THESIS

A CASE STUDY OF BARRIERS INHIBITING THE GROWTH OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN A CONSTRUCTION FIRM

Submitted by

Thejasvi Andipakula

Department of Construction Management

In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Fall 2017

Master's Committee:

Advisor: Bolivar A Senior

Mary Nobe
Hilla Skiba

ABSTRACT

A CASE STUDY OF BARRIERS INHIBITING THE GROWTH OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN A CONSTRUCTION FIRM

The purpose of this research is to study barriers that inhibit the growth of ICT in a construction firm operating in the state of Nevada. This paper focusses on three research objectives. The first research objective is to identify commonly used Information and communication technology tools in the selected firm. The second objective is to highlight significant barriers that hinder the growth of ICT implementation in the selected construction firm. The third research objective is to analyze strategies used by professionals of the selected construction firm for mitigating barriers that are encountered while attempting to implement ICT.

Different factors were highlighted which inhibit the growth of ICT. Literature review highlighted the most important ones as financial constraints, time constraints, lack of support from top management, lack of training, the reluctance of employees to learn new technology and lack of technical support. To mitigate the barriers to ICT adoption, literature has stated different strategies. These include support and encouragement from top management, training employees for ICT tools, motivating employees for using ICT, empowering a champion to overcome resistance from employees, learning by observation and giving employees sufficient time to learn. A case study approach was used, and one firm was the center of research, thereby data collection and analysis was limited to this particular firm. Nine interviews were conducted with employees belonging to different sectors in which firm operates. A thematic analysis of interview data was conducted using NVivo. Roger's model of Innovation Diffusion (1983) was employed as a tool

for considering ICT adoption attitudes in terms of the interviewees' personal preferences. The analysis showed that all interviewees had a clear understanding of importance and scope of ICT in the selected firm. However, their understanding was congruent with their stage of Roger's model (1983). The selected firm had the financial strength to adopt ICT, and top management supported new ideas and ICT adoption. Ample training was given to employees so that they can learn new technology with ease. A persistent barrier was the time available to implement ICT, as interviewees reported that they needed more time to explore the use of new technologies.

The selected firm used three strategies to facilitate ICT diffusion, i.e., training employees, motivating them and creating a culture of support. It was suggested that the selected firm should use 'learning by observation'; showing employees how ICT can help with their day-to-day work will motivate them and develop their interest in using it. Furthermore, giving employees time to explore the use of new technologies can also facilitate ICT implementation in the selected firm. The implications of findings for the selected firm and other firms in the construction sector are discussed in the thesis.

TABLE OF CONTENTS

Abstract……..ii

List of tables……..…….……..ix

List of figures…….……... x

Chapter 1: Introduction 1

1.1 Background of the study..... 1

1.2 Problem statement 1

1.3 Motivation of the study 2

1.4 Research objective..... 3

1.5 Research questions 4

1.5.1 Primary research question 4

1.5.2 Secondary research question 5

1.6 Significance of the study 5

1.7 Limitation 6

Chapter 2: Literature review..... 7

2.1 Theoretical background..... 7

2.2 Empirical studies 8

2.3 Current use of ICT in construction..... 8

2.4 Factors hindering the growth of ICT in construction industry..... 11

2.4.1 Financial constraint..... 11

2.4.2 Organizational/Industrial related hindrances..... 12

2.4.2.1 Rogers model of innovation diffusion in construction industry. 17

2.4.3 ICT diffusion constraints at the organizational level 18
2.4.3.1 ICT investment decision (C1a) 19
2.4.3.2 Organizational adoption (C1b) 20
2.4.3.3 Business result (C1c) 20
2.4.4 ICT diffusion constraints at the individual level 20
2.4.4.1 Personal learning and support gaps (C2a) 21
2.4.4.2 ICT investment gaps (C2b) 22
2.4.4.3 Personal gaps (C2c) 22
2.4.5 ICT diffusion constraints at the group level 22
2.4.5.1 Group learning gaps (C3a) 23
2.5 Strategies for mitigating factors that hinder ICT implementation in construction 23
2.5.1 Organizational policy and vision 24
2.5.2 Top management support 24
2.5.3 Encourage technology gate keeper 25
2.5.4 Build internal knowledge people 25
2.5.5 Establishing an effective support system 25
2.5.6 Empowering a “champion” 26
2.5.7 Creating proximity 26
2.5.8 Investing in the right technology 26
Chapter 3: Methodology 28

3.1 Research purpose 28
3.2 Research approach 29
3.3. Philosophical assumptions behind research 30
3.4. Method 31
3.4.1. In-depth interviews 31
3.5 Data source 32
3.6 Sampling 33
3.7 Data analysis 34
3.7.1 Data reduction 34
3.7.1.1 First phase for data reduction 35
3.7.1.2 Second phase for data reduction 35
3.7.1.3 Third phase for data reduction 35
3.7.2 Data display 35
Chapter 4: Analysis 36
4.1 Analysis of demographics 36
4.2 Thematic analysis 41
4.2.1 Use of ICT in firms operations 41
4.2.2 Importance of ICT in selected firm 42
4.2.3 ICT and cost-effectiveness of selected firm 44
4.2.4 Role of top management for ICT adoption 46
4.2.5 Change of sops for ICT adoption 46

