years construction information management has greatly benefited from advances in ICT through increasing the speed of information flow, enhancing the efficiency and effectiveness of information communication, and reducing the cost of information transfer. Current ICT support has been extended to construction site offices. However, construction projects typically take place in the field where

construction personnel have difficulty in gaining access to conventional information systems for their information requirements. The advance in affordable mobile devices, the increase in wireless network transfer speeds and the enhancement in mobile application performance, mean that mobile computing has a great potential to improve on site construction information management (Chen & Kamara, 2011:776).

Different literature have described and broken down information and communication technology in relation to the construction industry and a study of these different approaches can be seen in Fig 2.2 (Day *et al.,* 2006:21).

Fig: 2-2 The flow of information through a medium of communication.



Source: Day *et al*. (2006:21)

Sun and Howard (2004:12) states “that the impact of IT on modern society is profound”, and its growing speed has enabled globalisation especially through the

introduction of a global system of interconnected computer networks known as the 'Internet', used for communication between individuals, companies and institutions for sharing and exchanging information and data. The construction industry is faced with the on-going challenge of changing and improving current work practice in order to become more client-orientated, more competitive as well as productive through adoption of ICT as an integrated part of the construction process.

Much effort has been directed toward improving construction productivity and the use of ICT in construction which is an area worth concentrating upon, because it can decrease the time for data processing, communicating information and increase overall productivity (Weippert *et al.,* 2003:332).

The adoption of ITC stimulates a more standardised communication between different actors in construction. ICT is also creating many opportunities for a more efficient and effective project execution (Adriaanse *et al.,* 2010:73).

The construction industry is an information-intensive industry since hundreds and thousands of pieces of information need to be transferred and exchanged during the project life cycle. The implementation of construction projects takes place on construction sites where personnel have difficulty in gaining access to conventional computer systems. Managers, engineers and other key personnel move frequently from site to site and from site offices to the sites. It is often inconvenient to carry bulky drawings and documents to a construction site. The quality, quantity, and timing of information can either hinder or facilitate the success of a project during the construction stage (Chen & Kamara, 2011:777).

The evolution of technology which has led to the invention and development of telephones, computers, electronics and electrical equipment are all fundamental in the present day construction industry. The value thereof is very important as construction projects involve a large flow of construction documentary information linking project participants during both design and construction phases (Peansupap & Walker, 2005:368).

Rapid evolution of ICT offers opportunities to enhance communication between parties in construction projects and to enable more effective and efficient communication. The use of ICT is an area worth concentrating on because it can

decrease time for data processing and communicating information (Adriaanse & Voordijk, 2005:164).

ICT application also assists operational improvement through communication of construction information for effective decision-making and coordination (Peansupap & Walker, 2006:373).

ICT can support information integration and this in turn may help reduce the volume of information processed as well as data re-entry by transferring information through Internet/Intranet protocols. This can provide benefits throughout project phases such as design, construction, operation and Project Management (Anumba & Duke, 1997:59; Deng *et al.,* 2001:242; Mitev *et al.,* 1996:229).

The use of ICT can enhance collaboration by supporting communication among project members and sharing of information and documents, especially when team members are located in different geographical areas (Ahmad *et al.,* 2002:603; Sriprasert & Dawood, 2002:7).

ICT usage can support 'e-commerce' and create opportunities to extend business or provide improved customer service (Anumba & Ruikar 2002:267; Skibniewski & Nitithamyong, 2004:25).

The benefits of ICT adoption by construction organisations have motivated several construction organisations to adopt and invest in this technology and many recent survey results indicate and increasing trend of firms using ICT in the construction industry (Froese, 2010:531; Rivard, 2000:39).

ICT adoption occurs in a country when organisations invest in technology to support their business activities, and when people begin to use it. In the presence of an increasingly "flat" world, it is important to study ICT adoption at the multiple levels of the individual, the organisation, the industry and the economy (Friedman, 2005:28).

Construction ICT trends can be categorized into three eras. The first era of construction ICT (now more than four decades old and still continuing) focused on developing stand-alone tools to assist specific work tasks such as CAD, structural analysis tools, estimating, and more. These tools are well established within current practice. A more recent second era (from the mid-1990s) of construction

ICT has focused on computer-supported communication such as e-mail, the web and document management systems. This is a less mature field, with new tools and core features still emerging, and business processes still adapting. Most of the construction ICT research and development over the past decade has pursued a third era of construction IT focused not on individual applications or transactions, but on the potential for uniting all of these as a cohesive overall system through integration, building modelling. This emerging ICT has seen some impressive innovative use in industry but has yet to reach mainstream application (Froese, 2010:531).

Rapid evolution of ICT offers opportunities to enhance communication between parties in construction projects and to enable more effective and efficient communication. The use of ICT is an area worth concentrating on because it can decrease time for data processing and communicating information (Adriaanse & Voordijk, 2005:164).

For this research, ICT is defined as technologies that support data and information processing, storage and analysis, as well as data and information transmission and communication, via the Internet and other means.

2.7 THE DISABLERS OF INFORMATION COMMUNICATION TECHNOLOGY ADOPTION IN PROJECT MANAGEMENT.

By analysing literature, it becomes clear that the adoption of ITC in the construction Project Management field has traditionally been low and constraints exist that limits its adoption.

The magnitude of ITC adoption in the construction industry remains low compared to other industries (ABS 2002; ACIF 2002). The above literature explains this slow ICT uptake 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.

Constraints at the personal level include limited budget for ICT investment, commitment from other project participants, issues of ICT standardisation, and security problems. At the organisational level, constraints include basic levels computer experience, time available to learn, and the identification of clear benefits of ICT use. Constraints at the group level include time available to share information, quality of personal contact and geographical distance (Peansupap & Walker, 2006:364).

A study of architectural, engineering and construction professionals identified IT implementation barriers and coping strategies at the industry, organisation and project level (Stewart *et al.,* 2002:159). While many construction organisations attempt to gain benefits from ICT investment, they may merely obtain partial benefits if a few people actually adopt and use it (Kosekela & Kazi, 2003:69).

Successful communication technologies adoption requires a 'critical mass' of adopters. Reported research findings addressed group-level users learning and sharing barriers, such as geographical distance and personal contact. When users adopt ICT, they may require access to help from an experienced person. User learning and sharing barriers can block the growth in the number of users and ultimately not achieving the benefit of ICT (Peansupap & Walker, 2006:359).

The following is a division of the adoption factors (Weber & Kauffman, 2011:689):

- Economic factors of ICT adoption (reduction in employment, rising cost and limited trade);
- Social factors of ICT adoption (digital divide, security and lack of education);
- Other factors of ICT adoption (legal, environmental and cognitive).

Table: 2-1 displays a comparison of disablers of ICT adoption based on technical, individual and social, managerial and other factors.

The first is a comparison of barriers to IT implementation in developing countries (Stewart *et al.,* 2002:686).

The second is a practical view of ICT implementation problems (Thorpe, 2003:73).

Table: 2-1 Table showing disablers of ICT adoption in Project Management.

Technological	Individual &Social	Managerial	Other
Source: Stewart *et al.* (2002:686)			
• High cost of IT • Quality & quantity of IT infrastructure • System incompatibility	• Lack of IT skills • Lack of IT support • Computer literacy	• Low level of IT awareness • Lack of leadership • Cost-driven strategy • Client lack knowledge of IT benefits • Low profit margins • High work load	• Language barriers • Industrial fragmentation
Source: Thorpe (2003:73)			
• Perceived slowness of Internet • Lack of local Internet connection • Slow bandwidth • Slow Internet connection • Data security	• People trust in electronic transaction • Low user satisfaction • Perceived benefit • Lack of computer literacy • User reluctance	• Cost of system implementation • Commitment of others	
Source: Gyampoh-Vidogah *et al*. (2003:165)			
• System incompatibility • Storage problems • Searching & retrieval problems	• Internal culture • Social uncertainty • Unchanging individual dominants • Reaction to technology • No optimal utilisation of employee potential • Lack of internal champion • Lack of management commitment	• Cost escalation • Paper waste • Poor access to information • Labour intensive • Delays & misunderstandings • Lack of corporate system	
Source: Stewart *et al.* (2004:159)			
• Security issues • Privacy issues • Poor inter-operability	• Resistance to change by staff • Low technology literacy • Fear of change • Fear of uncertainty	• Low level IT awareness • Reluctance to invest in innovation by management • Lack of IT strategic planning • Lack of perceived return on investment • Conservative business practice • Limited resources • Tight project time frame • Lack of leadership • Limited IT expenditure on projects	• Construction industry fragmented • Security issues • Privacy issues

The third is an exploration of the issue of information management, vision of the future, and the impact of efficiency (Gyampoh-Vidogah *et al.,* 2003:165).

Lastly there are the barriers/problems of IT implementation to industrial level, organisational level, and project level (Stewart *et al.,* 2004:159).

ITC adoption in the Project Management field is hampered by technical, individual, social, managerial and other factors (Gyampoh-Vidogah *et al.,* 2003:165; Stewart *et al.,* 2002:686; Thorpe, 2003:73). The main division of adoption factors is economic (reduction in employment, rising cost and limited trade) social (digital divide, security and lack of education) and others (legal, environmental and cognitive) (Weber & Kauffman, 2011:689).

2.8 THE ENABLERS OF INFORMATION COMMUNICATION TECHNOLOGY ADOPTION IN PROJECT MANAGEMENT

The implementation and adoption of Information Communication Technologies (ICT) in construction Project Management is not always easy but enablers exist that help to promote the implementation and adoption.

Emerging ITC introduces opportunities for improving communication to enhance effectiveness of many construction processes at each project phase as well as creating new business opportunities. Thus, perceived ICT benefits have motivated numerous construction organisations and construction Project Managers to invest in this technology. However, many might have found that the ICT investment has failed their expectations. One significant problem is a lack of understanding of how to actually implement ICT to a construction organisation (Peansupap & Walker, 2005:193).

ICT implementation and adoption is a management-intensive activity. Managers should reframe IT implementation expectations, create small wins, and reduce any conflict of interest (Skibniewski & Abduh, 2000:68). A top manager's decision to adopt ICT often progresses ICT implementation to the individual and group

level. These people are key actors who play a significant role in how ICT diffuses throughout an organisation (Peansupap & Walker, 2005:203).

Investments in Information and Communication Technologies (ICT) around the world have grown at a staggering rate over the past two decades. Information Technology (IT) industry consultant, Gartner, reported that worldwide spending in this area was in the order of US$3.4 trillion in 2010, rising by about 5.3% to US$3.5 trillion in 2011, reflecting a new emphasis on consumer mobile devices, virtualization solutions and security software (Burt, 2010:53).

Nevertheless, some developing countries still lag behind the nations of the developed world. For example, Laos had just four Internet users per 1000 people in its population in 2005 (United Nation Development Programme, 2007). As a result, it cannot be expected to compete in a progressively technology-intensive global economy with countries like Sweden, which has 764 Internet users per 1000 people in its population in the same year. This is a potentially insurmountable difference between the two countries - a dramatic “digital divide” - and these kind of disparities occur around the world in different nations, in different ways and to different degrees (Dewan & Riggins, 2005: 309; Mehra *et al.,* 2004: 788). This kind of virtual inequality is crippling for a country like Laos, considering the necessity of Internet-based technologies to power all types of consumer, organisational, industry and economy-level activities (Mossberger *et al.,* 2003:291). Both Laos and Sweden adopt technology in a similar pattern, although they are in different maturity stages of their adoption and their industry make-up differs dramatically.

A visit to a foreign country, especially a developing country, typically is sufficient to convince most sceptics that the global spread of diffusion of ICT is occurring at a high rate and the effects of their adoption are prominent, even if they are regionally spotty and path dependent (Burt, 2010:53; Varian *et al.,* 2004:36).

Table: 2-2 displays a comparison of enablers of ICT adoption based on technological, individual and social, managerial and other factors.

Firstly, the critical factors for ICT implementation are examined (Weippert *et al.,* 2002:108).

Secondly criteria for ICT adoption decision within the construction industry (Huang *et al.,* 2003:10).

Table: 2-2 Table showing enablers of ICT adoption in Project Management.

Technological	**Individual &Social**	**Managerial**	**Other**
Source: Weippert *et al.* (2002:108)			
• System compatibility • Data accessibility • Reliability • Capability	• Internet users and project participants commitment • User involvement • Quality and accuracy of information and data input	• Supported by developers i.e. ○ Implementers and researchers • Create a feeling of trust (reliability, relevance, need) for users • Ensure users provides quality and accuracy information to system • User involvement • Training and support • Champion IT driver	• Legal issues authenticity integrity confidentiality
Source: Huang *et al.* (2003:10)			
• Relative advantage i.e. ○ Compatibility ○ Complexity ○ Observability ○ Technology opportunities ○ Centrality ○ Cost ○ Communicability ○ Divisibility ○ Profitability ○ Social approval and image ○ Voluntaries ○ Result demonstrated ○ Visibility ○ Preparedness	• Characteristics of key individuals	• Characteristics of organisational structure i.e. ○ Innovativeness of organisation ○ Characteristics of communication environment ○ Organisational training and learning ○ Management attitude ○ External environment ○ Leadership	• Supply chain change • Process adjustment resulting from company growth • Process adjustment resulting from increased complexity of high tech facilities • Client demand and other process problems • Market pull

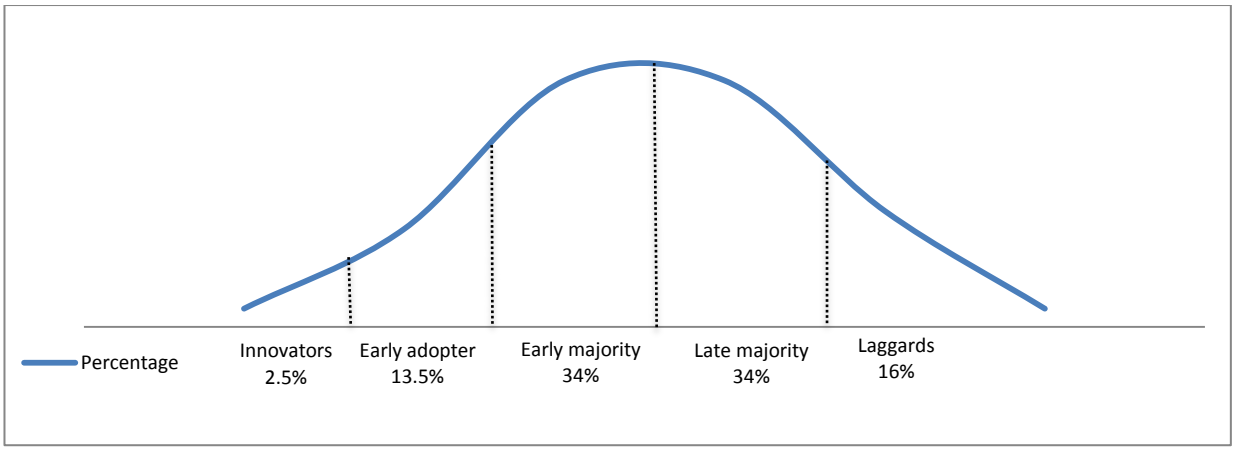
The criteria for adopting determinants are mainly inspired by the diffusion theory in which innovations were supposed to have a set of five characteristics (Rogers, 2003:5):

- Relative advantage;
- Complexity;
- Compatibility;
- Trial ability;
- Observe ability.

These help determining the subject's perception of an individual's attitude towards the technology as well as his/her innovativeness or timing of adoption decision. The perception of each of these characteristics is assumed to have a strong relationship with the innovativeness of an individual (as shown in figure 2-3):

- **Innovators**: are venturesome - they try new ideas at some risk.
- **Early Adopters**: are guided by respect – they are opinion leaders in their communities and adopt new ideas early but carefully.
- **Early Majority**: are deliberate – although they rarely are leaders, they adopt new ideas before the average person.
- **Late Majority**: are sceptical – they adopt an innovation only after a few have tried it.
- **Laggards**: are tradition-bound – they are suspicious of change and only adopt when the new idea becomes tradition itself (Rogers, 2003:6).

Fig: 2-3 Time of adoption of innovation.

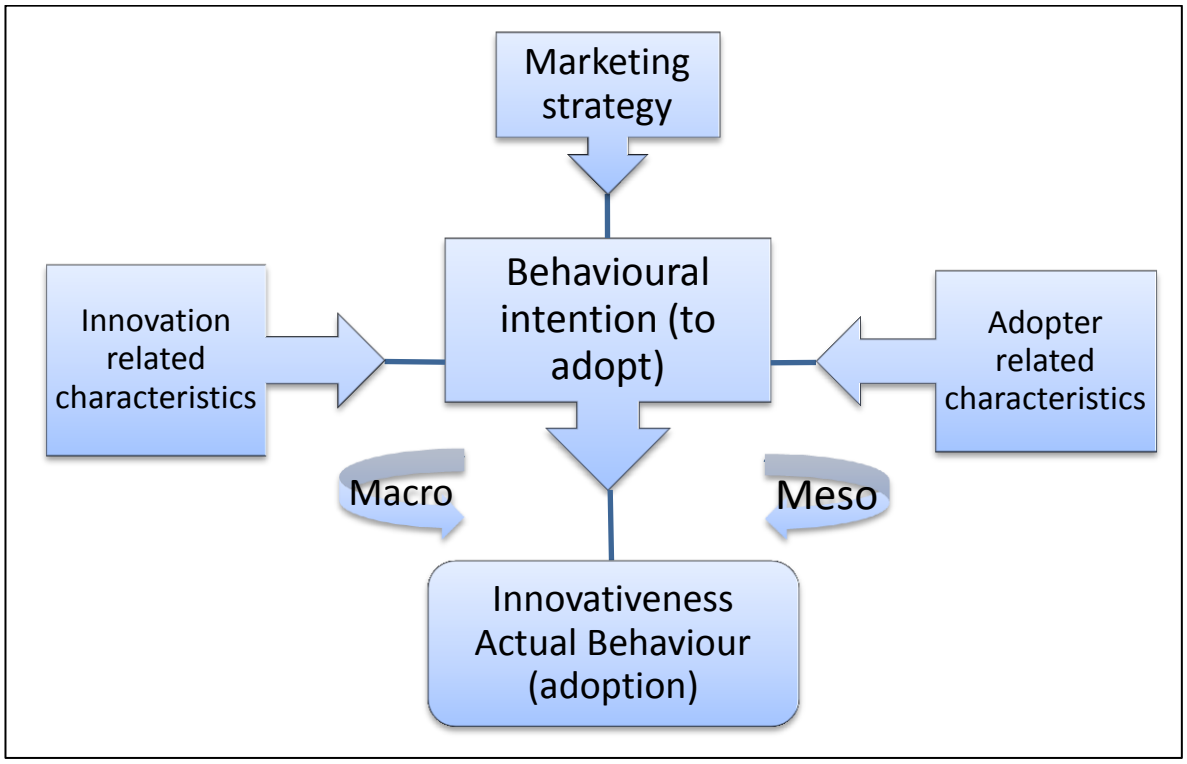


Source: Rogers (2003:7)

Innovators and early adopters, for example, are assumed to have a higher perception of relative advantage than the late majority segments, together with a lower perception of complexity of the innovation. Based on this the basic

theoretical model in figure 2-4 was developed focusing on innovation-related characteristics (De Marez, 2006:32).

Fig: 2-4 Basic theoretical model of innovation



Source: De Marez (2006:33)

Emerging ITC introduces opportunities for improving communication to enhance effectiveness of many construction processes at each project phase as well as creating new business opportunities (Peansupap & Walker, 2005:193).

Technological, individual, social, managerial and other critical factors have been identified that enables ICT adoption (Huang *et al.,* 2003:10; Weippert *et al.,* 2002:108).