4.2.6 Employees comfort for ICT usage 47

4.2.7 Opinion leader for ICT diffusion 48

4.2.8 Discussion among employees for ICT adoption 49

4.2.9 Overcoming barriers through training, top management support and follow up 50

4.3 Ranking of factors that hinder ICT implementation 51

4.4 Ranking of strategies for fostering ICT implementation 54

4.5 Findings according to Roger's model of innovation diffusion 56

Chapter 5: Discussion and Conclusion 60

5.1 Similarities with previous studies 60

5.1.1 ICT fosters communication in construction firms 60

5.1.2 The role of ICT for information management 61

5.1.3 Top management support for facilitating ICT innovation diffusion 62

5.1.4 Barriers to ICT implementation 62

5.1.5 Facilitating ICT innovation diffusion 63

5.2.1 Applications of ICT in the selected firm 65

5.2.2 The role of ICT in shortening lifecycle of projects in construction firms 66

5.2.3 Barriers in ICT implementation 67

5.3. Relation of findings to stated objectives 68

5.4. Implications of findings and recommendations 70

5.4.1. Implications and recommendations for construction industry 71

5.4.2. Implications and recommendations for the selected firm 72

5.5. The validity of findings 73

5.6. Conclusions 73

5.7. Limitations of study and suggestions for future studies 75

Bibliography 77

Appendix A: Ratings given to importance of video conferencing, procore and bim 90

Appendix B: Ratings given to importance of ICT for communication 91

Appendix C: Procore 92

Appendix D: Questions for interview 93

Appendix E: Data display in nvivo 102

LIST OF TABLES

TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF INTERVIEWEES……37

TABLE 2: RATINGS OF ATTRIBUTES GIVEN BY INTERVIEWEES……38

TABLE 3: RANKING OF FACTORS THAT INHIBIT ICT IMPLEMENTATION…….....50

TABLE 4: RANKING OF STRATEGIES FOR FACILITATING ICT IMPLEMENTATION…53

LIST OF FIGURES

FIGURE 1- ICT DIFFUSION CONSTRAINTS AT THE ORGANIZATIONAL LEVEL……18

FIGURE 2- ICT DIFFUSION CONSTRAINTS AT THE INDIVIDUAL LEVEL ……...21

FIGURE 3- ICT DIFFUSION CONSTRAINTS AT THE GROUP LEVEL …….22

CHAPTER 1: INTRODUCTION

This chapter contains seven sections. The first section highlights the background of this study. The second section puts forth the problem statement, while the third section illustrates the scope of this study. Research objectives are mentioned in the fourth section, and the research questions are elaborated in the fifth section. The sixth section sheds light on the significance of this research; however, the last section discusses its limitations.

1.1 Background of the study

The use of Information technology in the construction industry can possess a multitude of benefits, in the long-run as well as in the short run. Kodama (2012, pp. 190) and Kocarev, (2012, pp. 20) have stated that if a construction firm can strategically invest in Information and Communication Technology (ICT), it will enable the company to reduce both costs and time in the capital works process. Furthermore, it will assist the firm in fulfilling the needs of its clients and improving the delivery of services.

1.2 Problem statement

Keeping in mind the benefits that ICT implementation will render to construction firms, there are certain constraints and barriers that have been realized in the actual implementation of ICT in a company. These factors are identified as lack of ICT investment decisions, lack of organizational adoption and loss of business outcome in the construction industry (Lenny, 2009, pp. 209). According to Rogers (2003), some socio-economic perspectives including industry characteristics, market situation, managerial perspective and psychological perspective can serve as barriers to innovation diffusion in firms. Although Rogers did not talk about construction sector specifically, these socio-economic perspectives can be generalized to the construction industry.

Research has indicated that technological adoption in an organization should go through technical diffusion as the first step of the process. Samad, Loosemore, and David (2016) mentioned that organizational culture and management could aid in successful technological diffusion across it. Similarly, barriers to technology include cultural, organizational and institutional barriers. These include clients who undervalue and discourage innovation, the dynamic and unpredictable production environment in which buildings are constructed, general industry resistance to change and anti-intellectual culture (Slaughter, 2000). The barriers also include poor training and skills development and traditional and professional trade practices that are threatened by the introduction of new technologies (Brandon & Lu, 2008). Construction firms also lack investment in research and development processes (Sexton & Barrett, 2003). Moreover, factors that hinder the development of ICT include lack of uniformity of decision makers, the complexity of new projects and the variety of differentiated activities involved in any construction project (Lenny, 2009, pp. 209).

1.3 Motivation of the study

Over the past twenty years, ICT has witnessed tremendous innovations. Two decades before, technology was limited to PTT, which stands for Post, Telephone and Telegram. ICT was predominantly controlled by the government and public services. However, today, ICT sector includes hardware, software, internet and telephony content, applications, and support services. It should be noticed that these dynamic services are now provided by a wide variety of businesses including corporate giants, small and medium-sized enterprises (SMEs), entrepreneurs, individual developers and open-source networks (Avgerou, Hayes, & La Rovere, 2016).

From 2005 to 2013, there was an increase in the broadband internet subscriptions and mobile subscriptions (Blessing, 2012, pp. 188). Therefore, developing strong internet mobile

infrastructure leads to establishing an effective and efficient flow of communication across partners in different fields. Today, a multitude of businesses such as health, education, public services, and government-funded organizations and Non-Governmental Organizations (NGOs) use ICT for strengthening communication flow.

Similarly, business firms are increasingly using Enterprise Resource Planning (ERP) systems to improve their management processes and join global supply chains. Moreover, with respect to the diffusion of ICT in an organization, the extent to which it can reap benefits from ICT depends upon its capacity to adapt to changing work processes (Kling, 1980).

1.4 Research objective

This study methodologically examines the perception about the implementation and use of ICT by key personnel involved in a construction company located in Nevada, USA. It studies their opinions and compares them with similar studies in the construction industry. Moreover, it compares individual's perception about the scope and implementation of ICT in a specific firm according to their place at Roger's Model of Innovation Diffusion (1983). It contributes to improvement in the efficacy of current ICT applications used by the selected firm and provides insights into steps towards the implementation of new tools and methods. ICT has a promising future for construction firms (Ekholm et al., 2007), and other firms will be able to gain benefits from the issues explored in this study. The need for this research arises from the complexities of implementing ICT in a construction firm which is further aggravated by the uniqueness of construction products, the nature of the industry itself, the variability of the company's expertise, project-based organizations and operating across multiple locations, as suggested by Dubois and Gadde (2002). Construction business also entails different needs and products ranging from specialized tunneling companies, surveying services to building materials that further complicates

the process of implementing ICT in the construction industry (Ekholm et al., 2007).This research is based on the premise that when a construction firm tries to implement ICT, it faces a variety of barriers, which hinder the implementation of ICT, as illustrated by Davies (2008) and Peansupap and Walker (2005). Though research has identified several barriers that hinder ICT implementation, few studies address barriers that may occur from *'initial adoption to final implementation stage'* (Peansupap and Walker, 2006). This research thesis will address this gap by studying barriers to ICT implementation in the light of Roger's Model of Innovation Diffusion (1983). It should be noticed that Roger (1983) placed individuals into five different categories according to the time they take to adopt new technology. These categories include innovators, early adopters, early majority, late majority, and laggards. Can early adopters facilitate ICT implementation in construction firms by becoming its' advocates? How do late majority respond to ICT implementation in construction firms? Such questions will be answered in this study. In current literature, few researchers (Peansupap, Walker, Goldsmith, & Wilson, 2003; Pensaup & Walker, 2006; Shibeika, & Harty, 2015) have studied ICT implementation in construction firms by employing 'Innovation diffusion' approach.

1.5 Research questions

The need and scope of this research can be addressed as encompassing three research objectives that will analyze the scope of ICT in a construction organization. The study has one primary research question and two associated research questions. It is to be noted that all the research questions are broken down into further clarifying questions:

1.5.1 Primary research question

- To identify significant factors viewed by construction professionals of selected construction firm as hindering the application of ICT in this firm?

The clarified questions for this research objective are:

1. Which factors hinder the growth of ICT in the selected construction organization?
2. What strategies are used by this firm's employees to mitigate the factors hindering ICT's adoption?

1.5.2 Secondary research question

- To identify commonly used ICT tools in the selected firm?

  The clarified questions for this research objective are:

  1. How do professionals of selected firm view the usefulness of ICT in their firm?
  2. What are the main applications of ICT in the selected firm?

- To analyze strategies used by professionals of the selected firm for mitigating the hindrances they have encountered while attempting to implement ICT?

  The clarified questions for this research objective are:

  1. What strategies professionals of selected firm adopt for overcoming barriers to ICT implementation in their firm?
  2. What training or education employees of the selected firm receive for working effectively with ICT?

1.6 Significance of the study

In current times, the construction industry is becoming highly dependent on the flow of information. As mentioned earlier, different parties are involved in a single construction project; at a certain point in time, several professionals will be working in collaboration. In order to take effective decisions, it is imperative for them to obtain timely and accurate information pertaining

to their tasks. Murray, Nkado, and Lai (2001) mentioned that participants in the construction industry require information on regular intervals of the projects' lifecycle. It can be implied that documents, drawing, schedules, receipts, orders, and programs should be exchanged among different partners constantly and to take effective decisions, it is imperative for the professionals to obtain timely and accurate information pertaining to their tasks. The importance of exchanging information in construction is heightened because of its unique features that are further discussed in section 2.1. Construction projects are complex, dynamic and involve parties that are geographically dispersed. It has been witnessed that large and complex projects require a strong flow of communication among the partners and stakeholders.

1.7 Limitation

Researchers have discussed that as compared to other industries, the construction industry has shown reluctance for adapting ICT (Klein, 2008, p. 212; Dainty et al., 2007, p. 35). Aouad and Arayici (2009, p. 42) have attributed this reluctance to nature and flow of information across construction sector. Dainty et al. (2007, p. 35) explains that it is difficult to integrate ICT in this sector, because of its complexity and fragmentation. In short, it can be asserted that construction industry is different from other industries in manufacturing and services sector, pertaining to its complexity, uncertainty of environment and fragmented supply chain.

CHAPTER 2: LITERATURE REVIEW

This chapter conducts a detailed review of literature that is relevant to the research objectives and questions. The factors hindering the growth of ICT in the construction sector and strategies that mitigate factors hindering implementation of ICT in the construction sector are discussed in detail. Finally, Rogers's model of Innovation diffusion and its relevance to construction sector is studied with respect to the relevancy of respective research.

2.1 Theoretical background

UNESCO (2002, p. 13) refers to ICT as *"the combination of informatics technology with other, related technologies, specifically communication technology."* Christopher (2009, pp. 853) defines ICT as an umbrella term that encompasses several technologies that are used for accomplishing the purpose of communicating information from one end to another. Over the past twenty years, ICT has witnessed tremendous innovations. As mentioned earlier, two decades before, technology was limited to PTT. But ICT includes a wide array of technologies.

Onyegiri and Nwachukwu (2011) studied the importance, requirements, and obstacles for effective use of ICT in the construction industry. The authors conducted an in-depth analysis of relevant literature. The research mentioned that the major benefit of using ICT in the construction sector was that employees do not necessarily need to be present at the same venue; computer and internet allow them to coordinate from different locations. Moreover, the requirements mentioned in the study include having basic knowledge of communication technology and establishing a proper code of conduct and regulations by private boards. These factors facilitate efficient and effective implementation of ICT in the construction sector.

2.2 Empirical studies

The empirical studies of the respective research are divided into three categories on the basis of objectives and questions of this study. The first category studies the current use of ICT in the construction industry. The second category studies factors that hinder the growth of ICT in the construction sector. Finally, the strategies that mitigate factors hindering implementation of ICT in the construction sector are studied in the third category.