Information Communication Technology adoption according to the diffusion theory which is based on innovation, is supposed to have a set of five characteristics, such as relative advantage, complexity, compatibility, trial ability and observe ability (Rogers, 2003:5). From this was developed the basic theoretical model of innovation focusing on innovation-related characteristics combined with macro and meso characteristics taking into account individual behavioural intention (De Marez, 2006:32).

2.9 FUTURE STUDY OF INFORMATION COMMUNICATION TECHNOLOGY BASED ON THE NEXT FIVE TO TEN YEARS

A future study has been done with the focus on forecasted technologies that can promote Project Management through the medium of Information Communication Technologies (ICT).

The hardware level of key technical developments in the future will be digitization, increased processing power, micro-electronics, and reduced use of energy, miniaturization, technical integration and the use of sensors (Bouwman *et al.,* 2005:32, Bouwman *et al.,* 2012:421).

At the software level, the focus is on compression techniques, increased intelligence, agent technology, security and improved man-machine interface (Bouwman & Van der Duin, 2003:12; Bouwman *et al.,* 2012:423).

The top six trends in Communication and Media Technologies, Applications and Services for the next five to ten years as set out as follows (Australian Communication and Media Authority, 2009:1):

- **An accelerating pace of change** driven by overlapping developments in technology, and connections between people, databases and objects (Ewan, 2012:1).

- **Diversity in development of physical infrastructure** including broadband, digital broadcasting, smart radio systems, sensor networks, mesh networks, efficiency techniques in multimedia transmission, location sensing and context-aware technologies, intelligent transport systems and satellite services.
    - Broadband*:* Broadband is a class of data transmission technologies, including optic fibre (FTTx), Xdsl (such as ADSL, ADSL2+, and VDSL), HCF cable and wireless (such as WiMax, HSDPA, LTE and iBurst), offering a data rate significantly higher than narrowband services. Higher bandwidth is necessary to meet demand for increasing data-rich and multimedia traffic that is increasing two-way, that is, upstream and downstream. The highest broadband speed internationally is currently in Japan, where optic-fibre deployment provides local access rates nearing

100 Mbit/s. In the next ten years multi-Gigabit data rates over optic fibre networks is technically possible (Bakhshi, 2008:3; Gardiner, 2008:1; GSMWorld, 2012; Richards, 2008).

Mobile network operators are working currently on speeds of up to 40Mbits/s the HSPA + technology (3G). This is being increased to 100 Mbit/s in the (4G) configuration in the course of the next five years. The 1000Mbit/s (5G) is in development and will only become commercially available between five to ten years (Corner, 2012:1; GSMWorld, 2012). South Africa will stay on 3G for the next few years and implementation of 4G will be very limited due to cost constraints.

The advantage for Project Management is that communication will be improved as large data files (drawings etc.) can be sent to remote sites. Web-based construction Project Management systems will become viable on all projects as the required bandwidth is available for data transmittal. Project managers can be more mobile as information will be more readily available out of office (Nitihamyong & Skibniewski, 2004:492; Tsai, 2009:325).

- Smart Radio Systems: While some smart radio capabilities are available now, a variety of new technologies is expected to evolve over the next decade. Cognitive radio and software-defined radio technologies are frequency agile and share spectrum without interference. Ideally, Cognitive Radio can individually and dynamically adapt its spectrum usage, taking into account Radio Frequency conditions such as interference and demand (the number of users and the applications they are using).

  Software-Defined Radio operating parameters are defined by its software rather than its hardware, enabling it to tune into different frequencies and receive any modulation across a large frequency spectrum. By its design, Software-Defined Radio can receive and transmit different forms of radio protocols simply by running different software. Software-Defined

Radio enables fast upgrades and extremely flexible operation (Posavec, 2008:13).

Cognitive Radio is seen by many as a key enabling technology for making use of so-called 'white space' spectrum that is underutilised by existing services. Of particular interest are the UHF television bands. A given channel in these bands may be unavailable for a high-power service due to the potential for interference to an adjacent area, but may support low-power services such as wireless local area networks. Cognitive Radio is likely to be attractive to licensees who currently manage self-coordination issues manually (Directionsmag, 2012; Lomas, 2008:2).

The advantage for Project Management is that communication will be improved as smart radio systems will make it viable for companies to stay in communication with its workforce for a fraction of the cost of other mobile systems over a very large geographic area (Alshawi & Ingirige, 2003:351; El-Saboni *et al.,* 2009:130).

- Sensor Networks: Sensor networks refer to embedded sensing and intelligence in materials and the environment. An early example of this is the development and deployment of passive Radio Frequency Identification (RFID) tags. Miniature wireless data chips are being embedded in objects, such as security passes or medical patient's wristbands that provide broad access to digital content in the physical world, ushering in new consumer and business applications.

  Advances in nanotechnology and miniaturisation will mean that smaller objects will have the ability to interact and connect to networks more generally, such as local area networks in homes and offices. Elements within sensor networks can report on their location, identity, history, operational status and operational needs. With the deployment of sensor networks and ambient intelligence, networked and interconnected devices and the roll-out of *IPv6*, an 'internet of things' is expected to

emerge over the next five to ten years (Georgia Tech Information Security Centre, 2012).

Ultra wideband technology has also been used to create precision location RFID tags to allow the tracking of high-value items such as monitoring equipment, and doctors and patients in hospitals. (Ultra wideband technology can transmit data at very high speed over a wide spectrum of frequency over relatively short distances.) Some of these devices use very low-cycle active devices rather than more common RFID devices that only transmit when interrogated. This could potentially lead to issues with devices being active outside their normal operating confines (Gardiner, 2008:1; Madden, 2012:3).

Other examples of networked devices include domestic energy meter readings, smart measurement and control, status/fire/fault monitoring, smart fault rectification for electricity distribution and railway networks, and many more. Interconnection of these devices is done by combination of wireless networks and wired infrastructure (Bakhshi, 2008:3).

The advantage for Project Management is that communication will be improved as material can be monitored more accurately with RFID tags. In construction the use of intelligent systems will become more prevalent as all elements of construction and the completed project will be monitored including labour and material (Nitihamyong & Skibniewski, 2004:500; Tsai, 2009:324).

- Mesh Networks: Mesh networking enables wireless network-enabled devices to establish low-cost, high-bandwidth, self-configuring and self-healing peer-to-peer networks over local geographic areas independently of managed access and control points (Madden, 2012:4).

  Mesh networking has been used for border security and to provide communication links for large-scale public events (Comtesse & Huang 2012:3; Posavec, 2008:12).

<u>The advantage for Project Management</u> is that communication will improve on large sites as mesh networks are established to improve communication between all role players. Information will be available instantaneous and more complex projects will be completed in a shorter time span (El-Saboni *et al.,* 2009:131).

- Efficiency Techniques in Multimedia Transmission: There are on-going technological developments that increase the amount of data that can be transmitted over a given physical infrastructure. These developments occur in terms of:
  - Multiplexing - the number of channels that can be supported on the infrastructure, be it wireless, copper cable or fibre;
  - Encoding - the conversion of a signal from one format to another;
  - Compression - techniques used to reduce the actual amount of data carried while preserving as much of the original content as possible.

  Error Correcting - techniques used to detect, correct or reduce the impact or errors in data transmission (Bakhshi, 2008:5; Comtesse & Huang 2012:3; International Telecommunication Union, 2012; Pettey, 2012).

  <u>The advantage for Project Management</u> is that communication will improve through the use of multiplexing, encoding, compression and error correcting (Alshawi & Ingirige, 2003:349; El-Saboni *et al.,* 2009:133).

- Location Sensing and Context-Aware Technologies: Wireless devices may know with increasing accuracy where a user is. Location-based services are expected to evolve through devices or objects with RFID and GPS connectivity. The Geographic Information System (GIS) is becoming more widely deployed for tasks such as requesting directions, locating services or directing emergency service response. Content marked with location data has forged the development of what has become known as the Geospatial Web - the merging of geographical,

location-based information with web-based information, for example, Google Earth. People-tracking and location awareness by machines including position sensing and visual orientation, have emerged (Google, 2012; Somasegor, 2008:7).

The advantage for Project Management is that location of equipment and people can be more closely monitored that will help to reduce misunderstandings and errors and thereby improving the flow of communication (El-Saboni *et al.,* 2009:130).

- Intelligent Transport Systems Technologies: Intelligent Transportation Systems use a broad range of wireless technologies that, when integrated into the transportation system infrastructure and vehicles themselves, help to monitor and manage traffic flow, relieve congestion, provide alternative routes to travellers, improve safety and save lives. The Intelligent Transportation Systems technology is enabled using Dedicated Short Range Communications (DSRC) (Posavec, 2008:18).

  The advantage for Project Management is that safety will improve and time delays on transport can be minimised. This will also reduce fuel consumption and be more environmentally friendly.

- Satellite Services: Satellites are an increasingly capable substitute for terrestrial access infrastructure. Far from being banished to niche markets covering remote and sparse populations over huge distances, they are a common access method for many main-stream services such as pay and free-to air TV services. In telephony, remote area extensions to cellular services are using satellite services are moving from niche to mainstream, while broadband services to aircraft can only be provided by satellite and are becoming a basic facility for commercial international travel (Bergendaht, 2012:3; Gardiner, 2008:1; Quested, 2012).

  The advantage for Project Management is that on remote sites where GSM coverage is not available, satellite services are being used and will be used for communication, the cost to do this will continue to become

more affordable as the satellite network increase in bandwidth (Tsai, 2009:324).

- Continuing **spread of distributed connectivity** through the integration of information processing beyond the desktop into everyday objects and activities.

    - Computer Networking Technologies: This section includes peer-to-peer networking, data processing, compression and storage, platform interface architecture and system integration. The cost of storage is decreasing and demand is increasing. With solid state flash memory (no moving parts as opposed to hard drives) higher capacity storage can be incorporated into smaller form factors (e.g. smaller size iPods with multi-gigabyte storage capacity). Computers at the edge of the network, including PCs, game consoles and mobile devices, have ever-increasing processing and storage capacities. Increasing capacities and use of local storage and data re-use has possible implications for communication and media business models (Horrigan, 2012:3; Madden, 2012:2).

      Peer networks enable new forms of voice connectivity, social interaction and file sharing independent of the carriage service provider. Control over application or service use is continuing to migrate from service providers to end-users (Bakhshi, 2008:3; Somesegor, 2008:6).

      The advantage for Project Management is that more storage is available at lower cost. All forms of contract communication can be stored with space becoming less of a constraint (Alshawi & Ingirige, 2003:355; El-Saboni *et al.,* 2009:130).

    - IP-Based Services: The use of Internet protocol (IP)-based transmission technologies is driving the design and use of the telecommunications network and platform coverage. IP-based networks standardisation is an important international activity. Developed by the mobile communication industry, IP Multimedia System (IMS) is an open system architecture that supports a wide range of IP-based multimedia services over packet and circuit-switched networks. Internet Protocol Multimedia Subsystem may

form the basis of the coverage of fixed and mobile communication. Voice over IP (VoIP) and IPTV are examples of IP-based services and applications (Hruska, 2012:3).

The evolution of multimedia telephony is likely to include value-added services that blend voice with other applications and Web 2.0 features 'intelligent telephony' would take context into account, such as defaulting to voicemail when the user is asleep (Bergendaht, 2012:4; Kerravala, 2008:1).

An additional consequence may be that data carriage requirements will become more symmetrical. Currently, upstream and downstream data requirements for residential Internet access are generally asymmetrical, with the upstream path requiring much less data capacity than the downstream path. Increasingly, user interaction applications, such as Facebook, will require similar uplink and downlink capacities (Bergendaht, 2012:4; Facebook, 2012).

This will influence radiofrequency spectrum demand in wireless networks, as uplink and downlink Radio Frequency bandwidths will need to be more balanced, and require a revision of Xdsl deployment standards (Bakhshi, 2008:2; E-Marketer, 2012).

The advantage for Project Management is that Voice over IP (VoIP) will reduce the cost of communication substantially. With the use of multimedia telephony physical contact between projects, parties will be reduced; this will account for large cost and timesaving (Alshawi & Ingirige, 2003:355; Bergendaht, 2012:4).

- **Enhanced content and network management capabilities** are driven by development in deep packet inspection and content filtering technologies, coupled with the need to improve e-security, identity management, intellectual property protection and energy efficiency.

- Content Monitoring Technologies: Content monitoring technologies include deep packet inspection and content filtering software. Deep packet inspection examines the inside structure of data packets to determine their content. If the technology was to be deployed in Internet service providers' networks, it could potentially help them to know more about their users and traffic. Internet Service Providers would be able to block, shape, monitor and prioritise the traffic-in any direction. Deep packet inspection is an enabler of traffic price discrimination (Ohm, 2009:2).

  Deep packet inspection could be used by service providers to control or 'shape' traffic data flows to cope with heavy traffic threatening congestion. Likewise, it would help to prioritise differentiated traffic. It can be used to scrutinise content to decide whether to let it go through (Bergendaht, 2012:6; Posavec, 2008:12; Ohm, 2009:2).

  The advantage for Project Management is that time will be saved by the project manager as content monitoring technologies will prioritise and differentiate traffic (Tsai, 2009:326).

- E-security: As the Internet and associated applications such as email and web browsers are used for an ever-increasing number of business and social transactions, organised crime is focusing increasingly on Internet-related crime (Hruska, 2012:4).

  There will be a growing focus on website security to prevent legitimate websites from becoming unwitting host of malware. Social networking sites are likely to be prime targets of criminal attack, as are other websites with significant potential for the harvesting of personal identity information, including government websites.

  Improved authentication and validation systems for Internet communication and transactions need to be developed, both for high-level transactions such as Internet banking and for more routine communication such as email (Georgia Tech Information Security Centre, 2012:2; Lomas, 2008:3; Ohm, 2009:1).

<u>The advantage for Project Management</u> is that Internet related crime and identity theft can be reduced and this will reduce down time. The main advantage is that participants will feel more at ease to provide confidential information in electronic format and it will reduce one of the last barriers for full digital commerce (Hruska, 2012:4).

- Identity Management: A digital identity is a set of attributes for an entity such as a person, service, device or an application. In order to assert a particular identity in each case, it is necessary to enable the mutual exchange of information that is relevant to the provision of a particular service or application, but which may also be personal or sensitive. The structure, security, storage, interoperability and availability of digital identities are requirements that form part of an identity management framework. Identity management framework has been developed by the International Telecommunication Union to progress a standardisation process for digital identity attributes (Georgia Tech Information Security Centre, 2012:2; Lomas, 2008:1; Ohm, 2009:1).

  <u>The advantage for Project Management</u> is that identity security will improve, allowing individuals more freedom to share personal information digitally. All project detail can be shared with little risk of theft (Ohm, 2009:1).

- Access and Management of Digital Content Technologies: Digital rights management is the control and protection of intellectual property in content that is stored in digital form, including documents, images, video and audio. Digital right management attempts to limit what a user can do with the content even when in possession of it. The arrangement for managing digital rights might be a combination of encryption and validation processes, conditional access, for example smart cards, or any other means used to secure and control digital content (Lomas, 2008:2; Ohm, 2009:1).

- Energy Efficient Application: There is a growing awareness of the effect of climate change and a focus on saving energy.

This is a fast-developing technology driven by the unprecedented business opportunities for the 'greening of the bottom line'. Attention is being paid to techniques that measure energy usage parameters and allow energy data to be communicated and analysed. Video and web-conference tools now reduce the need to travel for work and allow more employees to work from home (International Telecommunication Union, 2012:2; Pettey, 2012:4).

The advantage for Project Management is that this will bring down the carbon footprint of communication on a project to the point where all paperwork should be eliminated, travel between projects by participants will be substantially reduced as this will take place increasingly in a digital environment. (Alshawi & Ingirige, 2003:357; Pettey, 2012:3).

- **The emerging social web** acting as both a platform and database, enabling innovation and creativity by users and service providers. Web-based technologies, falling under the umbrella 'Web-2.0', have ushered in the era of user-generated content, and the continuous and seamless update of data and reusable services. The web is now turning into both a platform and a database (Kerravala, 2008:1).

  Social Networking Sites: These sites enable individuals to 'put their lives online' by posting personal profiles and other information online (Madden, 2012:3).

  Social Networking Sites may evolve over the next five years to become integrated hubs for individuals, organisations and their extended networks to connect, communicate, access and share tailored news, information and entertainment. They are becoming social destinations in their own right, which can lead to a 'blurring of the boundaries' between online and offline worlds (Hendrickson, 2008:2; Hruska, 2012:3).

  Some organisations see real-time collaboration through social networking as an effective way to manage large-scale and geographically dispersed teams, and for organisational communication (Hendrickson, 2008:3; Posavec, 2008:4; Richards, 2008:2).

<u>The advantage for Project Management</u> is that this can be used by project participants as a means of communication to share ideas at a relatively low cost. All of them can participate in brainstorming sessions. The public can become involved in projects by raising concerns or suggestions in an unobtrusive way (Hendrickson, 2008:3).

- Mobile Web: Although web access has been mostly on PC during the last decade this is being augmented by web-enabled mobile devices. During the next five years this will only accelerate as more powerful devices are being introduced to the market (Bakhshi, 2008:2; Corner, 2012:1; Lomas, 2008:2).

  <u>The advantage for Project Management</u> is that the increased use of the Mobile Web will allow al project participants to communicate and give feedback on programs and drawings available on the web in a real time environment (Tsai, 2009:324).

- Internet TV: Beginning with online video streaming and downloading through applications like YouTube, more advanced Internet TV services such as Joost are now available. In five to ten years, Internet TV may have high-quality pictures and streaming, along with established web features such as sharing and personalisation (Bergendaht, 2012:3; Gardiner, 2008:1; Richards, 2008:2; Quested, 2012:2).

  <u>The advantage for Project Management</u> is that by utilising YouTube as an example project-specific problem and digital data can be shared in a shorter time frame than when all parties have to wait for a meeting to evaluate and look at the problem (Richards, 2008:3).

- Cloud Computing: Also known as ‘computing on demand’ or ‘software as a service’, cloud computing is the shared use of distributed computing resources as an alternative to in-house IT applications and services using local servers or personal devices. Cloud computing offers scale flexibility and cost-efficiency, and have the potential to be highly disruptive to desktop computing technology within the next five years (Horrigan,

2012:2; Hruska, 2012:2; Kerravala, 2008:1; Somasegor, 2008:6; Quested, 2012:3).

The advantage for Project Management is that project specific data can be placed in a central cloud database for all to access and to work on. The data available will always be up to date for all to use, backup concerns are also minimised (Alshawi & Ingirige, 2003:357; Quested, 2012:3).

- Virtual Identities: While currently dominated by online games such as Second Life and virtual identities such as avatars on social networking sites or other online interactions, more forms of virtual world activity are anticipated. Development may include enhanced reality (electrochemical stimulation of the brain), augmented reality (combination or blurring of real and digitally modified identities and physical environments) and tele-presence (video conferencing with more sophisticated video capture through holographic). The blurring of the boundaries of real and virtual identities is currently being experienced most intensively by young people, but many will become widely experienced over the next 10 years (Kerravala, 2008:1; Ohm, 2009:1).

  The advantage for Project Management is that by using virtual identities project participants can have meetings in cyberspace. This will be advantageous for projects where a lot of brainstorming is required while participants are dispersed over long distances (Alshawi & Ingirige, 2003:362; Ohm, 2009:1).

- Semantic Web: The semantic web involves using metadata to enable computers to process the meaning of data (intelligent agents). Although this has now been in 'gestation' for some time, an increasing number of companies are working to fully implement the semantic web. Over the long term, the aim is to develop a common framework that allows data to be shared and reused across application, enterprise and community boundaries so that a machine can perform particular tasks to the extent

that humans do now (Kerravala, 2008:1; Lomas, 2008:1; Moore, 2008:3; Ohm, 2009:1; Posavec, 2008:3).