2.3 Current use of ICT in construction

Hosseini et al. (2013) carried out an exploratory research that described the current state of ICT in the construction industry and introduced some successful methods as well. The study described the advantages of adopting ICT for enhancing the efficiency of construction processes. An exhaustive review of relevant literature was conducted by authors. According to this study, the driving forces behind implementation of ICT were productivity - increasing the level of productivity and efficiency in the organization; globalization - to overcome competition, tight scheduling; and geographical and organizational proximity issues - and idiosyncrasies of construction industry i.e. project-orientation of the industry, the structure of an organization, and temporary and short-term nature of business relationships. The authors stated that ICT should facilitate an organization for achieving its goals. In constructions sector, the goals included improving the construction processes in terms of cost, time, and quality and client satisfaction. Furthermore, the study disclosed that ICT has helped in facilitating collaboration and coordination of work processes that have improved scheduling. This has created a positive impact on costs and client satisfaction. Hence, ICT enables construction organizations to achieve their goals in an efficient manner.

Atalah and Seymour (2013) analyzed the use of wireless technology in the construction industry. A web-based survey was used to collect data. Quantitative analysis of data showed that participant's level of interest in wireless technology was much greater than their level of use. The results of the survey showed that new technology allows construction managers to improve their skills, productivity and customer service. However, it failed to improve their ability to bargain and supervise project costs. On the other hand, implementation of wireless technology was hindered by slow download speed.

Klinc et al. (2016) explored the use of information and communication technology in construction projects. The paper highlighted that for successful project delivery, a collaborative engineering environment for information sharing is required. Furthermore, it exposed that collaborative information sharing has resulted in two diverse communication typologies. Firstly, since information can be accessed anywhere in the world, the model of communication has become standardized. Secondly, the users of information sharing application could communicate with each other whenever they found it necessary. The main analysis of this research was focussed upon the second typology, which asserts that engineers, architects and project managers have to remain in contact with each other constantly. Thereby, developing successful applications can help them to communicate as easily as they do through social media.

Bower et al. (2001) tried to explore the effects of video conferencing on product and processes of the construction industry. The research showed that even though video conferencing had perceived advantages, its successful implementation in the construction sector is significantly affected by several factors. These include social and operational issues; for example, employees fear that their conversations might be monitored. Furthermore, personal and corporate attitudes

towards video conferencing impacted its usage; even a trivial attitude like disliking the use of technology across work practices can exert a significant impact.

Sarshar and Isikdag (2004) conducted a study to assess the use of ICT in Turkish construction industry. The authors wanted to explore current use and needs of Turkish firms relevant to ICT. Data was collected through 22 semi-structured interviews with senior construction professionals employed in both government and private sectors. The analysis showed that sixty percent of organizations used ICT at the strategic level, and considered it as an important part of business strategy for future. It was also found that 81% of the organizations used emails, which is most commonly-used electronic communication tool in the construction sector. Similarly, 64% of the firms used CAD to make 2D and 3D designs, and they were aware of the benefits of using VRML, i.e., a software for electronic drawing in their everyday professional operations. But they failed to implement it due to the lack of an educated staff. When they were asked about the use of databases, 50% of all respondents told that they used databases to store contact details of their customers, stock details, material specific information and machinery details.

Aladag et al. (2016) explained the use of BIM in construction firms of China. The study conducted an extensive review of the literature. A case study approach was used to collect data. Findings revealed that BIM helps in reducing errors and omissions in construction documents. Moreover, it allows project teams to develop efficient design solutions throughout design and construction phase. The study also revealed that 'BIM standardized tools' can be employed to increase the benefits of implementing BIM in construction projects.

Aladag et al. (2016) described an understanding of the use of BIM, its adoption, challenges and benefits of its application in Turkish construction industry. Qualitative research was carried out by conducting focus groups interviews with professionals in the construction field. Structure

and culture of the organization were greatest obstacles that Turkish construction firms were facing, in terms of BIM adoption. It was also observed that apart from increasing profitability of a firm, BIM increased the satisfaction of its customers. In terms of project management, BIM led to effective monitoring and reporting and improved budgeting and costing. The findings also stated that in the current era, firms are facing the pressure of becoming more competitive, because of globalization, improved technology and changing demands of consumers. To encounter these challenges, a construction firm can employ BIM and become more competitive at global level.

2.4 Factors hindering the growth of ICT in construction industry

ICT implementation in the construction industry is a complex process, which depends on several factors. Research divides the factors hindering the growth of ICT into broadly two categories. These include financial constraints and organizational constraints:

2.4.1 Financial constraint

Financial constraint is one of the restraining factors that can inhibit the growth of ICT in the construction industry. Research indicates that administrative bodies in the construction industry are unaware about the potential gains of ICT. Owing to their lack of awareness, they may not invest in ICT. Another plausible reason of financial constraint is that executives focus mainly on traditional methods of construction. For instance, they are at home in estimating costs manually. Therefore, they are reluctant to adopt new methods and to invest in technology (Hosseini et al., 2013). Reluctance in investment can also occur due to the uncertainty about positive outcomes of employing ICT. Managers may be hesitant to invest in technology if they are unconfident whether technology can garner fruitful results for their construction business or not (Bee, 2013).

Akinbile and Oni (2016) assessed the challenges and benefits of ICT in the construction industry in the Oyo state of Nigeria. They conducted both primary and secondary research. A well-

structured questionnaire was developed, to collect data from professionals in the construction sector. The study revealed that ICT could provide various advantages like improved productivity, a channel of information and enrichment of knowledge. The challenges included costs of employing computer professionals, inadequate power supply and lack of training. Some of the challenges pertained to the problems that are associated with the socio-economic development of Nigeria. For example, local firms lack finances to support an ICT project completely. Furthermore, few people have acquired higher education in Nigeria. As a result, they lack skills and need to be trained by professionals. These professionals may belong to another country, and this may again add up to their ICT installation costs. It should be noticed that developing countries are at higher risk of facing such problems.

Sekou (2012) aimed to discuss the current use of ICT practice and highlight barriers that hinder ICT usage of civil engineering contractors in Ghana. A detailed literature review was conducted, after which a well-structured questionnaire was developed. The findings of research showed that most of the construction firms in Ghana had not applied advanced ICT tools. The literature also highlighted critical factors that hinder the growth of ICT in the construction industry. These factors included budget constraints for ICT investment, lack of commitment by firm's management towards ICT implementation, lack of training and technical support for construction professionals in ICT, inadequate ICT content for construction education and lack of client's interest in ICT base of construction firms.