The advantage for Project Management is that in the future this can save a lot of time as routine tasks are done for project participants by computers (Ohm, 2009:1).

- **Continuing scientific and technological innovation**, which in combination is driving advances in computing power, display technologies, artificial intelligence and nanotechnology.

    - Computing Processor Power: Moore's Law is frequently quoted as the doubling of computer power every 18 months, a momentum which has held for the last three decades (Moore, 2008:3; Taylor, 2000:99).

      Computing power is expected to continue to grow consistent with Moore's Law over the next decade and beyond. The momentum around multi-core processors is building. IBM has recently announced a technological breakthrough whereby light is used instead of wires to connect hundreds of thousands of processing cores on a tiny chip. Expected benefits include reduction in cost and energy use, while increasing bandwidth. Research in quantum computing is also gathering momentum at a considerable cost (Ewan, 2012:1; Moore, 2008:3).

      The advantage for Project Management is that processor power affects the use of large scale CAD drawings on mobile devices as processor power increases; this will become viable and the speed will increase to a point where real time 3D rendering can be done on mobile devices (Ewan, 2012:1).

    - Display Technologies: There are several emerging display technologies that, according to their respective backers, do a better job than either of the current large screen contenders - LCD or plasma display. Canon has unveiled Surface-conduction Electron-emitter Display technology that is based on the same technology as traditional cathode ray tube (CRT)

television, miniaturised and packed inside a flat-panel display. Surface-conduction Electron-emitter Display technology can create HDTV video quality with all the benefits of a CRT display without the CRT size. Sony has developed Field Emission Display commercially known as Light Emitting Diode Display (LED) which has very low power consumption and the same high quality HDTV video quality.

There are steps towards the goal of selling enormous, ultra-thin displays (or even wallpaper) televisions to all homes at an affordable price. Developments are also likely in the form of electronic newspapers, or flexible screens, among others. Disposable screens on consumer products may also be feasible. There may evolve functional portable electronic-document readers with display that can unroll to a scale larger than the device itself. This can also be used for drawings on building sites (Bergendaht, 2012:4; Moses, 2008:3)

The advantage for Project Management is that these developments will lead to a much greater range of display surfaces, with electronic content consequently permeating virtually every corner of people's lives. Paper based contract drawings will in the near future be replaced with electronic format flexible drawings, which will also have the capability to handle 3D where current hard copy drawings can only handle 2D (Alshawi & Ingirige, 2003:362; Bergendaht, 2012:4).

- Artificial Intelligence (AI): Artificial Intelligence (AI) enables computers to recognise objects or patterns and perform tasks that usually require human intelligence. There is a growing interest in consumer-oriented robots, such as robot dogs that are capable of understanding some human speech and intelligent humanoids that can walk down stairs, respond to verbal instructions and talk. Most useful robots are unlikely to be humanoid as such, but they are likely to be extensive users of spectrum in a variety of ways. Although many are sceptical, the promise of AI on the web continues to attract interest, and the possibility of breakthroughs in this area over the next 10 years cannot be dismissed (Lomas, 2008:1; Somasegor, 2008:3).

<u>The advantage for Project Management</u> is that Artificial Intelligence will increase the capabilities of pattern recognition, which will have the effect that more routine tasks can become automated and does not require the input of the Project Manager.

- Nanotechnology: In broad terms, nanotechnology is the understanding and control of matter at the molecular and anatomic level. A widespread transition to nanotechnology techniques could occur around 2015. The impact of the developmental activities are already being felt in the market, facilitating the emergence of communication devices like digital cameras, mobile phones and flat-panel televisions (Horrigan, 2012:3).

  Battery technology generally is improving at a slower rate than processing and chip technology, potentially limiting application development. However, reducing conventional lithium ion batteries to Nano scale improves power density and recharge time dramatically. By developing computing in organic substrates rather than silicon, Nano-computing is likely to address the integration of information technology with biological systems (Horrigan, 2012:3).

  As a pervasive (disruptive) and fundamental technological shift, it is hard to predict impacts Nanotechnology might have on ITC, but they are important to monitor. The development and deployment of laser technology over the last four decades might provide an analogy. Further development in Nano- technology might result in a large increase in sensor networks, including networks that reside either on or in the human body (Somasegor, 2008:4; Horrigan, 2012:3).

  <u>The advantage for Project Management</u> is that battery storage will increase substantially making the use of more powerful mobile devices viable. With the increase in battery power, a full workday can be expected from the devices. This will have the effect that a Project Manager can be out of office a full workday and all mobile devices will function (Horrigan, 2012:3).

In the future, we can expect an ever-increasing pace of change driven by overlapping developments in technology, and connections between people, databases and objects (Ewan, 2012:1).

At the hardware level key technical developments in the future will be digitization, increased processing power, micro-electronics, and reduced use of energy, miniaturization, technical integration and the use of sensors (Bouwman *et al.,* 2005:32; Bouwman *et al.,* 2012:421).

At the software level, the focus in the future will be on compression techniques, increased intelligence, agent technology, security and improved man-machine interface (Bouwman & Van der Duin, 2003:12; Bouwman *et al.,* 2012:423).

Computing power is expected to continue to grow consistent with Moore's Law, thus doubling every 18 months over the next decade and beyond (Moore, 2008:3; Taylor, 2000:99).

The effect will be improved communication, an increase in the speed of data transmission, cost savings and fewer occurrences in miscommunication.

The effect of future developments in ITC will be profound and if applied correctly Project Management through the means of communication will be affected positively.

2.10 CONCLUSION

A Project Management methodology will become even more important in the future as the delivery of a project on time, within budget and with the required quality levels becomes more difficult to achieve with the increasing complexity of projects. The structured approach of a methodology will improve communication by means of communication management as per a defined structure.

The triple constraint of Project Management is within time, within cost and within performance/quality. As projects become more complicated the triple constraint will come under ever increasing pressure and as communication has been

identified as the root cause of most project failures this must be managed with increasing urgency.

Construction Project Management is a new mode of Project Management, which is consistent to the objective of construction engineering, which is a mode of taking the project as the start, the centre and the ending. It is based on the triple constraint of Project Management and will become under increasing pressure as project complexity and demands increases in the future. The importance of communication will increase in the future as the need to manage the flow of value adding activities across the supply chain is increased.

Project Managers can improve good decision making and increase organisational bottom line numbers by utilising quality information characterised by the following attributes - accuracy, completeness, consistency, uniqueness and timeliness.

ITC are defined as technologies that support data and information processing, storage and analysis, as well as data and information transmission and communication, via the Internet and other means.

It is clear that ICT can be disabled by economic (reduction in employment, rising cost and limited trade), social (digital divide, security and lack of education) and other (legal, environmental and cognitive) factors which must be managed to ensure that communication is not hampered.

ICT can also be enabled based on relative advantage, complexity, compatibility, trial ability and observe ability - this is a management-intensive activity: managers must create small wins and reduce conflict of interest. Identify a person in the organisation who will be available to help others with the new technology and also to help promote the technology under colleagues.

It is clear from the literature that ICT will be positively effected in the future through new developments in mobile technology, faster networks, better information security, increased use of satellite services, global use of cloud computing, better display technologies increasing tempo of nanotechnology development - the effect will be improved communication, an increase in the

speed of data transmission, cost savings and fewer occurrences of miscommunication.

2.11 CHAPTER SUMMARY

What is clear in all methodologies of Project Management is that communication forms a very important part thereof. In Project Management Body of Knowledge (PMBoK) it is called Communication Management and the same also applies to Projects in Controlled Environments (PRINCE2). Communication must form part of any successful methodology.

Where the emphasis has traditionally been on the need to manage the interface between the project and the client's organisation, it is now shifting towards the need to manage the flow of activities across the supply chain, concentrating on those activities that actually add value. This has increased the importance of communication at all stages in the Project Management process.

Current Project Management practices are often isolated and are concerned with managing problems related to individual stages of the project. This must change to where communication is the driver of all stages of Construction Project Management in an integrated method.

Rapid evolution of ITC offers opportunities to enhance communication between parties in construction projects and to enable more effective and efficient communication. The use of ICT is an area worth concentrating upon because it can decrease time for data processing and communicating information.

For this research, five characteristics common to high quality information is defined as information quality - accuracy, completeness, consistency, uniqueness and timeliness. High quality information will directly influence the quality of communication.

The main division of ICT disablers is economic (reduction in employment, rising cost and limited trade), social (digital divide, security and lack of education) and others (legal, environmental and cognitive).

ICT enablers have a set of five characteristics, namely relative advantage, complexity, compatibility, trial ability and observe ability.

Emerging ITC introduces opportunities for improving communication to enhance effectiveness of many construction processes at each project phase as well as creating new business opportunities. The effect of future developments in ITC will be profound and if applied correctly, Project Management through the means of communication will be affected positively.

In the next chapter, an empirical study was conducted. The results obtained from this study is thus presented and defined in the next chapter. The primary objective is to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment.

In the empirical study, the characteristics of quality information, the disablers and the enablers were investigated taking into account the current rate of ICT adoption in the South African Construction Management Environment.

CHAPTER 3

RESEARCH FINDINGS AND DISCUSSION

3.1 INTRODUCTION

The primary objective of this study was to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment. Project complexity has increased and that communication is more important today than ever before, this is supported by the fact that fewer projects get competed on time, within budget and with the required quality level than in the past.

The literature review conducted in Chapter 2 provided an overview of Construction Project Management and the characteristics of quality information, the disablers and also the enablers were used as basis to design a questionnaire to be used in the empirical study. The current rate of ICT adoption is also measured.

The empirical study was conducted by means of an electronically self-completed questionnaire distributed to participants through the web site SurveyMonkey (2012), web based survey tool to determine the current rate of ICT adoption as well as to focus on the adopter phases of the participants. (Refer to Annexure A for an example of the questionnaire and to Annexure B for survey results (Descriptive Statistics)).

This chapter provides insight into methods and procedures used in gathering the information for the empirical research of this study, the sample used (including the sampling method and size), the demographic structure, the method used for gathering information, the presentation and discussion of the research results.

3.2 GATHERING OF DATA

Permission was obtained from the South African Council for the Project and Construction Management Professionals (SACPCMP) to distribute the questionnaire to all people registered with them and subsequently on their data base. The questionnaire was distributed by (SACPMP) to all members via e-mail as a link to the SurveyMonkey website. The participants had to follow the instructions on the questionnaire, complete the survey by marking the appropriate box they selected with an “X”, the completed questionnaires were send to the SurveyMonkey website for later retrieval.

3.2.1 Study population

The South African Council sent out the questionnaire for the Project and Construction Management Professionals (SACPCMP) to 1200 registered members on their database via email. Of the registered professionals, 192 members replied to the email. One member outside South Africa responded and this was disregarded.

3.2.2 Questionnaire used in this study

In order to confirm and substantiate the outcomes of the literature review and to investigate the use of ITC in the South African Construction Project Management Environment, a structured questionnaire was used. The questionnaire was constructed and validated with the assistance of the North-West University Statistical Consultation Services. A covering letter to explain the purpose of the questionnaire to the respondents formed part of the document and the confidentiality of each respondent was ensured within this document.

Struwig and Stead (2004:107-108) stated that the construction of a questionnaire has to fulfil certain requirements, namely:

- The significance should be clearly and carefully stated on the questionnaire or in the letter that accompanies it:
- It only seeks information that cannot be obtained from other sources:

- It must be as short as possible and only long enough to obtain the essential data. The writing required from the respondent must be kept to a minimum and the response system must be made clear and easy;
- It must be attractive in appearance, neatly arranged, and clearly duplicated or printed:
- Directions need to be clear and complete. Important terms must be defined. Each question must deal with a single idea and must be worded as simply and clearly as possible. Avoid asking two questions contracted in one;
- The questions must be objective, with no leading question suggestions as to the response desired;
- Questions have to be presented in good psychological order, proceeding from general to more specific response. If possible, avoid annoying or embarrassing questions. When questions of a delicate nature are necessary, the questionnaire should be anonymous;
- It is important to allocate code numbers to all possible response to permit easy transference to the format of a computer programme

The questionnaire consists of nine sections, namely:

Part A: Demographical information (Question 1-11)

Section A comprised of the gathering of demographical information where participants had to indicate their registration type, age, gender, home language, highest level of education, years' working experience, years' industry experience, area of operation and how many people report to them.

Part B: Construction Project Management in general (Question 12-16)

Section B's purpose was to assess how respondents interpret the advantage of ITC in Construction Project Management Environment. The complexity of Construction Project Management was also analysed. Questions were answered based on a 4-point Likert type scale ranging from Strongly Agree (1) to Strongly Disagree (4). In respect of each question, respondents had to indicate the degree to which they agree or disagree with a certain statement.

Part C: Information Communication Technology adoption (Question 17-18)

In Section C, 6 items were identified to measure the current rate of ITC adoption in the Construction Project Management Environment that the Project Manager will have access to. In respect of each item, respondents had to indicate if they have access or own the technologies.

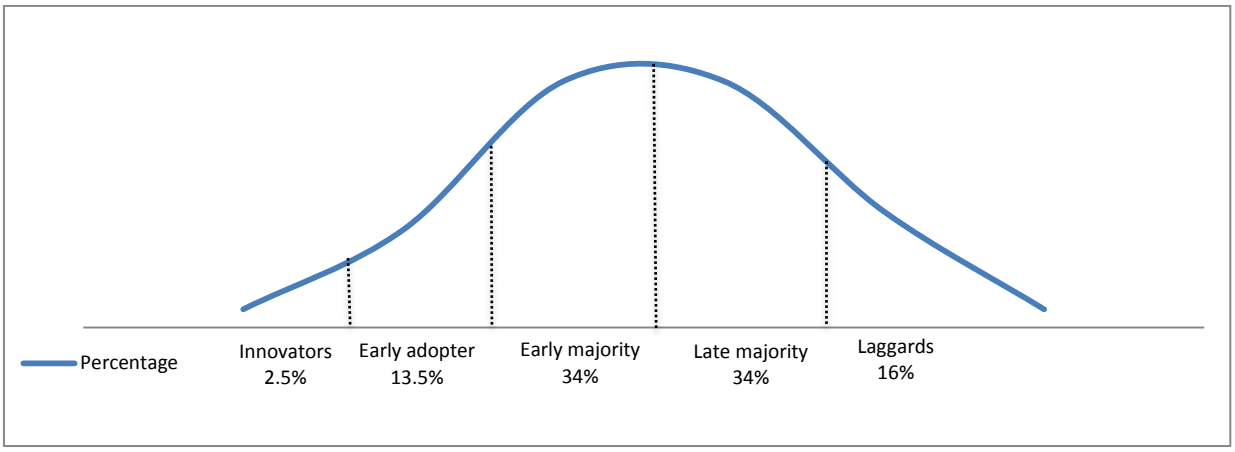
Part D: Adoption phase (Question 19-20)

Section D measured the respondent's adoption phase as per the diffusion theory in which innovations were supposed to have a set of five characteristics namely

- Relative advantage;
- Complexity;
- Compatibility;
- Trial ability;
- Observe ability.

These characteristics help to determine the subject's perception of an individual's attitude towards the technology as well as his/her innovativeness or timing of adoption decision (Rogers, 2003:5). The perception of each of these characteristics is assumed to have a strong relationship with the innovativeness of an individual as shown in figure 3-1.

Figure: 3-1 Time of adoption of innovation.



Source: Rogers (2003:7)

Part E: Hardware Replacement (Question 21-22)

In Section E the replacement intervals of hardware was measured in the Construction Project Management Environment based on a 7-point Likert scale. Ranging from do not own one (1) to more than 4 years old (7).

Part F: Internet access (Question 23-25)

In Section F, 26 items were identified to measure Internet access of participants based on a 4-point Likert scale. Ranging from *Almost always* (1) to *Almost never* (4). These 26 items determined Internet access and usage of participants.

Part G: Software applications hardware based or cloud based (Question 26-27)

Section G measured if software used were hardware based or cloud (web) based on a 5-point Likert scale. Ranging from *Almost always* (1) to *Almost never* (5).

Part H: General usage of devices (Question 28-32)

In Section H, 28 items were identified to measure usage and adoption of technology based devices, based on a 5-point Likert scale. Ranging from never heard of it (1) to I use this regularly (5). These 28 items determine and individual's general technology awareness and usage.

Part I: Difficulties experienced with technology (Question 33)

Section I measures on a 4-point Likert scale difficulties experienced with technology. The scale ranged from Almost always (1) to Almost never (4). These 4 items determine difficulties experienced with technology in the past.

3.2.3 Confidentiality

Confidentiality was ensured to all participants. Respondents' individual results could not be traced back as SurveyMonkey only allocates an IP address without the person's name, or email address. The system was also programed to protect the respondent's confidentiality by not allowing them to enter an email address into the survey.

3.2.4 Statistical analysis of data

Data collected during the survey was analysed by Statistical Consultation Services of the North-West University (Potchefstroom-Campus) using Statistica (Statsoft, 2008) and SPSS (SPSS, 2008). In this study, frequency distribution will be tabulated or portrayed graphically in the form of histograms or bar charts. The mean will be employed as measure of central tendency and the standard deviation to indicate dispersion of data.

3.3 RESPONSES TO THE SURVEY

In Table 3-1, a tabular presentation is given of the responses to the survey.

Table 3-1 Response to the survey

Response type	Frequency	Percentage
Number of questionnaires distributed	1200	100.00%
Number of questionnaires returned	192	16.00%
Number of questionnaires analysed	191	15.92%

A total of 1200 email links to the questionnaire were send out by the South African Council for the Project and Construction Management Professionals (SACPCMP). A total of 192 questionnaires were started on the SurveyMonkey link and 192 were completed by the cut of date of 27 July 2012. The response rate was 16.00%, but only 15.92% of the questionnaires distributed could be analysed. One questionnaire was disregarded as the respondent was outside South-Arica. The scope of the study only focused on South-Africa.

3.4 DESCRIPTIVE STATISTICS MEAN AND STANDARD DEVIATION

In a normal distribution, the majority of values lies within an interval plus or minus one standard deviation above or below the mean. The more dispersed the data, the larger the standard deviation (Levine *et al.,* 2008:118). The results of the means analysis are attached in Annexure B for survey results (Descriptive Statistics).

3.5 DEMOGRAPHIC INFORMATION OF RESPONDENTS

Section A of the survey questionnaire captured the demographical information of respondents where they had to indicate their registration type, age, gender, home language, highest level of education, years working experience, years industry experience, area of operation and how many people report to them.

3.5.1 Registration type

The purpose of this question was to determine the respondents' registration type and to determine if this plays a role in their ITC adoption. The mentor registration type has a double registration (Mentor plus Pr. CPM. or Mentor plus Pr.CM.) this explains why 199 frequencies were achieved and 192 questionnaires were returned.

Table 3-2 Registration type

Group	Registration type	Frequency	Percentage
1	Pr. CPM.	63	31.66%
2	Pr. CM.	22	11.06%
3	Mentor	7	3.52%
4	Candidate	81	40.70%
5	Other	26	13.07%
	Missing information	0	0.00%
	Total	**199**	**100.00%**

The majority of the respondents fall in the category Candidate (40.70%) and followed by Pr.CPM. (31.66%) respectively. These two registration types amount to 72.36% of the total responses. The Pr.CPM. registration is a legal requirement by government on consultants where Construction Company uses the Pr.CM. more but is not legally required at this stage. This explains the much higher percentage 31.66% Pr.CPM. compared to 11.06% Pr.CM.

3.5.2 Age group classification of respondents

Respondents were requested to supply their age which was divided into the 5 categories listed below. The purpose of this question was to understand the age distribution of respondents, as for example a group closer to retirement (60+) could have different views than the group of 29 and younger. The results of the age classification of participating respondents are presented in table 3-3.

Table 3-3 Respondents by age group

Group	Age Group	Frequency	Percentage
1	≤ 29	35	18.32%
2	30-39	56	29.32%
3	40-49	43	22.51%
4	50-59	31	16.23%
5	60+	17	8.90%
	Missing information	9	4.71%
	Total	**191**	**100.00%**

The majority of the participating respondents fall in the age group category 30 to 39 (29.32%) years old and 40 to 49 (22.51%) years old respectively. These two age group categories amount to 51.83% of the total responses. The mean is **41.41 years** and the standard deviation is **11.795** indicating a large percentage around the mean.

The age group 60+ had 8.90% of the respondents that is relatively high taking into account the retirement age of 63 in South Africa. Nine respondents did not complete this question.

3.5.3 Gender of respondents

Respondents indicated their gender by selecting a block termed “Male” or “Female” in section A of the questionnaire. The results are presented in Table 3-4.

Table 3-4 Gender of respondents

Group	Gender	Frequency	Percentage
1	Male	158	82.72%
2	Female	32	16.75%
3	Missing information	1	0.52%
	Total	**191**	**100.00%**

Of the 191 respondents, 32 (16.75%) were female respondents and 158 (82.72%) were male respondents. One respondent did not complete this question. The mean is **1.17** and the standard deviation is **0.375** where group one is (Male) indicating the high percentage of males completing the questionnaire.

3.5.4 Home language of respondents

Respondents were requested to provide their home language. Table 3-5 indicated the frequency distribution per home language.

Table 3-5 Home language of respondents

Group	Home language	Frequency	Percentage
1	English	60	31.41%
2	Afrikaans	51	26.70%
3	Xhosa	26	13.61%
4	Zulu	15	7.85%
5	Venda	3	1.57%
6	Ndebele	1	0.65%
7	Sepedi	9	4.71%
8	Setswana	9	4.71%
9	Southern Sesotho	7	3.66%
10	Swati	5	2.62%
11	Tsonga	2	1.05%
12	Portuguese	1	0.52%
	Missing Information	2	1.05%
	Total	**191**	**100.00%**

If the above languages are grouped together Xhosa 26 (13.61%), Zulu 15 (7.85%), Venda 3 (1.57%), Ndebele 1 (0.65%), Sepedi 9 (4.71%), Setswana 9 (4.71%), Southern Sesotho 7 (3.66%), Swati 5 (2.62%) and Tsonga 2 (1.05%) the combined total are 77 (40.31%) which forms the largest section of respondents; followed by English 60 (31.41%), Afrikaans 51 (26.70%) and lastly Portuguese 1 (0.52%). Two respondents did not complete this question.

3.5.5 Highest level of education

The purpose of this question was to determine the respondents' highest academic qualification seeing that their education background could play a role in their ITC adoption.

Table 3-6 presents the highest academic qualification achieved by the participating respondents.

Table 3-6 Highest level of education

Group	Education level	Frequency	Percentage
1	Matric (Grade 12)	1	0.52%
2	Certificate	6	3.14%
3	Diploma	54	28.27%
4	Degree	65	34.03%
5	Honours Degree	33	17.28%
6	Master's Degree	25	13.09%
7	PHD Degree	0	0.00%
	Missing information	7	3.66%
	Total	**191**	**100.00%**

Most of the respondents (34.03%) have a degree. From table 3.6 it can be derived that the three groups, which make up the majority of the respondents, obtained a Diploma (28.27%), a degree (34.03%) or an honours degree (17.28%) respectively. None of the respondents had a PHD Degree. Seven respondents did not complete this question. The mean is **4.08** and the standard deviation is **1.094** where group four is (Degree), indicating that most respondents have a degree.

It must be mentioned that if a respondent does not have at least a diploma the path to registration is much longer, where exams and proof of capability becomes a prerequisite.

3.5.6 Years working experience

Respondents were requested to supply their years working experience and this was divided into the 6 categories listed below. The results of the years working experience classification are presented in table 3-7.

Table 3-7 Years working experience

Group	Years working experience	Frequency	Percentage
1	≤ 2	7	3.66%
2	3-5	20	10.47%
3	6-10	36	18.85%
4	11-20	39	20.42%
5	21-30	42	21.99%
6	31≥	35	18.32%
	Missing information	12	6.28%
	Total	**191**	**100.00%**

The majority of the participating respondents fall in the years working experience category of 21-30 years (21.99%) with the second largest group (20.42%) for the group with 11-20 years working experience. The third largest group was between 6-10 years (18.85%) of the total responses.

The fourth largest group 31 years and longer (18.32%) is an unexpected high percentage. 12 respondents did not complete this question. The mean is **18.6 years** and the standard deviation is **12.26** - it is clear from the mean that respondents are highly experienced.

3.5.7 Years Industry Experience

Respondents were requested to supply their years industry experience and this was divided into the 6 pre-determined categories listed below. The results are presented in table 3-8.

Table 3-8 Years industry experience

Group	Years industry experience	Frequency	Percentage
1	≤ 2	8	4.19%
2	3-5	23	12.04%
3	6-10	41	21.47%
4	11-20	40	20.94%
5	21-30	36	18.85%
6	31≥	29	15.18%
	Missing information	14	7.33%
	Total	**191**	**100.00%**

The majority of the participating respondents fall in the years industry experience category of 6-10 years (21.47%) with the second largest group (20.94%) for the group with 11-20 years working experience. The third largest group was between 21-30 years (18.85%) of the total responses.

14 respondents did not complete this question. The mean is **17.28 years** and the standard deviation is **11.98** - it is clear from the mean that respondents are highly experienced in the industry.

3.5.8 Geographic Area Of Operation

The purpose of this question was to determine the respondents' geographic area of operation seeing that their geographic area could play a role in their ITC adoption. The results are presented in table 3-9.

Of the 191 respondents, the geographic area of operation of 124 (64.92%) was in the city, 32 (16.75%) of respondents were in small towns' and the remaining 19 (9.95%) were in rural areas. 16 respondents did not completed this question. The mean is **1.40** and the standard deviation is **0.678** where group one is City. It is clear that most respondents are based in the city.

Table 3-9: Geographic area

Group	Geographic area	Frequency	Percentage
1	City	124	64.92%
2	Small Town	32	16.75%
3	Rural	19	9.95%
	Missing information	16	8.38%
	Total	**191**	**100.00%**

This will naturally follow the trend of where construction work is taking place in South Africa. The majority of work is done in cities followed by small towns and then rural areas.

3.5.9 People reporting to project manager

Respondents had different challenges on a day-to-day basis depending on how many people work under them. This may have an effect on ITC adoption.

Most of the respondents (41.36%) have 1-5 people working under them. From table 3.9 it can be derived that the three groups which make up the majority of the respondents, have 6-10 (16.75%), 11-25 (11.52%) or 1-5 (41.36%) people working under them respectively. 18 respondents (9.42%) did not indicate the number of people working under them. The results are presented in table 3-10.

Table 3-10 People reporting to Project Manager

Group	People reporting to Project Manager	Frequency	Percentage
1	1-5	79	41.36%
2	6-10	32	16.75%
3	11-25	22	11.52%
4	26-50	13	6.81%
5	51-100	7	3.66%
6	101-250	9	4.71%
7	251-500	6	3.14%
8	501-1000	0	0.00%
9	1000≥	5	2.62%
	Missing Information	18	9.42%
	Total	**191**	**100.00%**

The mean is **2.53** and the standard deviation is **2.028** where group two is (6-10 people). From the registration type it was clear that most people are Candidate or Pr.CPM. This registration type tend to work for consultants of other professional people with fewer people to manage, where the Pr.CM. registration type work for Construction Company's and will tend to have more people under them.

Because of the demographical information and the large number of respondents, 191 of the 1200 registered Construction Project Management Professionals, the p-value could be used to generalize to the population.

3.6 CONSTRUCTION PROJECTS IN GENERAL

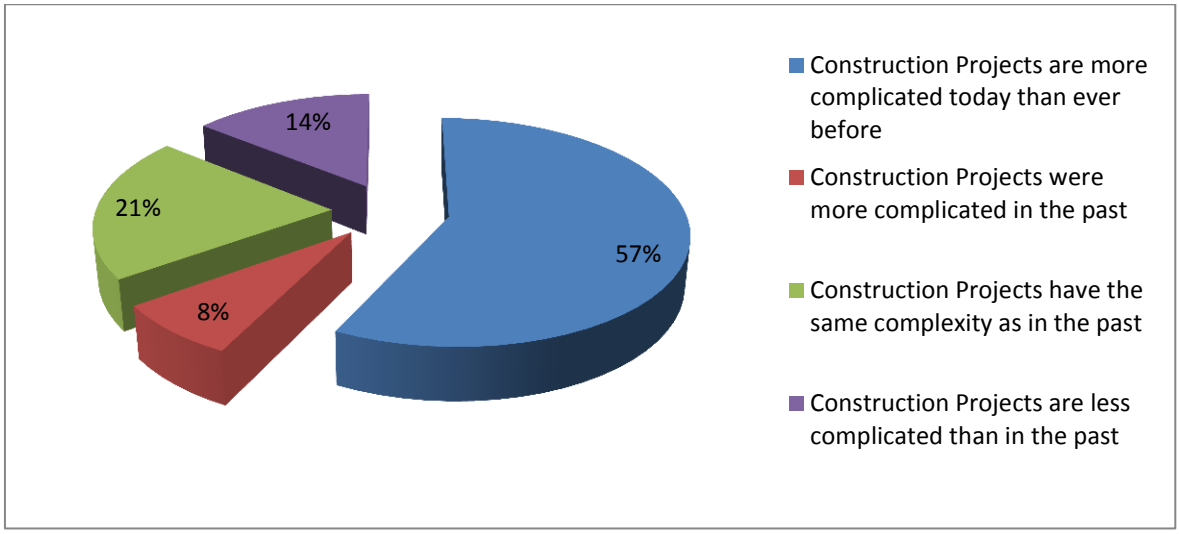
Section B of the survey questionnaire assessed how respondents interpret the advantage of ITC in the Construction Project Management Environment. The complexity of Construction Project Management was also analysed. Questions were answered based on a 4-point Likert scale ranging from Strongly Agree (1) to Strongly Disagree (4).

3.6.1 Describe Construction Projects Complexity

In figure 3-2, the complexity of construction projects was analysed as reported by respondents. 22 respondents did not complete this question.

Most of the respondents (57%) stated that construction projects are more complicated today than ever before, followed by (21%) that felt construction projects are as complicated as in the past. It is clear that the majority of respondents felt than construction projects are more complicated today than ever before.

Figure 3-2 Construction Projects Complexity

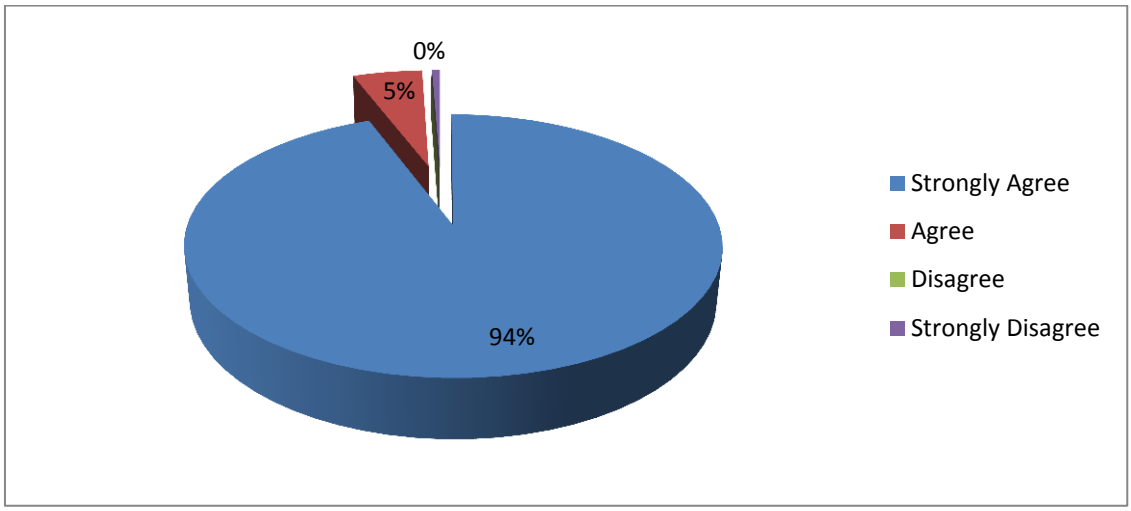


The mean is **1.92** and the standard deviation is **1.162** which supports the findings where group one is Construction Projects are more complicated today than ever before. The findings support the literature review of Chapter 2 where it was stated that Construction Projects are more complicated today than ever before.

3.6.2 Importance of communication in construction project management

Figure 3-3 illustrates the importance of communication in Construction Project Management. 18 respondents did not complete this question.

Figure 3-3 Importance of communication



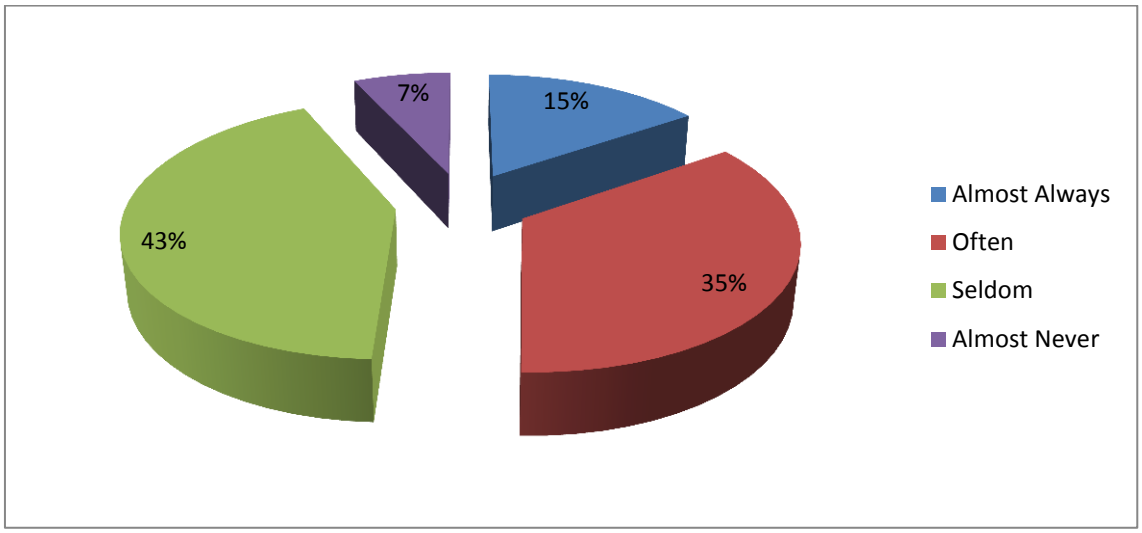
The majority (94%) of participating respondents agreed that communication is very important in Construction Project Management. The remainder was made up by (5%) that agreed that it was important and only (1%) felt that it was not important. The mean is **1.07** and the standard deviation is **0.315** this supports the findings where group one is Strongly Agree communication is very important.

3.6.3 Does projects get completed on time, within budget and with required quality

In figure 3-4 Project Management triple constraint was used as a basis for measuring projects - are projects completed on time, within budget and with the required quality? 18 respondents did not complete this question.

Most of the respondents (43%) stated that projects seldom are completed within the required time, budget or quality level, followed by (35%) that felt it often are completed in the required time, budget or quality level. What is clear is that there is definite room for improvement, as (7%) felt it never gets completed on time, budget or quality level. The mean is **2.41** and the standard deviation is **0.833** this supports the findings where group two is *Seldom*.

Figure 3-4 Completion of projects within time, cost and quality



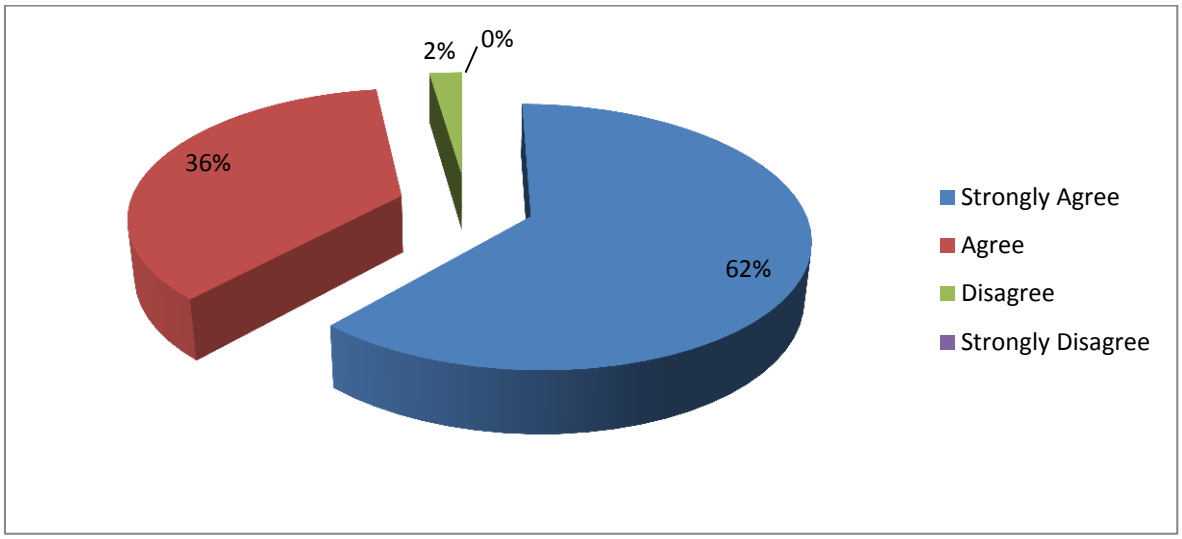
This also supports the previous findings stating that construction projects are more complicated today than ever before, based on (43%) of respondents stating that projects seldom get completed within time, cost or quality.

3.6.4 Characteristics of quality information is accuracy, completeness, consistency, uniqueness and timeliness

The question was asked if respondents agree that the characteristics of quality information were accuracy, completeness, consistency, uniqueness and timeliness. 20 respondents did not complete the question.

Most of the respondents (62%) strongly agree with the characteristics of quality information, followed by (36%) who agreed with the characteristics of quality information. Only (2%) disagreed with the characteristics of quality information. The mean is **1.41** and the standard deviation is **0.538** this supports the findings where group one is Strongly Agree the characteristics of quality information is accuracy, completeness, consistency, uniqueness and timeliness. The results are presented in figure 3-5.

Figure 3-5 Do you agree with the characteristics of quality information



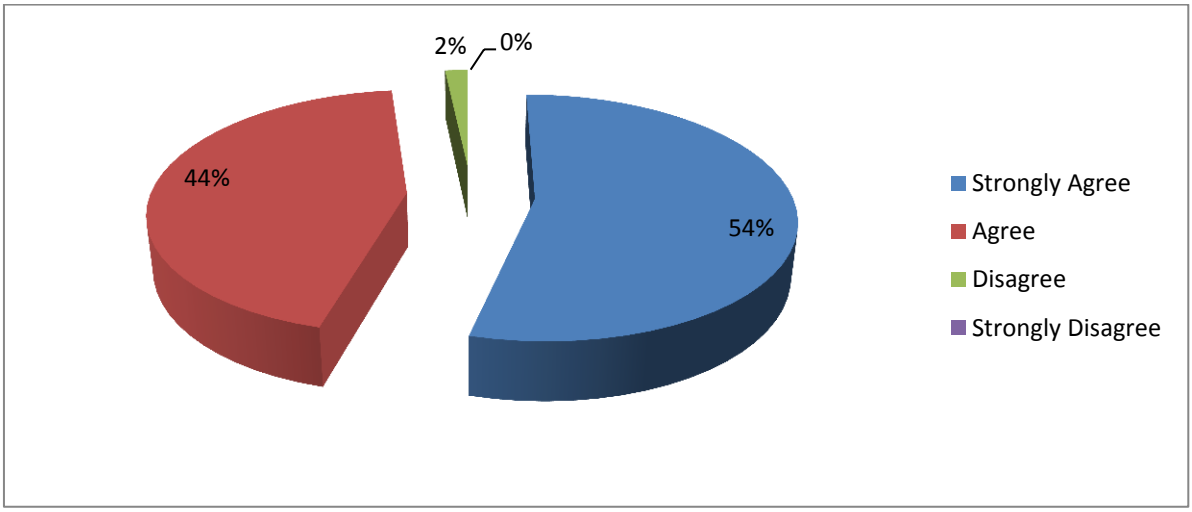
This support chapter 2 literature review where the characteristics of quality information was defined as accuracy, completeness, consistency, uniqueness and timeliness.