2.4.2 Organizational/Industrial related hindrances

Organizational barriers include the culture of the organization, top executives' attitude, business processes and company size. Culture is by far the strongest component of an organization. It is intangible in nature but has a strong impact on an organization. Culture helps to foster a

positive attitude and seriousness towards technology adoption. If the culture of a construction company is inclined towards continuous improvement, then technology diffusion in the organization takes place easily (Onyegiri and Nwachukwu, 2011). However, if the organization is not open to innovation, the technology diffusion is complex and time-consuming.

Top managers of organizations are comfortable with the practices already existing in the organization. These practices become embedded in the culture of the organization. Senior managers apprehend that introducing something new in the organization will create a ripple effect that will be hard for them to control. Therefore, construction organization's top managers resist ICT adoption (Khosrowshahi and Arayici, 2012).

Another factor that causes organizational constraint is that the construction industry conforms to strict timelines. Thus, the employees will invest less time in learning new technology as they fear that they will have to compromise their time. Moreover, IT tools and business processes need to be skewed. A misalignment between these two hinders the adoption of ICT in the construction industry. Therefore, synchronizing the company's activities with reliable technology is essential. The right technology should be customized according to the nature of the industry and needs of the organization, so maximum efficiency can be achieved (Ofori, 2012).

A potential cause of senior managers' reluctance to ICT adoption is that when they encounter challenges adopting ICT, they develop a negative attitude towards ICT (Dace, 2007). Negative experiences lead to user reluctance towards ICT adoption. Similarly, if managers of the organization fail to implement technology, it can minimize users' acceptance of technology, leading to user reluctance (Davies, 2008).

Peansupap and Walker (2005) carried out a study to explore ways for adopting and diffusing Information and Communication Technology into an organization. Semi-structured interviews were conducted. The study was based on analysis of eleven factors. Three of these factors had a weak influence on ICT, and eight factors had a strong influence. These eight factors were divided into four categories, i.e., managerial factors, individual factors, technological factors and work environment. The weak factors were negative feelings towards ICT usage and frustration experienced while using ICT. The strong factors included professional development and technical support, understanding clear benefits of using ICT, supporting individual characteristics, supporting technology characteristics, supporting supervisor and organization, open discussion environment, colleague's support and positive feelings towards using ICT.

Every organization has specific Standard Operating Procedures (SOP) to execute its business operations. These procedures need to be changed for implementing ICT. Hence one of the most important factors in ICT adoption is how the organization maneuvers its operations in order to conform to the changes caused by ICT.

There is a great risk associated with re-engineering business processes while adopting new technology. Time is the most important factor in the construction industry. Projects have a constricted schedule, and the employees of the industry should work accordingly. Introducing a technological change in an organization and re-engineering methods are time-consuming processes (Kasim, 2011). Thus, time factor should be considered before adopting ICT procedures in the construction industry.

Another dimension of ICT implementation is that business processes are based on historical trial and error, which depend upon work practices established in the organization. Adapting new technology incurs changes across the entire organization. After adopting new

technology, business processes have to integrate it throughout the construction project. For instance, Japanese construction industry has fully incorporated technology into its operations. In Japan, BIM is used to design buildings. Furthermore, drones and quadcopters are used to analyze and study both construction processes and construction sites. Through drones, managers monitor construction operations and look for discrepancies between construction designs and their execution. All of the industry's decisions are made by using Knowledge Management Systems, whereby important information collected from the professionals is stored. The example of Japanese construction industry depicts that incorporating ICT at every level of construction is essential, in order to automate the industry completely.

Krogh (2002) contends that automation requires re-engineering of entire business processes. It necessitates training and education of employees so that they can be equipped to embrace new technology. Continuous efforts and step-by-step development of employees are important to make technological adjustments. Successful technological adjustments pave the way for organization towards automation. However, if automation process becomes extremely slow, the industry's stakeholders might lose their interest in the adoption of ICT.

Cherian and Aravindh Kumaran (2016) discussed the benefits, opportunities, and challenges of adopting ICT and e-business processes in Indian construction industry. The research was based on a theoretical framework adopted from previous literature, magazines, reports, and books. It was found that Indian construction firms were employing speedy communication tools to get their work accomplished in an efficient manner. Furthermore, the study discovered the challenges associated with adopting e-business practices in India. These challenges include system maintenance, security and lack of software knowledge. Linderoth and Jacobsson (2008) explained that when construction projects have limited costs and time, it becomes difficult to implement ICT.

Peansupap and Walker (2006) talked about the existence of drivers and barriers to ICT adoption in construction organizations. The research objective was to explain how different barriers and enablers obstruct and facilitate the diffusion of ICT at organizational, group and individual level. The research was completed by using three case studies of Australian construction firms. The study stated that constraints on a personal level include lack of budget for investing in ICT, lack of commitment from project participants and lack of ICT standardization. Organizational level issues included inadequate time to learn new skills, lack of basic computer expertise and failure to identify clear benefits of ICT. Time unavailable to share information, poor-quality personal contact and geographical distance are some of the issues at the group level. Research also demonstrated that for successful implementation of ICT, a strong management intervention is required that can establish a supportive workplace environment.

Wong and Lam (2010) discussed the difficulties faced by end-users of ICT in the construction industry. The research was carried through literature review, structured interviews, and questionnaires. It showed that majority of participants believed that ICT implementation is beneficial for a construction firm. However, organizations failed to provide adequate technical and psychological support. The study also indicated that some cultural and behavioral adjustments should be made, in order to create a paperless environment. Also, a change in habit and process reorientation is required. Therefore, managers were required to devise strategies such as imposing printing quotas and timely technical support system.

Wilson et al. (2013) conducted a survey to assess the use of ICT among construction firms of Sultanate of Oman. This main objective of the study was to explore structure, limitations, current practices and specific practices of ICT. The results from questionnaire showed that less than 17% of firms had a strategy in place, and 36.7% of the Omani construction firms did not use computers

at all. In terms of barriers, education, training and a shortage of skilled personnel were prominent. Furthermore, Omani firms lacked the ability to acknowledge the benefits of information sharing which had created a restrained culture towards technology adoption.

2.4.2.1 Rogers model of innovation diffusion in construction industry

The four main parts of diffusion of a new idea are innovation, channels, time and the members of a social system (Rogers, 1983). Innovation is an idea, practice or an object that is perceived as new by an individual for adoption. Before an innovation is selected, its attributes are studied in detail. There are five attributes of innovation. These are perceived by the members of the social system and include (Yang & Leskovec, 2010):

1. Relative advantage: The relative advantage for innovation diffusion can be measured in different ways, including economic advantage, social prestige, convenience, and satisfaction.
2. Compatibility: An innovation is considered compatible if it is consistent with the existing values, past experiences, and needs of potential adopters.
3. Complexity: Complexity refers to the degree to which an innovation is perceived as difficult to understand and use. The complexity of innovation is directly proportional to the time undertaken to adopt it.
4. Trialability: This refers to the experimentation of innovation with a limited bias. The innovations that can be tried out are more likely to be adopted.
5. Observability: This particular attribute measures the extent to which the results of innovation are visible to others. The easier it is for an individual to see the results, for example, benefits of adopting an innovation, the more likely they are to adopt it.

This study draws its theoretical foundation from the Rogers Model of Innovation Diffusion (1983). For facilitating the respective study, the Rogers model is aligned with the current research in three domains, i.e., ICT diffusion constraints at organizational, individual and group level.

2.4.3 ICT diffusion constraints at the organizational level

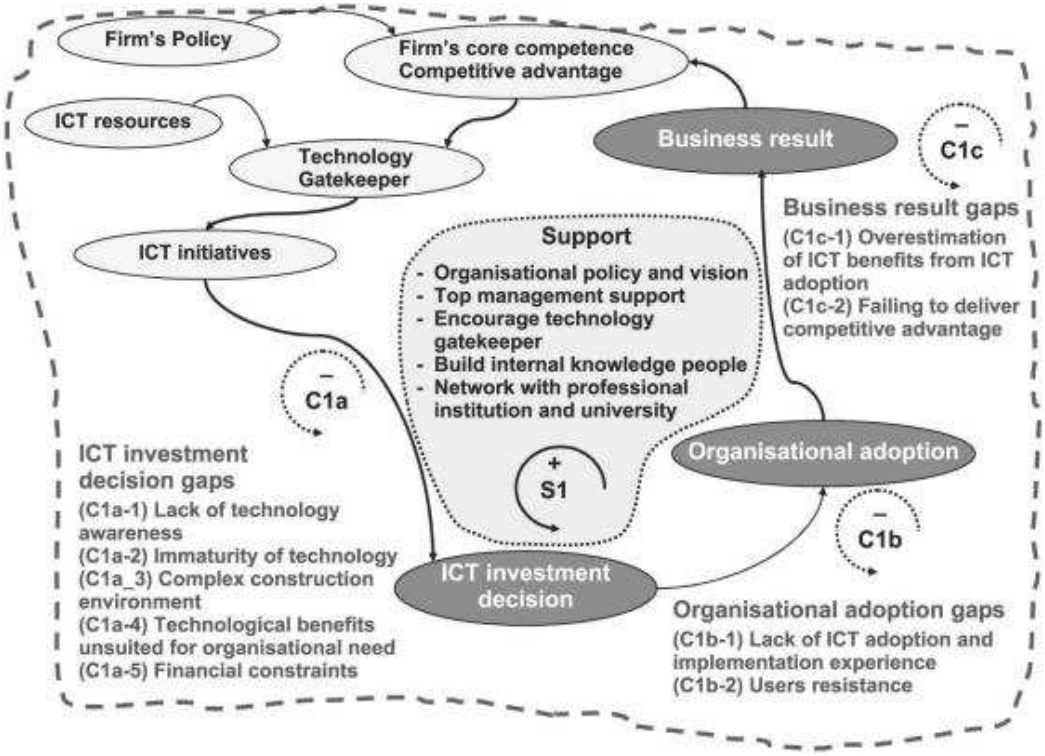


Figure 1: ICT diffusion constraints at the Organizational Level

Source: Peansupap and Walker (2006)

The above figure clearly shows the drivers as well as the restraining forces that influence ICT initiative at the organizational level. The area where ICT is diffused and adopted is encircled by a dashed line. The process starts with the firm's policy on how to increase ICT competencies. The knowledge to potential ICT users is introduced by technological gatekeepers; they also edit messages as per their understanding that influences perceived business results. After that, an ICT initiative investment decision is made, and the adoption phase starts. Then, the organization adopts

the initiative further, thereby deriving outcomes from the respective adoption. The supportive cycle described as (S1) in the figure 1 will be described in the later part of this study where strategies for mitigating factors that hinder ICT implementation in the construction industry are discussed. The constraining barriers can be linked to three main gaps that are indicated in the figure 1 with heavily shaded ellipses. These include ICT investment decisions, organizational adoption, and business result/outcome.

2.4.3.1 ICT investment decision (C1a)

(C1a-1, lack of technology awareness) The first gap exists because the senior IT managers are unaware of the key ICT benefits, thereby this lack of awareness may obscure the ICT investment opportunity.

(C1a-2, immaturity of technology) The immaturity of technology may cause investment reluctance as the IT manager chooses documentation sharing ICT ports instead of developing an in-house solution.