3.6.5 Do you agree the adoption of Information Communication Technology will improve project management

The question was asked if respondents agreed that by increasing the adoption of ITC Construction Project Management would be improved. 20 respondents did not complete the question.

If Strongly agree (54%) and Agree (44%) are grouped together then (98%) of the respondents was of the opinion that increasing adoption of ITC would improve Construction Project Management. Only (2%) of the respondents disagreed. The mean is **1.48** and the standard deviation is **0.535** this supports the findings where group one is Strongly Agree. The results are presented in figure 3-6.

Figure 3-6 The adoption of ICT in Construction Project Management



Based on construction projects are more complicated today than ever before 57% of respondents, it is clear that the adoption of ITC (98%) will improve Construction Project Management.

3.7 THE CURRENT RATE OF INFORMATION COMMUNICATION TECHNOLOGY ADOPTION IN PROJECT MANAGEMENT

Respondents were requested to indicate which of the following (ICT) hardware they owned.

The majority of participating respondents indicated laptop computers with 75.92% owning one, followed by Smartphone with 55.50% of respondents owning one. Desktop computers 39.27% were surprisingly low indicating the trend to go mobile.

What was interesting is that if e-Book readers and tablet computer are combined, a massive 35.60% own a mobile reading device. 20 respondents did not complete this question.

Table 3-11 Do you own one of the following

Group	Do you own one of the following	Frequency	Percentage
1	Desktop Computer	75	39.27%
2	Laptop Computer	145	75.92%
3	Netbook Computer	13	6.81%
4	Tablet computer	51	26.70%
5	e-Book reader (Kindle)	17	8.90%
6	Handheld device (Smartphone)	106	55.50%
	Missing Information	20	10.47%
	Total	**191**	**100.00%**

What was clear is that respondents were more focussed on mobile technologies - the trend is specifically focussing on laptop computers while smartphone and mobile readers are gaining ground. Project Managers are embracing mobile technologies.

3.8 SAMPLE RESPONSES

Statistical significance tests have a tendency to yield small p-values (indicating significance) as the size of the data sets increase. The effect size is independent of sample size and is a measure of practical significance. It can be understood as a large enough effect to be important in practice and is described for differences in means, for the relationship in two-way frequency tables and also for a multiple regression fit (Levine *et al.,* 2008:114).

Statistical inference draws conclusions about the population from which a random sample was drawn, using the descriptive statistics in this case, effect size can be determined. Practical significance can be understood as a large enough difference to have an effect in practice (Levine *et al.,* 2008:3).

As a result of the demographical information and the large amount of respondents - 191 of the 1200 registered Construction Project Management Professionals - in

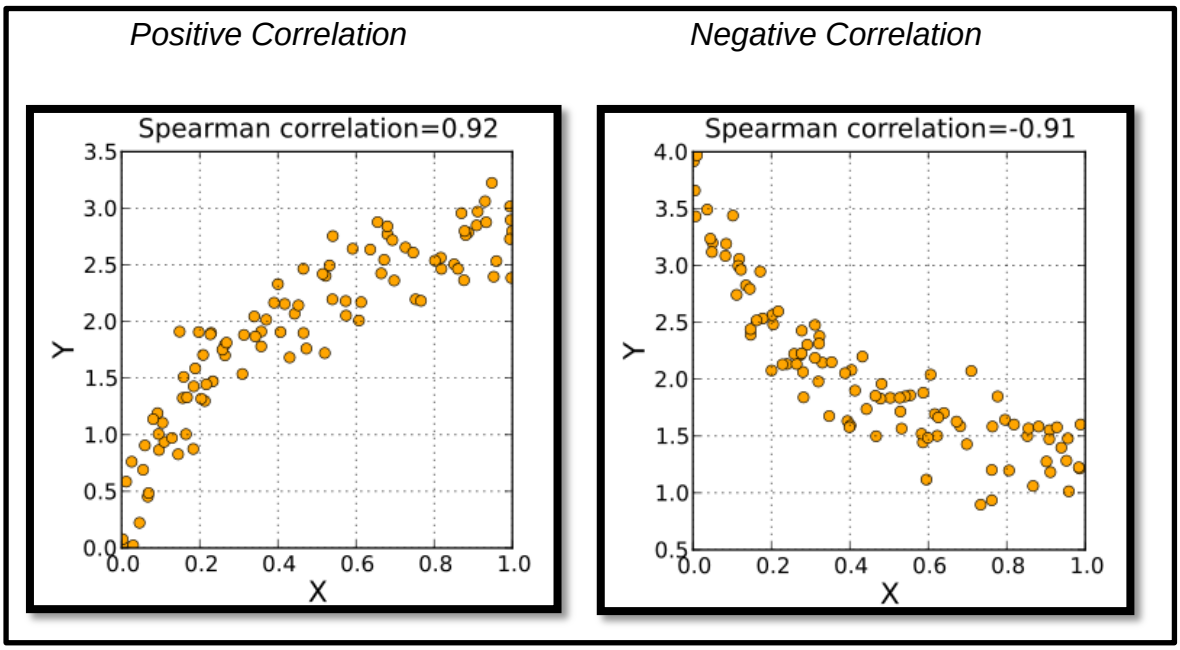
my view the p-value can be used to generalize to the population, but I leave this up to the reader to decide.

In this study statistical significance and practical significance were investigated.

It can be assumed that the sample is normally distributed since n > 30 based on the central limit theorem. Parametric tests may be used, however even more appropriate given the other assumptions of parametric tests such as homogeneity, when tests are deemed equally powerful, *non-parametric tests* will be used.

Spearman's rank correlation coefficient (Spearman's rho); denoted by the Greek letter p is a *non-parametric* measure of statistical association between two variables. It assesses how well the relationship between two variables can be described by using linear function. If there are no repeated data values, a perfect Spearman correlation of +1 or -1 occurs when each of the variables is a perfect linear function of the other (Levine *et al.,* 2008:128).

Figure 3-7: Spearman's rank correlation coefficient (rho)



Values between 0 and 1 will be interpreted by means of the Cohen rating scale (Cohen, 1988:79-81).

Table 3-12 Cohen rating scale

Effect	Rating
Small	r = .10 to .29
Medium	r = .30 to .49
Large	r = .50 to 1.0

The Cohen rating scale is a measure of dividing the data into groups as presented by the Spearman's rho and Pearson correlation where small has little practical significance and medium and large is practically significant.

3.9 CORRELATION WITH AGE

In table 3-13 the correlations between age and other variables were analysed - where significance is observed it was reported.

Table 3-13 Spearman's (rho) between age and other variables

Questions'	Compare Correlations	n	p	r
2 - 6	Age vs Years experience	171	.000	.954
2 – 23.2	Age vs Use of edge, GPRS, 3G	120	.000	.326
2 – 25.2	Age vs Use of text messaging	148	.000	.335
2 – 25.3	Age vs Use of instant messaging	129	.001	.302
2 – 25.4	Age vs Use of twitter	127	.000	.338
2 – 25.6	Age vs Use of social web (Facebook)	138	.000	.425
2 – 25.8	Age vs Contribute to blogs	124	.000	.374
2 – 25.14	Age vs Download music from Internet	127	.000	.337
2 – 25.16	Age vs Playing online games	129	.000	.314
2 – 28.4	Age vs Using e-Book reader (Kindle)	133	.000	.334

Example: *The relationship between age and years' experience* was investigated using Spearman's rank correlation coefficient (rho). There was a **large**, positive correlation between the two variables, r = .954, n = 171, p < 0.01, with experience increasing with age.

The relationship between age and use of Edge, GPRS, and 3G was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .326, n = 120, p < 0.01, with use of Edge, GPRS, and 3G decreasing with age.

The relationship between age and use of text messaging was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .335, n = 148, p < 0.01, with the use of text messaging higher under the younger age group.

The relationship between age and use of instant messaging was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .302, n = 129, p < 0.01, with use of instant messaging higher under the younger age group.

The relationship between age and use of Twitter was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .338, n = 127, p < 0.01, with use of Twitter higher under the younger age group.

The relationship between age and use of Social media (Facebook) was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .425, n = 138, p < 0.01, with use of social media (Facebook) higher under the younger age group.

The relationship between age and contributing to blogs was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .374, n = 124, p < 0.01, with contributing to blogs higher under the younger age group.

The relationship between age and downloading music from the Internet was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .337, n = 127, p < 0.01, with downloading music from Internet higher under the younger age group.

The relationship between age and online games was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .314, n = 129, p < 0.01, with playing games online from the Internet higher under the younger age group.

The relationship between age and using e-Book reader (Kindle) was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .334, n = 133, p < 0.01, with use of an e-book reader (Kindle) higher under the older age group.

3.9.1 Correlation with age summary

It is clear that mobile technology was a lot more utilised by the younger age groups than the older ones. The younger age group has embraced the new mobile platforms such as 3G, text messaging; Twitter, social web (Facebook), blogs and many more to a larger extend than the older age groups.

What was interesting is that the older age group has adopted e-book readers more than the young age group.

3.10 CORRELATION WITH EDUCATION

In table 3-14 the correlations between education and other variables were analysed where significance are observed it is reported.

Table 3-14 Spearman's (rho) between education and other variables

Questions'	Compare Correlations	n	p	r
5 – 26.1	Education vs Word processing software	154	.004	-.228
5 – 31.1	Education vs Collaboration technology	145	.005	.234

The relationship between education and use of word processing software (Word, Pages and est.) was investigated using Spearman's rank correlation coefficient (rho). There was a **small**, negative correlation between the two variables, r = -

.228, n = 154, p < 0.05, with the use of word processing software increasing with education.

The relationship between education and use of collaboration technologies (projectors etc.) was investigated using Spearman's rank correlation coefficient (rho). There was a **small**, positive correlation between the two variables, r = .234, n = 145, p < 0.05, with use of collaboration technology's increasing with education.

3.10.1 Correlation with Education Summary

The use of word processing software and presentation technology increased with the increase of education levels, it is clear that higher educated respondents are more at ease with the technologies and that exposure to technologies definitely increase the use of technologies.

3.11 CORRELATION WITH WORK EXPERIENCE

In table 3-15 the correlations between work experience and other variables were analysed where significance are observed it is reported.

Table 3-15 Spearman's (rho) between work experience and other variables

Questions'	Compare Correlations	n	p	r
6 – 24.2	Work experience vs Edge, 3G	141	.000	.327
6 – 25.2	Work experience vs Text messaging	153	.000	.349
6 – 25.5	Work experience vs Twitter use	131	.000	.348
6 – 25.6	Work experience vs Social networking	143	.000	.429
6 – 25.8	Work experience vs Using blogs	129	.000	.348
6 – 28.4	Work experience vs E-book reader (Kindle)	138	.000	.359

The relationship between work experience and use of Edge, GPRS, and 3G was investigated using Spearman's rank correlation coefficient (rho). There was a

medium, positive correlation between the two variables, r = .327, n = 141, p < 0.01, with the use of Edge, GPRS, and 3G decreasing with work experience.

The relationship between work experience and the use of text messaging was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .349, n = 153, p < 0.01, with the use of text messaging decreasing with the increase of work experience.

The relationship between work experience and use of Twitter was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .348, n = 131, p < 0.01, with the use of Twitter decreasing with the increase of work experience.

The relationship between work experience and the use of social networking (Facebook) was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .429, n = 143, p < 0.01 - the use of social networking (Facebook) decreased with the increase of work experience.

The relationship between work experience and the use of blogs was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .348, n = 129, p < 0.01 - the use of blogs decreased with the increase of work experience.

The relationship between work experience and use of e-Book reader (Kindle) was investigated using Spearman's rank correlation coefficient (rho). There was a **medium**, positive correlation between the two variables, r = .359, n = 138, p < 0.01 - the use of e-Book readers' with the increase of work experience.

3.11.1 Correlation with work experience summary

It was clear that as work experience increases, the use of 3G, text messaging, Twitter, social web (Facebook), blogs and many more decreased.

What was interesting is that with more work experience the use of e-book readers increased. Respondents only use what they feel may add value to their work performance.

3.12 CORRELATION WITH GENDER

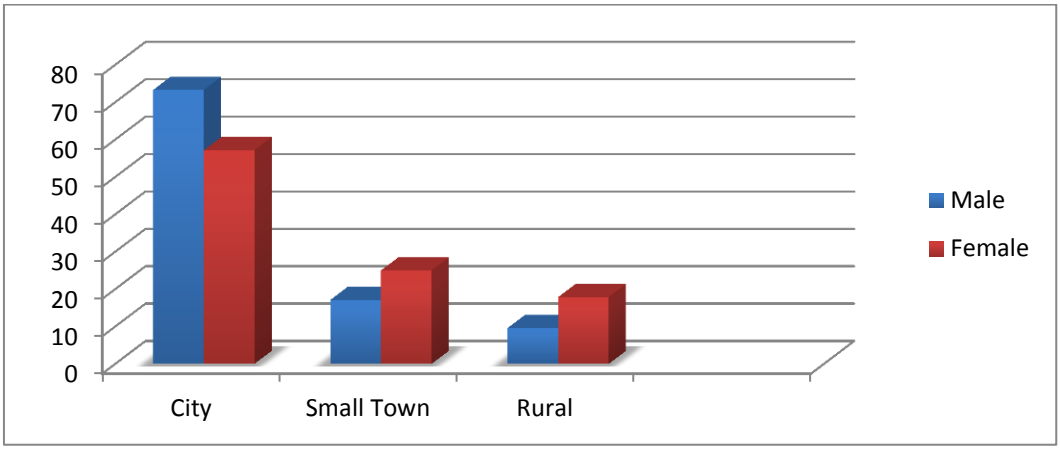
In table 3-16 the Pearson product-moment correlations between gender and other variables were analysed where significance are observed it is reported.

Table 3-16 Pearson correlation between gender and other variables

Questions'	Compare Correlations	n	p	w
3 – 8	Gender vs Area where you work	174	.000	.312
3 – 20	Gender vs Prefer reading a book on media	167	.000	.310
3 – 21.1	Gender vs Desktop computer replacement	117	.000	.331
3 – 21.3	Gender vs Lightweight netbook replacement	68	.000	.704
3 – 21.4	Gender vs Tablet computer	91	.000	.839
3 – 21.6	Gender vs Smartphone replacement	130	.000	.873
3 – 32.1	Gender vs Wireless network (Wi-Fi) usage	148	.000	.751

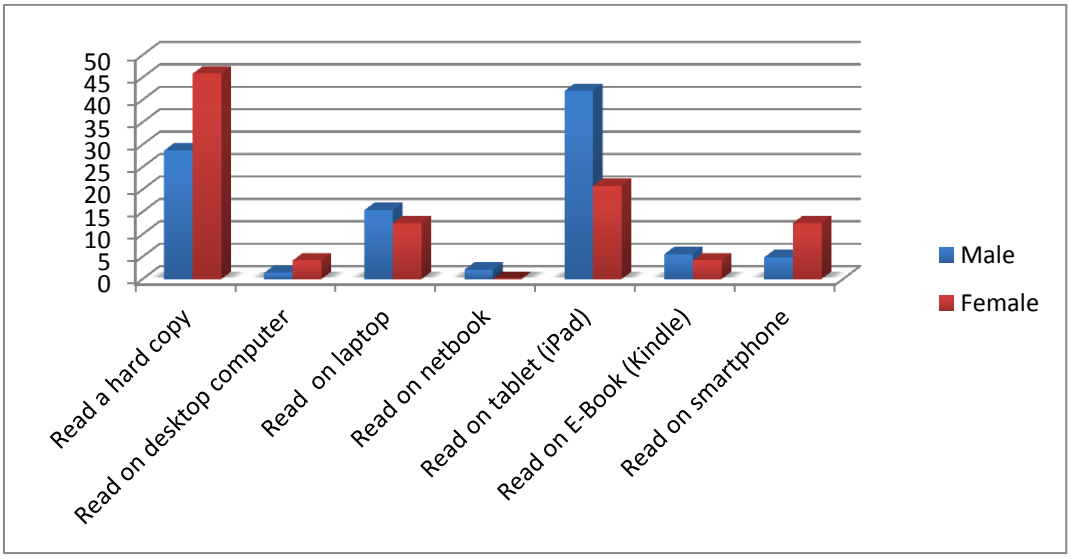
The relationship between gender and area where you work was investigated using Pearson product-moment correlation coefficient. There was a **medium practical visible effect**, positive correlation between the two variables, w = .312, n = 174, $p < 0.05$ - the results are presented in figure 3-8. What was clear is that females are more prevalent in small towns and rural areas than males.

Figure 3-8 Gender vs. area where you work



The relationship between gender and preference for reading a book or magazine was investigated using Pearson product-moment correlation coefficient. There were a **medium practical visible effect**, positive correlation between the two variables, w = .310, n = 167, p < 0.05 - the results are presented in figure 3-9. What is clear is that the use of tablet computers is more prevalent under males than females, while females preferred reading a hard copy.

Figure 3-9 Gender vs. preference for reading a book or magazine



The relationship between gender and desktop computer was investigated using Pearson product-moment correlation coefficient. There was a **medium practical visible effect**, positive correlation between the two variables, w = .331, n = 117, p < 0.05. What is clear is that male has less desktop computers than females.

The relationship between gender and lightweight netbook computers was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .704, n = 68, p < 0.05. What is clear is that females use lightweight netbook computers significantly more than males.

The relationship between gender and tablet computer was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .839, n = 91, p < 0.05. What is clear is that females use tablet computer significantly less than males.

The relationship between gender and smartphones' replacement was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .873, n = 130, p < 0.05. The replacement interval for males and females is visibly the same.

The relationship between gender and wireless network usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .751, n = 148, p < 0.05. The usage of wireless networks for male and females is visibly the same.

3.12.1 Correlation with gender summary

It was shown that females are more prevalent in rural areas and small towns- they tend to prefer to read hard copy books and magazines while males prefer a tablet computer version of the book or magazine.

Females used lightweight netbook computers substantially more than their male counterparts. The use of smartphones and wireless networks were basically the same for males and females.

3.13 CORRELATION WITH HOME LANGUAGE

In table 3-17 the Pearson product-moment correlations between gender and other variables were analysed where significance are observed it is reported.

The relationship between home language and desktop computer usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .607, n = 116, p < 0.05. The usage of desktop computers was practically the same for all language groups.

Table 3-17 Pearson correlation between home language and other variables

Questions'	Compare Correlations	n	p	w
4 – 21.1	Home language vs Desktop computer usage	116	.000	.607
4 – 21.4	Home language vs Tablet computer	90	.000	.979
4 – 21.5	Home language vs E-book reader (Kindle)	75	.000	.992
4 – 28.1	Home language vs Laptop computer usage	154	.000	.648
4 – 29.1	Home language vs GPS usage	153	.000	.833
4 – 31.1	Home language vs Projectors usage	148	.000	.652

The relationship between home language and tablet computer usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .979, n = 90, p < 0.05. The usage of tablet computers was visibly higher for the English and Afrikaans speaking language groups.

The relationship between home language and e-book reader (Kindle) was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .992, n = 75, p < 0.05. The usage of e-book reader (Kindle) was practically higher for the English-speaking language groups.