(C1a-3, complex construction environment) The complex nature of construction industry may result in a delay of ICT investment decision as the IT manager observes that the construction industry is slow to adopt new changes. Similarly, it requires different supply chain partners resulting in a complex partnership structure.

(C1a-4, technology benefits unsuited for organizational needs) If a certain technology is not suitable for meeting organizational needs, it will not benefit the organization. In such circumstances, an investment in ICT would result in a waste of firm's resources.

(C1a-5, financial constraints) The financial considerations pose a significant delay in major ICT decisions. For example, the process of budget approval might be very time-consuming.

2.4.3.2 Organizational adoption (C1b)

(C1b-1, Lack of ICT adoption and implementation experience) The manager's lack of experience in ICT adoption may result in the second gap, i.e. *(C1b-2, user resistance)*. When a manager is inexperienced in using a certain technology, subordinate employees also hesitate to exploit that technology, which might lead to user resistance across the entire organization.

2.4.3.3 Business result (C1c)

(C1c-1, overestimation of ICT benefits from ICT adoption) The third gap is discussed in the context of failing to gain expected results or to obtain financial support from top management. At times, organizations overestimate the benefits of employing ICT tools, and the business results after deploying ICT are not as efficient as predicted

(C1c-2, failing to deliver competitive advantage) Sometimes the organization misunderstands its true level of ICT readiness or compatibility. In such cases, the firm will not gain the competitive advantage which it had expected from ICT implementation.

2.4.4 ICT diffusion constraints at the individual level

The ICT constraints and diffusion drivers at the individual level are illustrated in Figure 2. The people boundary within an organization is shown by the dashed line. After the organization decides to adopt an ICT innovation, the focus shifts from application's acquisition to promoting its use. The use of ICT tools or application can be promoted through organizational and technical support. The supportive cycle described as (S2) in the figure will be described in the later part of this study where strategies for mitigating factors that hinder ICT implementation in the construction industry are discussed.

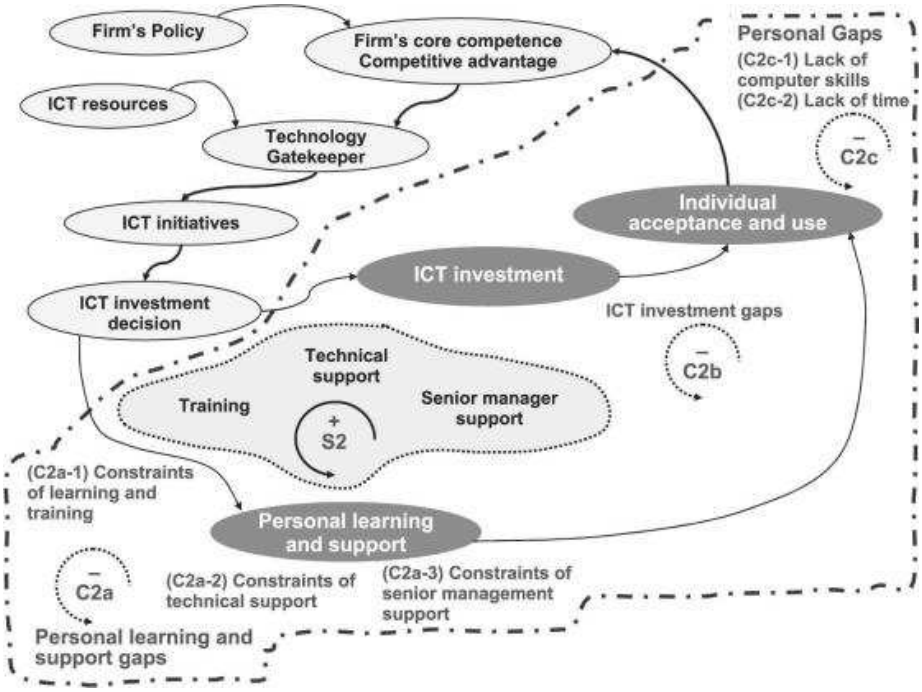


Figure 2: ICT constraints at the individual level

Source: Peansupap and Walker (2006)

2.4.4.1 Personal learning and support gaps (C2a)

(C2a-1, constraints of learning and training) Lack of training and learning opportunities hinder ICT implementation in construction firms. If employees are not trained properly, they will not feel comfortable when they use it.

(C2a-2, constraints of technical support) The users of ICT require a sound and well defined effective support system to help them solve their technical problems.

(C2a-3, constraints of senior management support) Lack of support from senior managers will hinder ICT innovation diffusion in construction firms.

2.4.4.2 ICT investment gaps (C2b)

User's adoption outcomes are influenced by ICT investment gaps. If the firm does not have enough capital to invest in ICT, it won't be able to reap its benefits.

2.4.4.3 Personal gaps (C2c)

(C2c-1, lack of computer skills) Construction workers are generally occupied by site work and do not have enough time to sit and learn about the new ICT innovation *(C2c-2, lack of time)*