The relationship between home language and laptop computer usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .648, n = 154, p < 0.05. The usage of laptop computers was marginally higher under English and Afrikaans speakers.

The relationship between home language and GPS navigation usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .833, n = 153, p < 0.05. The usage of GPS navigation was marginally higher under English and Afrikaans speakers.

The relationship between home language and collaboration technologies (projectors) usage was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .652, n = 148, p < 0.05. The usage of projectors was visibly higher under English and Afrikaans speakers.

3.13.1 Correlation with home language summary

It has been proved that there was no practical difference between the usages of desktop computers between language groups.

The use of laptop computers and GPS navigation devices was marginally higher under the English and Afrikaans speaking language groups.

The use of tablet computers and projectors was visibly higher under the English and Afrikaans speaking language groups. e-book readers (Kindle) were visibly higher under the English-speaking language group.

3.14 CORRELATION WITH WORK AREA

In table 3-18 the Pearson product-moment correlations between work area and other variables were analysed - where significance are observed it is reported.

Table 3-18: Pearson correlation between work area and other variables

Questions'	Compare Correlations	n	p	w
8 – 21.1	Work area vs Desktop computer use	115	.000	.478
3 – 21.4	Work area vs Tablet computer usage	89	.000	.960
3 – 21.6	Work area vs Smartphone use	126	.000	.556
3 – 28.1	Work area vs Laptop computer usage	148	.000	.913
3 – 29.2	Work area vs GPS application on smartphone	139	.000	.534
3 – 32.1	Work area vs Wireless networks (Wi-Fi) use	142	.000	.792

The relationship between work area and desktop computer was investigated using Pearson product-moment correlation coefficient. There was a **medium practical visible effect**, positive correlation between the two variables, w = .478, n = 115, p < 0.05. What was clear is that persons in cities have less desktop computers than people in rural areas. Small towns rate between the two.

The relationship between work area and usage of tablet computer was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .960, n = 89, p < 0.05. The usage of tablet computers is visibly higher in cities than rural areas and small towns.

The relationship between work area and usage of smartphones was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .556, n = 126, p < 0.05. The usage of smartphones is visibly higher in cities than rural areas and small towns.

The relationship between work area and usage of laptop computers was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .913, n = 148, p < 0.05. The usage of laptop computers is visibly higher in cities than rural areas and small towns.

The relationship between work area and usage of GPS applications' on smartphone was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .534, n = 139, p < 0.05. The usage of GPS applications on smartphones is visibly higher in cities than rural areas and small towns.

The relationship between work area and usage wireless networks was investigated using Pearson product-moment correlation coefficient. There was a **large practical significant effect**, positive correlation between the two variables, w = .792, n = 142, p < 0.05. The usage of wireless networks is visibly higher in cities than rural areas and small towns.

3.14.1 Correlation with work area summary

It has been proven that the use of desktop computers was more prevalent in rural areas and small towns compared to cities.

The use of tablet computers, smartphones, laptop computers and GPS-based applications on smartphones and wireless networks was more prevalent in cities compared to small towns and rural areas.

3.15 CHAPTER SUMMARY

The empirical study, detailed in this chapter, used a survey questionnaire to investigate the creation of a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment. The questionnaire consisted of nine sections. 192 of the questionnaires were returned out of a population of 1200, and 191 (15.92%) of the questionnaires were used - one was rejected as it felt outside the scope of the study South Africa.

The demographic information of respondents were analysed in terms of registration type (Pr.CPM. = 63, Pr.CM. = 22, Mentor = 7, Candidate = 81, Other =

26), age group (≤ 29 = 35, 30-39 = 56, 40-49 = 43, 50-59 = 31, 60+ = 17), gender (158 males and 32 females), language group (English = 60, Afrikaans = 51, Indigenous grouped = 77, Portuguese 1), highest level of education (matric = 1, certificate = 6, diploma = 54, degree = 65, honours degree = 33, master's degree = 25). Years working experience - the two largest groups are 21-30 years (21.99%) and 11-20 years (20.42%). Geographic area of work (city = 124, small town = 32, rural 19). Lastly, how many people work under you - 1-5 people by far the largest on 41.36%, this can be explained by the high Pr.CPM. registration that works predominately for consultants and not construction companies.

In section B the respondents were ascertained on their perceived advantage of ITC in the Construction Project Management Environment. Describe construction project complexity with (57%) reporting feeling it is more complicated today than ever before, followed by (21%) that felt the complexity is the same as in the past. Importance of communication in Construction Project Management with (94%) feeling it was very important. Do projects get completed on time, within budget and with required quality with (43%) reporting that this seldom happened and (35%) reporting that it often happened.

Due to the increased complexity of projects (57% of respondents reported), it is clear that the importance of communication (94% reported) needs to increase. This is underlined by the fact that projects seldom get completed on time, within budget and with the required quality with 50% reporting it seldom or never happens.

Characteristics of quality information are accuracy, completeness, consistency, uniqueness and timeliness with 62% agreeing strongly followed by 36% that agreed. Do you agree increasing the adoption of ITC will improve Construction Project Management with 54% strongly agreeing and 44% agreed.

It is clear that respondents (98%) felt accuracy, completeness, consistency, uniqueness and timeliness are the characteristics of quality information and that 98% of respondents feeling that ITC will improve Construction Project Management.

Determine the current rate of ICT adoption, it was clear that laptop computers (75.92%) and Smartphones (55.50%) rated the highest showing a very strong tendency towards mobile ICT solutions. Desktop computers on 39.27% rated surprisingly low. Interestingly if tablet computers and e-book readers are grouped together handheld reading devices on 35.60%, rate higher than what might have been expected.

Statistical significance test have a tendency to yield small p-values (indicating significance) as the size of the data sets increase. Statistical inference draws conclusions about the population from which a random sample was drawn, due to the large demographical response the p-value that was used to generalize the population.

Spearman's rank correlation coefficient (Spearman's rho) and Pearson product-moment correlations denoted by the Greek letter *p* are a *non-parametric* measure and was used to draw statistical association between two variables, the linear function was described.

Age correlation - it was clear that mobile technology was a lot more utilised by the younger age groups than the older groups. The younger age group have embraced the new mobile platforms such as 3G, text messaging, Twitter, social web (Facebook), blogs and many more. What was interesting is that the older age group has adopted e-book readers (Kindle) more than the younger age group.

Correlation with education - the use of word processing software and presentation technology increased with education.

Correlation with work experience - it was clear as work experience increased the use of 3G, text messaging, Twitter, social web (Facebook), blogs and many more decreased. The use of e-book readers increased.

Gender correlation - it was shown that females were more prevalent in rural areas and small towns; they tend to prefer to read a hard copy of a book or magazine. Females use lightweight netbook computers substantially more than their male

counterparts. The adoption of wireless networks and smartphones were the same for males and females.

Correlation with home language - it was shown that there was no visible difference in the use of desktop computers between the language groups. The use of laptops and GPS navigation devices was marginally higher with the English and Afrikaans speaking language groups. The use of tablet computers and projectors were visibly higher under the English and Afrikaans speaking language groups. E-book readers (Kindle) were the highest under the English speakers.

Work area correlation - the use of desktop computers was more prevalent in rural areas and small towns. The use of tablet computers, smartphones, laptop computers, GPS-based applications on smartphones and wireless networks were more prevalent in cities compared to small towns and rural areas.

In chapter four, conclusions will be drawn from the findings discussed in this chapter and recommendations will be made on how to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 INTRODUCTION

The purpose of this final chapter on the influence of ITC in the South African Construction Project Management Environment, is to discuss the implications and draw conclusions from the findings of the empirical study as presented in chapter 3 combined with the literature review of chapter 2.

This chapter will mainly consist of two sections, keeping the primary and secondary objectives in mind as formulated in chapter 1, the discussion focusses on the creation of a framework for the improvement and flow of communication by means of ICT in the South African Construction Project Management environment.

The first section will focus on the conclusions drawn from the results of the literature review as well as the findings of the empirical study. The relevance of the relationships between demographic variables such as registration type, age, gender, home language, highest level of education, years working experience, years industry experience, area of operation and how many people report to them will also be described.

The second section will focus on the literature study confirmed by the empirical study as to the advantage of ICT in the Construction Project Management Environment, the complexity of Construction Project Management, the completion of projects based on the triple constraints of time, cost and performance, the characteristics of quality information and will the adoption of ICT improve Construction Project Management.

Lastly, adherence to the objectives of the study is determined and areas subject to further research is proposed.

4.2 CONCLUSIONS

The conclusions will follow the basic structure of the questionnaire, and will firstly address the demographic information, and then construction projects in general will be evaluated. The correlation coefficient and the use *of non-parametric* measure of statistical association between two variables are described to establish reliability of the measurement used, and finally the relationship between some demographic variables will be focused on.

4.2.1 Demographic Information

Demographic information of respondents was obtained regarding their registration type, age, gender, home language, highest level of education, years working experience, years industry experience, area of operation and how many people report to them. From the results of the questionnaire, the following conclusions about demographical information can be drawn:

- The registration type representation in the South African Construction Project Management is uneven, with 40.70% candidates followed by 31.66% Pr.CPM - the very low Pr.CM registration type of 11.06% being attributed to the fact that the registration type is not yet legally required as the Pr.CPM registration type is.
- Age groups 30 to 39 (29.32%) and 40 to 49 (22.51%) summates to 51.83%, meaning that more that the halve of the respondents are more than 50 years old. The age group 60+ makes up 8.90%. It is clear that respondents are older than what would have been expected. This can cause problems for the industry in the coming years, as more people retire from the profession. This is confirmed with only 18.32% of respondents under the age of 29.
- The gender representation in Construction Project Management is uneven, with more than three quarters (82.72%), identified as male and less than one quarter (16.75%) as female.
- The largest group of respondents' home language are traditional black languages (40.31%), followed by English (31.41%) and Afrikaans (26.70%).

- Most of the respondents have a degree (34.03%) followed by a diploma (28.27%) and a honours degree (17.28%), with masters' degree being 13.09%.
- Years working experience (21-30 years) was the highest at 21.99%, with the second largest group being (11-20 years) at 20.42% followed by (6-10 years) at 18.85% and longer than (31 years) at 18.32%.
- The majority of participants fall in the years industry experience (6-10 years) at 21.47%, with the second largest group (11-20 years) at 20.94%. The third largest group was (21-30 years) at 18.85%.
- By far the largest group in geographic area was city (64.92%) followed by small town (16.75%) and lastly rural area (8.38%).
- Most of the respondents had 1-5 people (41.36%) working under them followed by 6-10 people (16.75%) and 11-25 people (11.52%).

4.2.2 Construction projects in general

Construction projects in general are described based on the literature review of chapter 2 and the empirical study of chapter 3 As well as the advantage of ITC in Construction Project Management Environment - the complexity of Construction Project Management, the completion of projects based on the triple constraints of time, cost and performance, the characteristics of quality information and will the adoption of ICT improve Construction Project Management.

Construction project complexity - It became clear in the literature review that Construction Projects are more complicated today than ever before, this was supported in the empirical study with 57% of respondents stating that it is more complicated today than ever before and 21% of respondents feeling it is as complicated today as in the past.

Importance of communication in construction project management - The majority of respondents (94%) felt that communication is very important in Construction Project Management and 5% feeling that it was important. This is supported by the literature where, Biggs (1997:190) stated that communication has been listed as the root cause of most project failures.

Do projects get completed on time, within budget and with required quality - Project Management is designed to manage or control company resources on a given activity, within time, within cost, and within performance. This is called the triple constraint: time, cost, and performance (Kerzner, 2009:5). From the empirical study it is clear that the majority of respondents (43%) feel that projects seldom are completed within the required time, cost, and performance, however 35% felt that it was completed within the triple constraint. What is clear is that there is definite room for improvement with 7% feeling that it never gets completed on time, within budget or quality.

Characteristics of quality information are accuracy, completeness, consistency, uniqueness and timeliness - The literature review highlighted the fact that there are different characteristics of quality information. Based on Baltzan & Phillips (2010:81) accuracy, completeness, consistency, uniqueness and timeliness was identified as most appropriate. The empirical study supported this assessment as 62% of respondents strongly agreed with the characteristic of quality information followed by 36% that agreed with this. Only 2% did not agree with the characteristics of quality information.

Increasing the adoption of ITC will improve construction project management - The empirical study supports the literature review. If strongly agree (54%) and agree (44%) are grouped together then 98% of respondents was of the opinion that increasing the adoption of ITC would improve Construction Project Management.

Based on construction projects that are more complicated today than ever before as indicated by 57% of respondents, it is clear that the adoption of ICT (98%) will improve Construction Project Management.

4.2.3 Reliability of the questionnaire used

Taking the results of the survey into account and the demographical information combined with a large response to the survey from 191 of 1200 registered Construction Project Management Professionals, the p-value was used to generalize to the population, on the base that n > 30 based on the central limit theorem. The study used primary *non-parametric* measures of statistical

association between two variables. It assesses how well the relationship between variables can be described using linear function.

Spearman's rank correlation coefficient (Spearman's rho) and Pearson product-moment correlation, was employed. A perfect correlation of +1 or -1 occurs when each of the variables is a perfect linear function of the other (Levine *et al.,* 2008:128).

Correlation with age - On the Cohen rating scale the following all rated medium r = .30 to .49 it is clear that mobile technology is used a lot more by the younger age groups than the older ones. The younger age group embraced the new mobile platforms such as 3G, text messaging; Twitter, social web (Facebook), blogs and many more to a larger extend than the older age groups.

Interestingly the older age group adoption of e-book (Kindle) readers was higher than the young age group.

Correlation with education - The correlation between education and other variables are reported based on the Cohen rating scale small r = .50 to 1.0 are reported on the following, use of word processing software and presentation technology increased with the increase of education levels.

Correlation with work experience - Work experience decreased the use of 3G, text messaging, Twitter, social web (Facebook), blogs and many more. Interestingly the use of e-book (Kindle) readers increased. The findings is supported by the correlation of medium r = .30 to .49 based on the Cohen rating scale.

Correlation with gender - The correlation between gender and other variables are reported based on a medium to large Cohen rating scale r = .30 to 1.0 - it is clear that females are more prevalent in rural areas and small towns; they tend to prefer to read hard copy books and magazines where males prefer a tablet computer version of the book or magazine.

Females use lightweight netbook computers substantially more than their male counterparts. The use of smartphones and wireless networks are basically the same for both groups.

Correlation with home language - There is no visible difference between the uses of desktop computers between language groups. The use of laptop computers and GPS navigation devices is slightly higher under English and Afrikaans speakers.

The use of tablet computers and projectors are visibly higher under English and Afrikaans speakers, and lastly e-book readers (such as Kindle) are the highest under English speakers. The above is supported by the correlation of large r = .50 to r = 1.0.

Correlation with work area - The correlation between work and other variables are reported based on a medium to large Cohen rating scale r = .30 to 1.0 - it is clear that the use of desktop computers is higher in rural areas compared to cities.

The use of tablet computers, smartphones, laptop computers, GPS-based applications on smartphones and wireless networks is more prevalent in cities compared to small towns and rural areas.

4.3 RECOMMENDATIONS & FRAMEWORK

The primary objective of the study is to create a framework for the improvement and flow of communication by means of Information Communications Technology (ICT) in the South African Construction Project Management Environment.

To realise this secondary objectives was set to realise the primary objective.

4.3.1 Common characteristics of quality information in project management

In chapter 2, literature review - the common characteristics of quality information were discussed and it was determined that high quality information can significantly improve the chances of making a good decision and directly increases an organisation's bottom line (Baltzan & Philips, 2010:82). High quality information will directly influence the quality of communication.

From the literature, the following was identified as the five characteristics of quality information (Baltzan & Philips, 2010:81):

- Accuracy: Are all the values correct? For example, is the name spelled correctly? Is the rand amount recorded properly?
- Completeness: Are any of the values missing? For example, is the address complete including street, city, state, and area code?
- Consistency: Is aggregate or summary information in agreement with detailed information? For example, do all total fields equal the true total of the individual fields?
- Uniqueness: Are each transaction, entity, and event represented only once in the information? For example, are there any duplicate customers?
- Timeliness: Is the information current with respect to the business requirement? For example, is information updated weekly, daily, or hourly?

In chapter 3, empirical study - in question 3.6.4 the characteristics of quality information was tested with a mean of **1.42** and a standard deviation of **0.538** that support the findings of group one (Strongly Agree), with 62% of respondents strongly agreeing and 36% of respondents agreeing. The combined percentage of 98% is overwhelming in support of the findings of the characteristics of quality information as being accuracy, completeness, consistency, uniqueness and timeliness.

4.3.2 The disablers of Information Communication Technology adoption in project management

In chapter 2, literature review - the disablers of ICT adoption in Project Management was analysed. It became clear that many different disablers existed but the following was determined to be the most applicable in the Project Management environment.

A division of adoption factors limiting ICT implementation (Weber & Kauffman, 2011:689).

- Economic factors (reduction in employment, rising cost and limited trade);
- Social factors (digital divide, security and lack of education);
- Other factors (legal, environmental and cognitive).

In chapter 3, the following was analysed as disablers in ICT adoption and was confirmed with Spearman's rank correlation coefficient.

Age: Under the older age group the adoption of mobile ICT technology was significantly less than under the younger age group.

It is clear that the older age group does not accept new mobile technologies as readily as the younger age group and they tend to use less of the capabilities of the technology, this can become more problematic in the coming few years as more ICT technologies will become mobile as could be seen in the future study.

Education: A lack of education was identified as a barrier to the use of word processing software and presentation solutions.

It is clear as education increased respondents' exposure to ICT technologies such as word processing software and presentation software increased. It is important to educate people and not to have this be the barrier for limiting the use of technologies.

Work experience: It reduced the use of mobile ICT systems such as text messaging, Twitter, social web (Facebook) and blogs.

As work experience increases, respondents tend to have less time available for social mediums such as Twitter, Facebook and blogs. They will also tend to use text messaging less as it takes more time than a phone call and for them their time is more valuable than the cost of the phone call. As work experience increases, respondents will only use ICT technologies that they feel will save them time, money and improve communication.

Gender: Females tend to adopt tablet computers less than males.

This can be attributed to the fact that females were more prevalent in rural areas and thus have less access to 3G broadband networks and feel that a tablet type of technology *cannot deliver what they require.*

Home language: The indigenous language groups use laptop computers, GPS navigation devices and tablet computers less than their English and Afrikaans counterparts.

Work area: It was shown that rural areas, followed by small towns, adopt mobile ICT technology (tablet computers, smartphones, laptop computers, GPS-based applications on smartphones and wireless networks) substantially less than their counterparts in the cities.

It became clear that access to 3G broadband networks was the main reason for this lower adoption. This will remain a limiting factor in South Africa and will need to be managed, as many areas still do not have access to 3G networks. New devices already available in South Africa has 4G capability, this will increase the digital divide between rural areas and cities in the coming years, as cell phone networks will not see the need to spend vast sums of money in rural areas for broad band networks.

Companies will need to asses areas and investigate alternatives if broadband networks are not available - such as satellite links. The use of cloud based backup systems will also necessitate the availability of high-speed connections.

4.3.3 The enablers of Information Communication Technology adoption in project management

In chapter 2, literature reviews, the criteria for adoption determinants mainly inspired by the diffusion theory in which innovations were supposed to have a set of five characteristics, was set out (Rogers, 2003:5):

- Relative advantage;
- Complexity;
- Compatibility;
- Trial ability; and
- Observe ability.

Determining the subjects' perception of an individual's attitude towards the technology, as well as his/her innovativeness or timing of adoption decision, is important. The perception of each of these characteristics is assumed to have a strong relationship with the innovativeness of an individual, as shown in figure 4-1, where the diffusion theory as proposed by Rogers is compared to respondents in this study based on chapter 3, empirical study:

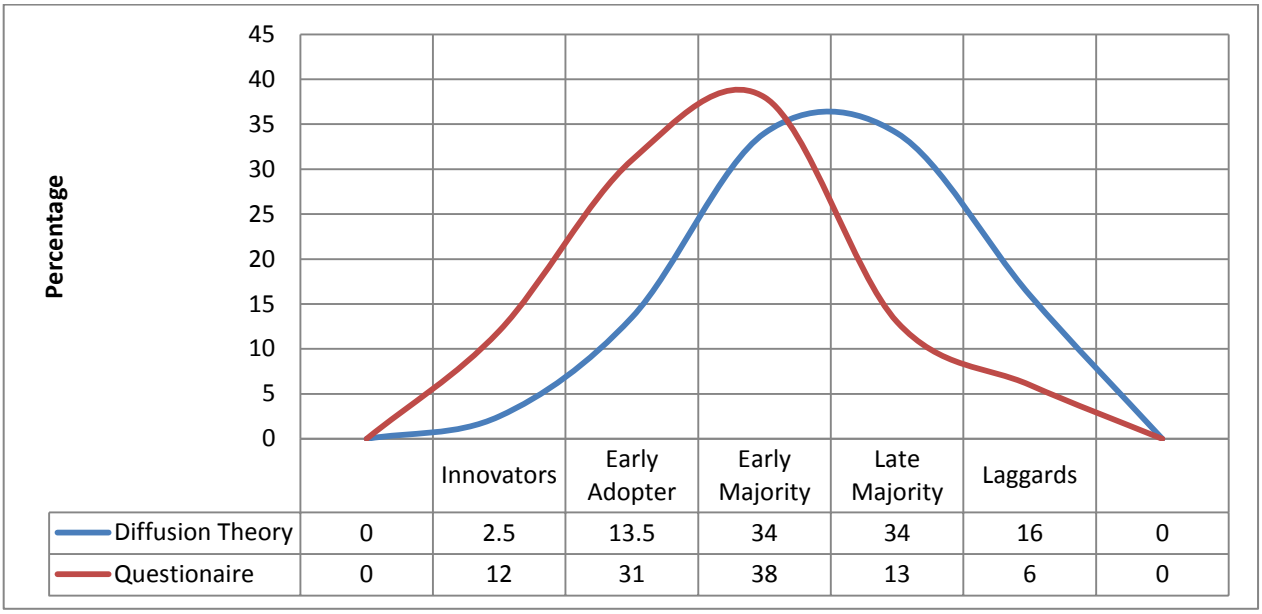
- *Innovators*: are venturesome - they try new ideas at some risk.
- *Early Adopters*: are guided by respect – they are opinion leaders in their communities and adopt new ideas early but carefully.
- *Early Majority*: are deliberate – although they rarely are leaders, they adopt new ideas before the average person.
- *Late Majority*: are sceptical – they adopt an innovation only after a few have tried it.
- *Laggards*: are traditions bound – they are suspicious of change and only adopt when the new idea becomes tradition itself (Rogers, 2003:6).

Innovators and early adopters, for example, are assumed to have a higher perception of relative advantage than the late majority segments, together with a lower perception of complexity of the innovation:

- *Innovators:* 12% in questionnaire and 2.5% in diffusion theory;
- *Early adopter:* 31% in questionnaire and 13.5% in diffusion theory;
- *Early majority:* 38% in questionnaire and 34% in diffusion theory;
- *Late majority:* 13% in questionnaire and 34% in diffusion theory; and
- *Laggards:* 6% in questionnaire and 16% in diffusion theory.

It is clear from these results that respondents felt that the above five determinants should be more positive (enabled) than proposed by the diffusion theory. It is clear that respondents are more technology orientated than proposed by the diffusion theory.

Figure 4-1 Diffusion theory compared to respondents



		Innovators	Early Adopter	Early Majority	Late Majority	Laggards	
Diffusion Theory	0	2.5	13.5	34	34	16	0
Questionaire	0	12	31	38	13	6	0

This can to a large extend be explained by the fact that Construction Project Management is a highly technology driven field and that most of the respondents (34.03%) have a degree followed by 28.27% with a diploma and thirdly 17.28% with a honours degree. It was determined earlier that as the education level increases, the respondent's awareness and capability with ICT increases. It will be easier to introduce new ICT to the Construction Project Managers than the general model proposers, due to the fact that they are more innovative orientated.

ICT implementation and adoption is a management-intensive activity. Managers should reframe ICT implementation expectations, create small wins, and reduce conflict of interest (Skibniewski & Abduh, 2000:68). Identify a person in the organisation that will be available to help others with the new technology and also to help promote the technology under colleagues.

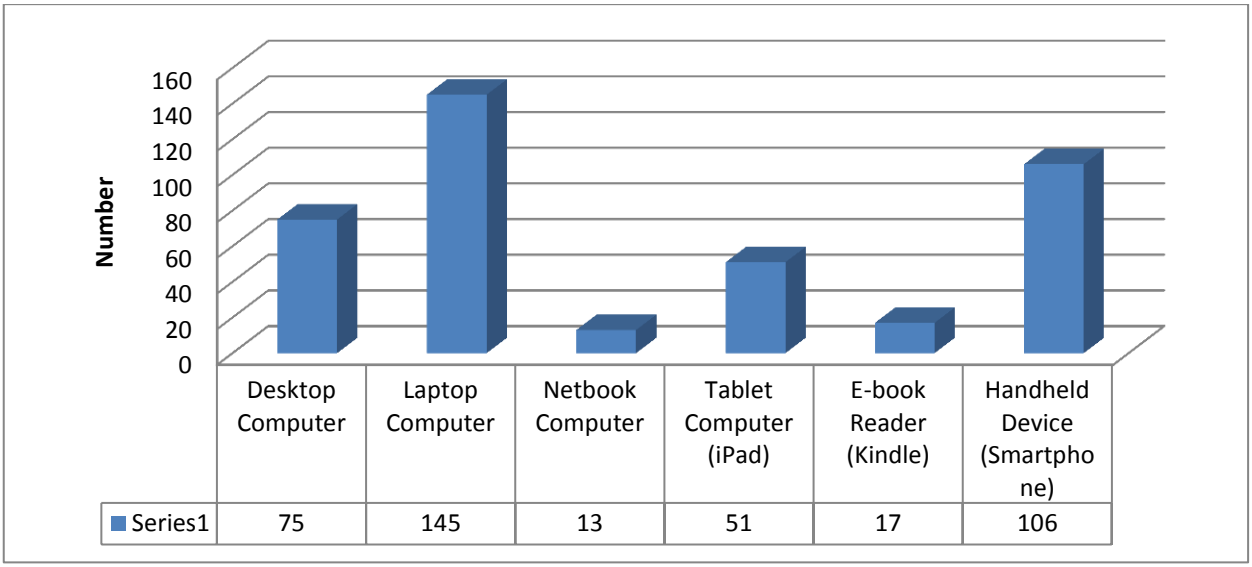
A top manager's decision to adopt ICT often progresses ICT implementation to the individual and group level. These people are key actors who play a significant role in how ICT diffuses throughout an organisation.

Computing power is expected to continue to grow consistent with Moore's Law, thus doubling every 18 months over the next decade and beyond (Moore, 2008:3; Taylor, 2000:99). This will enable new opportunities in the field of ICT that must be constantly evaluated as can been seen in the future study in chapter 2.

4.3.4 The current rate of Information Communication Technology adoption in project management

In chapter 3, empirical research Part C, the majority of participating respondents indicated owning a laptop computer (75.92%), followed by Smartphones (55.50%). Desktop computers (39.27%) are surprisingly low indicating the trend to go mobile. The findings are presented in figure 4-2.

Figure 4-2 Current rate of ICT adoption in Project Management



The rate of handheld reader ownership such as tablet computers and e-Book readers is also surprisingly high on 35.60%, indicating the trend to be more mobile and to have instant access to data.

Part E: Hardware replacement, Part F: Internet access, Part G: Software applications hardware based or cloud based, Part H: General usage of devices was all incorporated in the empirical research in the section sample responses correlations in chapter three section 3.7. The results of this were also used in the interpretation of findings.

What is clear from the above is that Construction Project Managers are focused a lot more on mobile solutions and this can be explained, as they are out of the office a lot on construction sites or in project meetings. This indicates that the mobile solution will always be very important to them.

Based on the shift to the ISO 9002 quality assurance system, standardisation on larger projects, the adoption of ITC is accelerated based on the fact that all data must be sent to a data warehouse. Many local clients, specifically the mining sector, have moved over to the Fidic International Federation of Consulting Engineers Construction Contract that requires the use of the ISO 9002 systems quality assurance system in the construction process (Fidic, 2012:1).

Larger companies are working increasingly internationally where the Fidic contract has been used for at least 10 years extensively - this knowledge is brought to South Africa and has been incorporated into the companies' base of operations. These companies all make use of data warehouses. All people in the company must have access to ICT to access the data warehouse.

4.3.5 Future study of Information Communication Technology based on the next five to ten years

From the literature study in chapter 2, it follows that emerging ITC introduces opportunities for improving communication to enhance effectiveness of many construction processes at each project phase as well as creating new business opportunities (Peansupap & Walker, 2005:193).

It is clear from literature that ICT will be positively effected in the future through new developments in mobile technology, faster networks, better information security, increased use of satellite services, global use of cloud computing, better display technologies increasing tempo of nanotechnology development; the effect will be improved communication, an increase in the speed of data transmission, cost savings and fewer occurrences in miscommunication.

Moor's Law frequently quoted as the doubling of computer power every 18 months which has held for the last three decades, will see ICT positively affected as the pace of computing power is ever increasing.

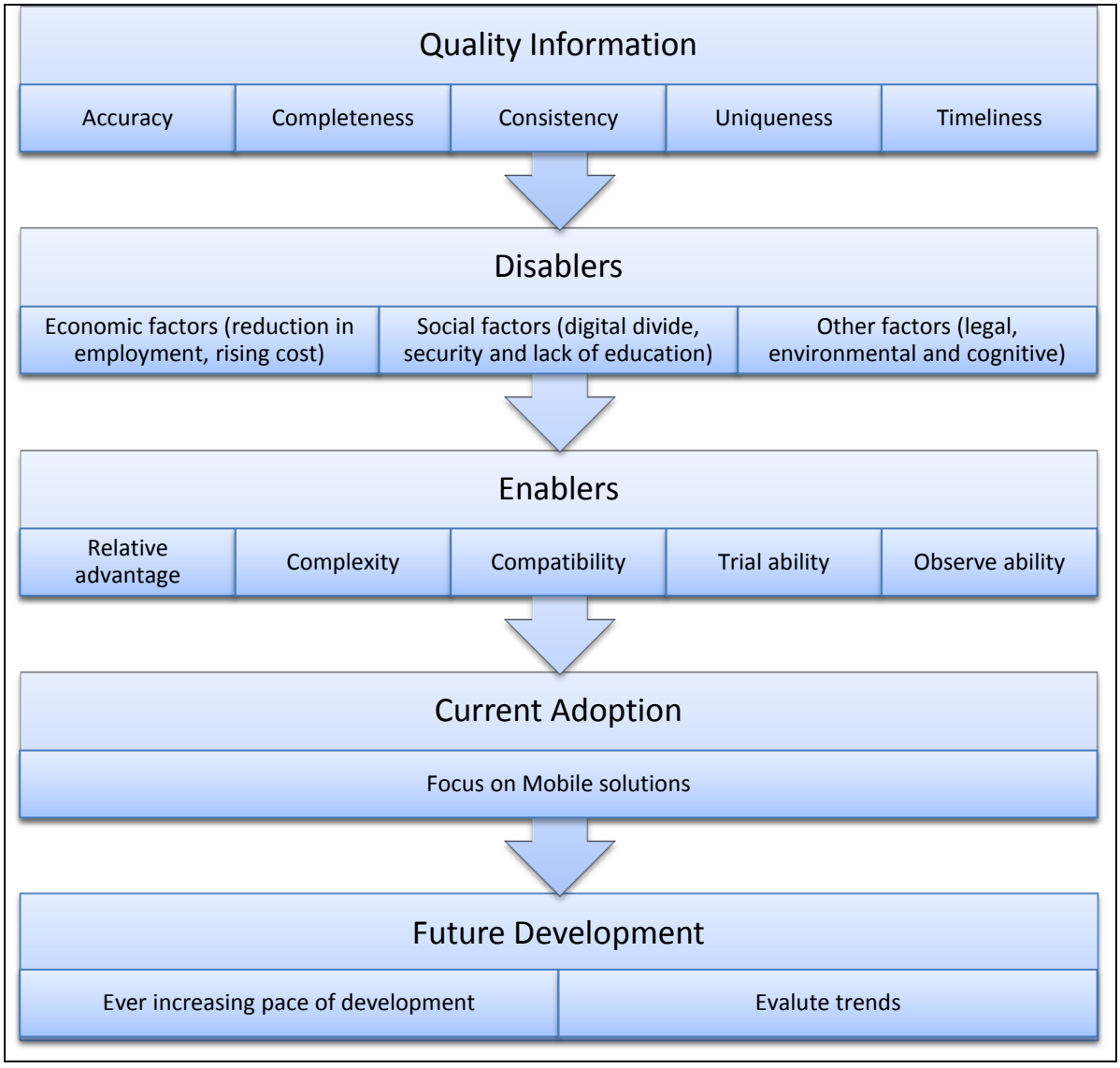
The effect of future development in Information and Communication Technology will be profound and if applied correctly, Project Management through the means of communication will be affected positively.

4.4 ACHIEVEMENT OF OBJECTIVES

4.4.1 Primary objective

The primary objective of the study was to create a framework for the improvement and flow of communication by means of ITC in the South African Construction Project Management Environment.

Figure 4-3: Framework for the improvement of ICT in Project Management



The primary objective was achieved by realising the secondary objectives of the study as set out in framework above.

4.4.2 Secondary objective

In order to achieve the primary objective the following secondary objectives were formulated:

- Common characteristics of quality information in Project Management:
    - Accuracy;
    - Completeness;
    - Consistency;
    - Uniqueness;
    - Timeliness.
- Disablers of Information Communication Technology in Project Management;
- Enablers of Information Communication Technology in Project Management;
- The current rate of Information Communication Technology Adoption in Construction Project Management;
- Future trends in Information Communication Technology for the next five to ten years pertaining to Project Management.

The secondary objectives were achieved as set out from point 4.3.1 to 4.3.5 in framework.

4.5 SUGGESTION FOR FURTHER RESEARCH

Based on the findings of the study, the following suggestions are made regarding considerations pertaining to future research on ITC in Construction Project Management:

The scope of the study was limited to South Africa. In the future this could be expanded to other African countries were South African Project Managers function, to determine if other factors that affect ICT.

The study was based on 2012 data and with the fast pace of developments in the ICT field the study will need to be updated in the coming years to keep it relevant.

4.6 SUMMARY

Conclusions drawn from the empirical research results provided in chapter three were discussed in more detail in this chapter. The basic demographics of registration type, age, gender, home language, highest level of education, years working experience, years industry experience, area of operation and how many people report to them.

Construction projects in general were discussed based on the literature review of chapter two and the empirical research of chapter three - the advantage of ITC in the Construction Project Management Environment, the complexity of the Construction Project Management, the completion of projects based on the triple constraints of time, cost and performance, the characteristics of quality information, and will the adoption of ICT improve Construction Project Management.

Reliability of the questionnaire used was proven. Spearman's rank correlation coefficient and Pearson product moment correlation was employed to analyse results. A Perfect correlation of +1 or -1 occurs when each of the variables is a perfect linear function of the other. Correlations were done with age, education, work experience, gender, home language and work area.

Recommendations were based on the framework as set out in chapter one: The common characteristics of quality information in Project Management?; What disables Information Communication Technology to work in Project Management?; What enables Information Communication Technology to work in Project Management?; Determine the current rate of ICT adoption in Construction Project Management?; Lastly a future study was done on trends in ICT for the next five to ten years pertaining to Project Management.

The chapter concluded by addressing the achievement of all the objectives of the study and by recommending possible future research that could be done based on this study.

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ANNEXURE A

Dear Sir / Madam

RESEARCH PROJECT: DETERMINING THE ADOPTION LEVEL OF INFORMATION COMMUNICATION TECHNOLOGY (ICT) IN CONSTRUCTION PROJECT MANAGEMENT ENVIROMENT

I am an MBA student at the Potchestroom Business School part of the North-West University. I am conducting research on the use of Information Communication Technology in Construction Project Management.

The research is undertaken as partial fulfilment of an MBA degree under the supervision of Mr Johan Coetzee of the Business School.

The study is designed to measure the current rate of Information Communication Technology (ICT) adoption in the Construction Project Management field in South Africa.

I request a few minutes of your time to complete the on-line questionnaire.

https://www.surveymonkey.com/s/PVMRV2F

The questionnaire should take approximately 15 minutes to complete. The information you provide will be treated in strictest confidence and will only be used for academic purposes.

You can withdraw at any stage without any reason or consequence from the study.

For further information please contact the researcher or supervisor at the following addresses;

Researcher / Student

Contact: Deon Geldenhuys

Cell: 083 283 5420

e-mail: deongeldenhuys123@gmail.com

Supervisor / Study Leader

Contact: Johan Coetzee

Cell: 082 821 7177

e-mail: Johannes.Coetzee@nwu.ac.za

I trust that you would give a favourable consideration to my request.

Information Communication Technology in Construction Project

General Information

1. Please select your current registration type

1.1 ☐ Pr. CPM
1.2 ☐ Pr. CM
1.3 ☐ Mentor
1.4 ☐ Candidate
1.5 ☐ Other

2. Please supply your age

Age

Please select from drop down selection

3. What is your gender?

◯ Male ◯ Female

4. Please select your home language?

Other (please specify)

5. What is highest level of education you have completed?

5.1 ◯ Matric (Grade 12)
5.2 ◯ Certificate
5.3 ◯ Diploma
5.4 ◯ Degree
5.5 ◯ Honours Degree
5.6 ◯ Masters Degree
5.7 ◯ PHD Degree

Other (please specify)

Information Communication Technology in Construction Project

General Information

6. Years working experience in total?

Years working experience?

Please select from drop down selection

7. Years industry experience?

Years industry experience?

Please select from drop down selection

8. Please select area where you work most of the time

◯ City ◯ Small Town ◯ Rural

Other (please specify)

9. Are you stationed the majority of the time in South Africa?

◯ Yes ◯ No

10. How many people are employed by the company you work for?

people employed

Please select from drop down selection

11. How many people work under you?

People working under you?

Please select from drop down selection

Information Communication Technology in Construction Project

Construction Project Management

12. Choose one of the following that best describes construction projects at present

12.1 ◯ Construction Projects are more complicated today than ever before

12.2 ◯ Construction Projects were more complicated in the past

12.3 ◯ Construction Projects have the same complexity as in the past

12.3 ◯ Construction Projects are less complicated than in the past

Please elaborate

13. What is your view of the following statement? Communication in construction project management is very important for the success of a project

13.1 ◯ Strongly Agree

13.2 ◯ Agree

13.3 ◯ Disagree

13.4 ◯ Strongly Disagree

14. How often does projects get completed on time, within budget and with required quality?

14.1 ◯ Almost always

14.2 ◯ Often

14.3 ◯ Seldom

14.4 ◯ Almost never

Information Communication Technology in Construction Project

Construction Project Management

15. What is your view of the following statement? The characteristics of quality information consist of the following (Accuracy, Completeness, Consistency, Uniqueness, Timeliness)

15.1 ◯ Strongly Agree

15.2 ◯ Agree

15.3 ◯ Disagree

15.4 ◯ Strongly Disagree

16. Do you agree that the adoption of information communication technology (ICT) will improve construction project management.

16.1 ◯ Strongly Agree

16.2 ◯ Agree

16.3 ◯ Disagree

16.4 ◯ Strongly Disagree

General Meening of Terms

GENERAL MEENING OF THE TERMS USED FOR DEVICES

1. A DESKTOP COMPUTER is one that was not designed to be portable; the keyboard and monitor are usually seperate units.

2. A full-sized LAPTOP COMPUTER is one that is designed to be portable; it usually weighs more than 1 kg; they keyboard and monitor are usually attached to each other.

3. A lightweight NETBOOK COMPUTER is highly portable; it usually weighs less than one kilogram; its monitor is small (usually 25cm or less) and the keyboard is small and built in.

4. A TABLET COMPUTER is highly portable; it usually weighs less than 1 kg; its monitor is small (usually less an 25cm) and the keyboard may be small and built in or the keys may be displayed in video on a touch scree. iPad is included here.

5. A dedicated E-BOOK READER is a portable device whose sole function is a platform for reading electronic books and certain other electronic publications. Examples include the Kindle, NOOK, and the like; iPad and similar devices serve many other functions and so are not included here.

6. A HANDHELD DEVICE is usually about the size of a cellular telephone and often includes one; it has a screen that can show e-mail messages, web pages, video, etc; and its keyboard is a few cm across, at most or the keys may be displayed in video on a touch screen. (This includes Personal Digital Assistants (PDA), Cellular phones, and smart Phones.)

Information Communication Technology in Construction Project

Information Communication Technology

17. Do you own any of these?

17.1 ☐ Desktop Computer
17.2 ☐ Laptop Compnuter
17.3 ☐ Netbook Computer
17.4 ☐ Tablet Computer (iPad)
17.5 ☐ E-Book Reader (Kindle)
17.6 ☐ Handheld Device (Smart Phone, PDA)

18. Do you have access to any of these?

18.1 ☐ Desktop Computer
18.2 ☐ Laptop Computer
18.3 ☐ Netbook Computer
18.4 ☐ Tablet Computer (iPad)
18.5 ☐ E-Book Reader (Kindle)
18.6 ☐ Handheld Devices (Smart Phone, PDA)

Information Communication Technology in Construction Project

Adoption Phase

19. Which of the following best describes you? (Choose only one)

19.1 ◯ I am skeptical of new technologies and use them only when I have to

19.2 ◯ I am usually one of the last people I know to use new technologies

19.3 ◯ I usually use new technologies when most people I know do

19.4 ◯ I like new technologies and use them before most people I know do

19.5 ◯ I love new technologies and am among the first to experiment with and use them

20. If money wasn't an issue, which of the following devices would you prefer for interacting with your magazines and books?

20.1 ◯ I prefer to read a hardcopy

20.2 ◯ I prefer to read on my desktop computer

20.3 ◯ I prefer to read on my full-sized laptop

20.4 ◯ I prefer to read on my lightweight netbook computer

20.5 ◯ I prefer to read on my tablet computer (iPad)

20.6 ◯ I prefer to read on my e-book reader (Kindle)

20.7 ◯ I prefer to read on my handheld device (Smartphone, PDA)

Information Communication Technology in Construction Project

Hardware Replacement

21. How old is your own personal?

	1 Don't own one	2 Less than 1 year old	3 1 year old	4 2 years old	5 3 years old	6 4 years old	7 More than 4 years old
21.1 Desktop computer	◯	◯	◯	◯	◯	◯	◯
21.2 Laptop computer	◯	◯	◯	◯	◯	◯	◯
21.3 Lightweight netbook	◯	◯	◯	◯	◯	◯	◯
21.4 Tablet computer (iPad)	◯	◯	◯	◯	◯	◯	◯
21.5 Dedicated e-book reader (Kindle)	◯	◯	◯	◯	◯	◯	◯
21.6 Internet capable handheld device (Cell phone, Smartphone or PDA)	◯	◯	◯	◯	◯	◯	◯

22. How often does the company you work for replace the following?

	1 Don't have one	2 More than once per year	3 Every 1 year	4 Every 2 years	5 Every 3 years	6 Every 4 years	7 More than every 4 years
22.1 Personal desktop computer?	◯	◯	◯	◯	◯	◯	◯
22.2 Personal laptop computer?	◯	◯	◯	◯	◯	◯	◯
22.3 Personal lightweight netbook computer?	◯	◯	◯	◯	◯	◯	◯
22.4 Personal Tablet Computer (iPad)?	◯	◯	◯	◯	◯	◯	◯
22.5 Personal e-book reader (Kindle)?	◯	◯	◯	◯	◯	◯	◯
22.6 Personal internet capable handheld device (cell phone, smartphone or PDA)?	◯	◯	◯	◯	◯	◯	◯

Information Communication Technology in Construction Project

Internet Access

23. Do you use the following wireless mediums to gain access to the internet at office?

		1 Almost always	2 Often	3 Seldom	4 Almost never
23.1	Cellular networks - voice/cell phone (Cell C, Vodacom, MTN)	◯	◯	◯	◯
23.2	Edges, GPRS, 3G	◯	◯	◯	◯
23.3	Bluetooth or Infra Red on your laptop or cell phone	◯	◯	◯	◯
23.4	WiFi (eg. Hotspots, Wireless LAN)	◯	◯	◯	◯
23.5	WiMAX (Wireless broadband networks spanning up to 50km)	◯	◯	◯	◯

24. Do you use the following wireless mediums to gain access to the internet out of office?

		1 Almost always	2 Often	3 Seldom	4 Almost never
24.1	Cellular network - voice/cell phone (Cell C, Vodacom, MTN)	◯	◯	◯	◯
24.2	Edge, GPRS, 3G	◯	◯	◯	◯
24.3	Bluetooth or Infra Red on your laptop or cell phone	◯	◯	◯	◯
24.4	WiFi (eg. Hotspots, Wireless LAN)	◯	◯	◯	◯
24.5	WiMAX (Wireless broadband network spanning up to 50km)	◯	◯	◯	◯

Information Communication Technology in Construction Project

Mobile Device Activities

25. Do you take part in any of these Internet activities from your mobile device?

		1 Almost always	2 Often	3 Seldom	4 Almost never
25.1	Place and receive telephone calls	◯	◯	◯	◯
25.2	Text messaging	◯	◯	◯	◯
25.3	Instant messaging	◯	◯	◯	◯
25.4	E-mail	◯	◯	◯	◯
25.5	Use Twitter or similar applications	◯	◯	◯	◯
25.6	Use social networking websites (Facebook, LinkedIn, etc.)	◯	◯	◯	◯
25.7	Check information (news, weather, sport, facts, etc.)	◯	◯	◯	◯
25.8	Read or contribute to blogs	◯	◯	◯	◯
25.9	Use maps (find places, get directions, or plan routes.)	◯	◯	◯	◯
25.10	Conduct personal business (banking, shopping, ect.)	◯	◯	◯	◯
25.11	Use photo-sharing websites (Flickr, Snapfish, Picasa, ect.)	◯	◯	◯	◯
25.12	Use data storage websites (Dropbox, Google Docs, ect.)	◯	◯	◯	◯
25.13	Watch mobile TV	◯	◯	◯	◯
25.14	Download/stream music	◯	◯	◯	◯
25.15	Download or watch videos online	◯	◯	◯	◯
25.16	Download or play games online	◯	◯	◯	◯

Information Communication Technology in Construction Project

Software Applications

26. Do you use the following computer based applications...?

	1 Almost always	2 Often	3 Seldom	4 Almost never	5 Never heard of it
26.1 Word processors (Word, Pages, etc.)	◯	◯	◯	◯	◯
26.2 Spreadsheets (Excel, Numbers, etc.)	◯	◯	◯	◯	◯
26.3 Presentation software (PowerPoint, etc.)	◯	◯	◯	◯	◯

27. Do you use the following network (cloud) based application...?

	1 Almost always	2 Often	3 Seldom	4 Almost never	5 Never heard of it
27.1 Word processors (Google Documents, etc.)	◯	◯	◯	◯	◯
27.2 Spreadsheets (Google Spreadsheets, etc.)	◯	◯	◯	◯	◯
27.3 Presentation software (Google Presentation, etc.)	◯	◯	◯	◯	◯

Information Communication Technology in Construction Project

General Usage of Devices

28. General usage mobile devices

		1 Never heard of it	2 I've heard the name but not really sure what it is	3 I know what it is but have never used it	4 I use this occasionally	5 I use this regularly
28.1	Laptop computers	◯	◯	◯	◯	◯
28.2	Smart Phones	◯	◯	◯	◯	◯
28.3	Tablet PC (iPad, Samsung Galaxy)	◯	◯	◯	◯	◯
28.4	E-Book Reader (Kindle)	◯	◯	◯	◯	◯

29. General usage geo-surveillance

		1 Never heard of it	2 I've heard of the name but not really sure what it is	3 I know what it is but have never used it	4 I use this occasionally	5 I use this regulary
29.1	GPS Navigation	◯	◯	◯	◯	◯
29.2	GPS Smart Phone in work situation	◯	◯	◯	◯	◯
29.3	GPS based surveying instrument (Total Station)	◯	◯	◯	◯	◯
29.4	Laser Range Finder / Measure	◯	◯	◯	◯	◯
29.5	Digital Surveying instrument	◯	◯	◯	◯	◯

Information Communication Technology in Construction Project

General Usage of Devices

30. General usage sensors & scanners

		1 Never heard of it	2 I've heard the name but not really sure what it is	3 I know what it is but have never used it	4 I use this occasionally	5 I use this regularly
30.1	Alcohol Breath Tester	◯	◯	◯	◯	◯
	Barcode Scanner	◯	◯	◯	◯	◯
30.2	Biometric Systems (finger print scanner)	◯	◯	◯	◯	◯
30.3	Circuit Tracers	◯	◯	◯	◯	◯
30.4	Thermal Imaging Scanner	◯	◯	◯	◯	◯
30.5	Concrete Scanners	◯	◯	◯	◯	◯
30.6	Ground Penetrating Radar	◯	◯	◯	◯	◯
30.7	Drug Saliva Tester	◯	◯	◯	◯	◯
30.8	Radio-frequency identification device (RFID) / Auto-ID	◯	◯	◯	◯	◯

Information Communication Technology in Construction Project

General Usage of Devices

31. General usage other hybrid technologies

		1 Never heard of it	2 I've heard the name but not really sure what it is	3 I know what it is but have never used it	4 I use this occasionally	5 I use this regularly
31.1	Collaboration Technologies (projectors, est)	◯	◯	◯	◯	◯
31.2	Machine Control	◯	◯	◯	◯	◯
31.3	Virtual Reality / Virtual Construction	◯	◯	◯	◯	◯
31.4	Augmented Reality	◯	◯	◯	◯	◯
31.5	Tele-presence (Skype)	◯	◯	◯	◯	◯
31.6	BIM (Build Industry Matrix)	◯	◯	◯	◯	◯

32. General usage wireless application and services

		1 Never heard of it	2 I've heard the name but not really sure what it is	3 I know what it is but have never used it	4 I use this occasionally	5 I use this regularly
32.1	Wireless Network (WiFi)	◯	◯	◯	◯	◯
32.2	Wireless Intranet (Company specific)	◯	◯	◯	◯	◯
32.3	Project Intranet (one location)	◯	◯	◯	◯	◯
32.4	Project Extranet (numerous location's)	◯	◯	◯	◯	◯

Information Communication Technology in Construction Project

Difficulties experienced with technology

33. Have you experienced any of the following?

		1 Almost always	2 Often	3 Seldom	4 Almost never
33.1	Reception problem with cell phone networks (Communication)?	◯	◯	◯	◯
33.2	Problem with speed of mobile network availability (3G, Edge)?	◯	◯	◯	◯
33.3	Dust causes devices to malfunction?	◯	◯	◯	◯
33.4	No service center's available to repair communication devices?	◯	◯	◯	◯

ANNEXURE B

Question	Description	n	mean	standard deviation	Missing
Q.1	Registration1 (Pr. CPM)	191	.33	.471	0
Q.1	Registration2 (Pr. CM)	191	.12	.320	0
Q.1	Registration3 (Mentor)	191	.04	.188	0
Q.1	Registration4 (Candidate)	191	.42	.496	0
Q.1	Registration5 (Other)	191	.14	.344	0
Q.2	Age	182	41.41	11.795	9
Q.3	Gender	190	1.17	.375	1
Q.4	Home Language	189	3.98	2.245	2
Q.5	Education	184	4.08	1.094	7
Q.6	Work Experience	179	18.60	12.268	12
Q.7	Industry Experience	177	17.28	11.989	14
Q.8	Work Area	175	1.40	.678	16
Q.9	Stationed South Africa	180	1.01	.075	11
Q.10	People Employed	182	5.13	2.511	9
Q.11	People Supervised	173	2.53	2.028	18
Q.12	Projects complexity	169	1.92	1.162	22
Q.13	Is communication important	174	1.07	.315	18
Q.14	Projects quality, time, budget	174	2.41	.833	18
Q.15	Characteristics of information	172	1.41	.538	20
Q.16	Adoption of ICT improve management	172	1.48	.535	20
Q17.1	Do you own desktop computer	191	.39	.490	1
Q17.2	Do you own laptop computer	191	.76	.429	1
Q17.3	Do you own netbook computer	191	.07	.253	1
Q17.4	Do you own tablet computer (iPad)	191	.27	.444	1
Q17.5	Do you own e-book reader (Kindle)	191	.09	.285	1

Question	Description	n	mean	standard deviation	Missing
Q17.6	Do you own handheld device	191	.55	.498	1
Q18.1	Access to desktop computer	191	.50	.501	1
Q18.2	Access to laptop computer	191	.77	.419	1
Q18.3	Access to netbook computer	191	.09	.285	1
Q18.4	Access to tablet computer (iPad)	191	.30	.461	1
Q18.5	Access to e-book reader (Kindle)	191	.10	.300	1
Q18.6	Access to handheld device	191	.55	.499	1
Q.19	Which best describes you?	167	3.44	1.045	25
Q.20	If money was not an object?	168	3.55	1.993	24
Q21.1	How old is your desktop computer	118	3.46	2.210	74
Q21.2	How old is your laptop computer	152	3.59	1.613	40
Q21.3	How old is your netbook computer	68	1.50	1.113	124
Q21.4	How old is your tablet computer (iPad)	91	1.89	.948	101
Q21.5	How old is your e-book reader (Kindle)	75	1.53	1.044	117
Q21.6	How old is your handheld device	130	2.86	1.084	62
Q22.1	Replace desktop computer	119	4.24	2.212	73
Q22.2	Replace laptop computer	142	4.94	1.403	50
Q22.3	Replace netbook computer	71	1.73	1.723	121
Q22.4	Replace tablet computer (iPad)	73	2.03	1.803	119
Q22.5	Replace e-book reader (Kindle)	69	1.43	1.345	123
Q22.6	Replace handheld device	104	3.34	1.537	88

Question	Description	n	mean	standard deviation	Missing
Q23.1	Internet access office Cell phone	136	1.91	1.036	56
Q23.2	Internet access office Data card	125	2.07	1.025	67
Q23.3	Internet access office Bluetooth	108	2.92	1.169	84
Q23.4	Internet access office Wi-Fi	135	2.17	1.200	57
Q23.5	Internet access office Wi Max	98	3.47	.997	94
Q24.1	Mobile Internet Cell phone	134	1.57	.880	58
Q24.2	Mobile Internet Data card	143	1.57	.916	49
Q24.3	Mobile Internet Bluetooth	101	2.92	1.230	91
Q24.4	Mobile Internet Wi-Fi	114	2.36	1.153	78
Q24.5	Mobile Internet Wi Max	91	3.48	.935	101
Q25.1	Mobile device place or receive calls	153	1.31	.746	39
Q25.2	Mobile device Text messaging	154	1.42	.712	38
Q25.3	Mobile device Instant messaging	135	1.91	1.168	57
Q25.4	Mobile device e-mail	155	1.66	1.009	37
Q25.5	Mobile device Twitter	131	3.36	1.082	61
Q25.6	Mobile device Facebook	143	2.63	1.179	49
Q25.7	Mobile device check weather, news	147	2.20	1.038	45
Q25.8	Mobile device blogs	129	3.52	.885	63
Q25.9	Mobile device maps	143	2.22	.987	49
Q25.10	Mobile device banking, shopping	140	2.31	1.157	52
Q25.11	Mobile device photo sharing	130	3.52	.891	62
Q25.12	Mobile device Drop box (data storage)	134	2.93	1.218	58

Question	Description	n	mean	standard deviation	Missing
Q25.13	Mobile device TV	134	3.84	.565	58
Q25.14	Mobile device download music	132	3.48	.920	60
Q25.15	Mobile device download videos	131	3.48	.889	61
Q25.16	Mobile device download games	134	3.61	.803	58
Q26.1	Computer based Word processing	158	1.20	.535	34
Q26.2	Computer based Spread sheets	156	1.15	.437	36
Q26.3	Computer based Presentation	155	1.86	.996	37
Q27.1	Web based Word processing	155	3.17	1.419	37
Q27.2	Web based Spread sheet	149	3.38	1.353	43
Q27.3	Web based Presentation	150	3.46	1.324	42
Q28.1	General usage laptop computer	155	3.86	.559	37
Q28.2	General usage smartphones	145	3.81	.565	47
Q28.3	General usage tablet computer (iPad)	141	3.39	.695	51
Q28.4	General usage e-book (Kindle)	138	2.96	.796	54
Q29.1	GPS Navigation	154	3.74	.614	38
Q29.2	GPS Smart phone	144	3.49	.738	48
Q29.3	GPS Surveying	144	2.99	.802	48
Q29.4	Laser range finder	146	2.99	.917	46
Q29.5	Digital Surveying instrument	146	2.92	.784	46
Q30.1	Alcohol Breath Tester	152	3.09	.690	40
Q30.2	Barcode Scanner	147	3.12	.707	45
Q30.3	Biometric System	147	3.30	.735	45

Question	Description	n	mean	standard deviation	Missing
Q30.4	Circuit tracer	144	2.47	.916	48
Q30.5	Thermal Imaging scanner	146	2.71	.886	46
Q30.6	Concrete Scanner	148	2.83	.899	44
Q30.7	Ground penetrating radar	145	2.72	.903	47
Q30.8	Drug saliva tester	145	2.59	.786	47
Q30.9	RFID	146	2.45	.940	46
Q31.1	Collaboration Technologies	149	3.34	1.057	43
Q31.2	Machine control	143	2.38	.963	49
Q31.3	Virtual Reality	143	2.45	1.019	49
Q31.4	Augmented Reality	142	1.96	.937	50
Q31.5	Tele-presence (Skype)	144	3.31	.970	48
Q31.6	BIM (Build Industry Matrix)	142	2.11	1.043	50
Q32.1	Wi-Fi	149	3.86	.386	43
Q32.2	Wireless Intranet	148	3.61	.705	44
Q32.3	Project Intranet	144	3.16	1.022	48
Q32.4	Project Extranet	144	2.77	1.029	48
Q33.1	Reception problem cell phone	153	2.16	.711	39
Q33.2	Speed of mobile network	151	1.99	.658	4641
Q33.3	Dust cause problems	146	3.10	.803	46
Q33.4	No service centre	146	2.96	.821	46

ANNEXURE C: DECLARATION BY LANGUAGE EDITOR

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October 21, 2012

To whom it may concern

Re: Letter of confirmation of language editing

The MBA mini-dissertation "*Communication Technology in the South African construction project management environment*" by GT Geldenhuys (1310634) was language, technically and typographically edited. The sources and referencing technique applied was checked to comply with the specific Harvard technique as per North-West University prescriptions. Final editing and printing remains the responsibility of the student.

Antoinette Bisschoff
BA (Languages); MBA
SA Translators' Institute (SATI)/SA Vertalersinstituut (SAVI) Membership: 1001891
Officially approved language editor of the NWU