2.4.5 ICT diffusion constraints at the group level

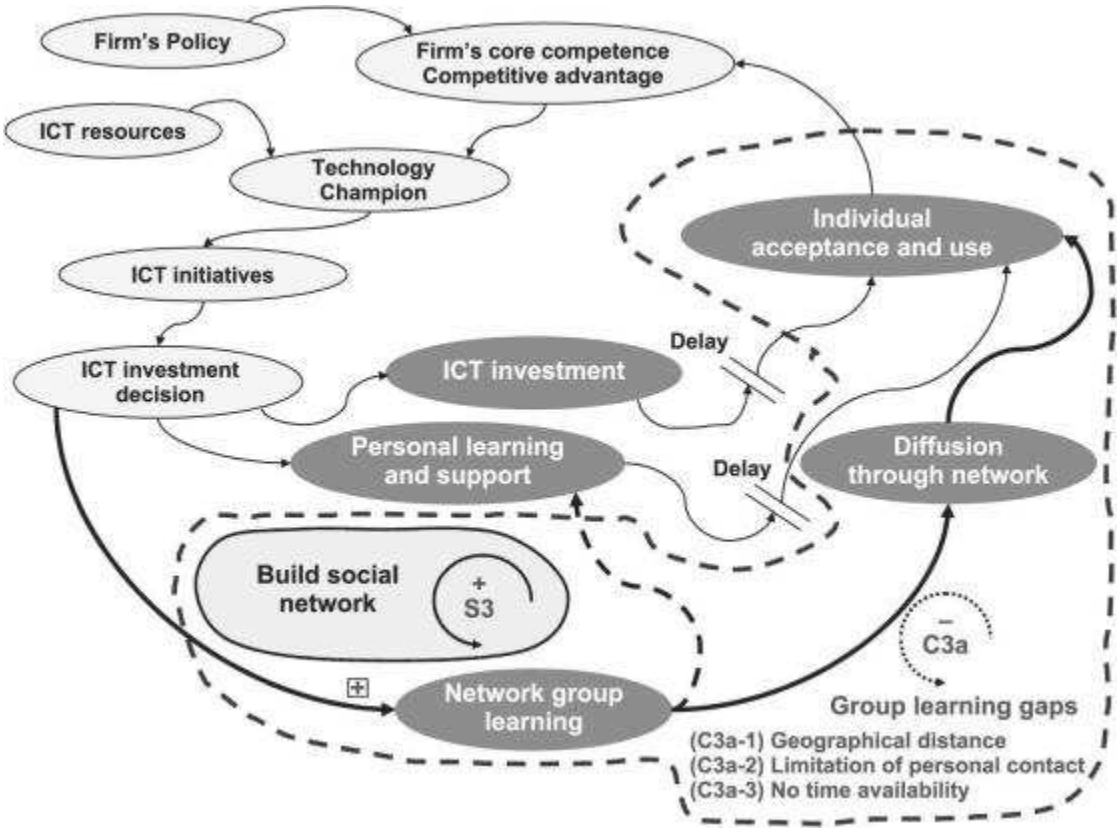


Figure 3: ICT diffusion constraints at group level

Source: Peansupap and Walker (2006)

Figure 3 shows how groups of individuals within an organization face barriers to ICT diffusion. Support cycle (S3) considers that humans are social beings who ask for help when needed. While

barriers exist as described at the other two levels, discrete ICT application diffusion barriers also exist for groups as the figure 3 depicts.

2.4.5.1 Group learning gaps (C3a)

(C3a-1, geographical distances) It is known that proximity plays a vital role in learning by observation. Humans learn by observing others. In the context of ICT, learning by observation strengthens ICT users' absorptive capacity (Cohen and Levinthal, 1990). However, in the construction sector, there is the geographical distance between different parties like contractors, on-site workers, and in-house engineers. This distance hinders leading by observation.

(C3a-2, limitations of personal contact) If the personal contact is limited, the pace of group learning becomes slower. Personal contact in the construction sector is limited by geographical distance among parties.

(C3a-3, No time availability) As discussed before, the construction workers operate on sites under severe time pressure. They find it challenging to manage some time for learning ICT skills.

2.5 Strategies for mitigating factors that hinder ICT implementation in construction

ICT implementation and adoption are management-intensive activities that require strong commitment and will of the top management. In this regard, top management holds power to devise and implement strategies for overcoming barriers to ICT implementation in the construction sector. Regan and O'Connor (2000) mention that top managers are the key players, who are responsible for the diffusion of ICT in an organization. Strader, Ramaswami, and Houle (2007) also explain that top executives should identify the factors that limit ICT implementation and develop strategies accordingly, as they have the capacity to invest in ICT and to encourage automation in their respective organizations.

As mentioned in the previous section, the factors that hamper ICT application in construction fall into two categories: financial constraints and organizational factors of the respective nature of the industry. It should be noticed that cost of ICT implementation cannot be controlled by top management. Similarly, the nature of the industry is a factor that lies outside the domain of top management. Therefore, managers can majorly control the organizational factors that obstruct ICT implantation by designing appropriate strategies. Verburg, Bosch-Sijtsema, and Vartiainen (2013) have discussed some strategies that facilitate implementation of ICT in business. The strategies that are relevant to the construction sector are discussed below:

2.5.1 Organizational policy and vision

A company's vision and policy have a direct influence on strategic ICT adoption and implementation within a construction organization. The long-run strategic objectives of ICT adoption by the company are derived from its vision, and the company's policy fosters implementation of ICT.

2.5.2 Top management support

Senior management can provide adequate support to ICT users. They need to understand that their junior staff members will take the time to learn the use of new technology. Hence, time lags are inevitable and organizational productivity might decrease for a short period of time i.e., time required for becoming accustomed to new technology. It is important to acknowledge that if employees are not given ample time, they will feel frustrated; consequently, they will be demotivated for adopting new technology. Hence, both senior managers and project managers should seriously consider the time required for employees to using new technology in an efficient manner (Smith & Love, 2004).

2.5.3 Encourage technology gate keeper

The firm should develop employee's knowledge about effectively applying ICT to support their work practices because successful ICT use and adoption appear to be a key motivator for ICT diffusion. Without effective ICT adoption by expected users, the firm cannot gain full benefit from its ICT investment. Sharing and building internal group knowledge can also facilitate ICT diffusion.

2.5.4 Build internal knowledge people

Research suggests that in order to inhibit barriers to ICT implementation at the individual level, adequate training, technical support, and senior management support are inevitable (Thamhain, 2013; Smith & Love, 2004). Through personal training, employees shall develop a rudimentary understanding of basic ICT concepts and its usage. However, Thamhain (2013) explains that ICT trainers should not only focus on explaining the technical aspects of ICT like its menus, functions, and interfaces, but also emphasize on the application of ICT innovation across work-processes. It should be noticed that trainers have to maintain a fine balance between technical and personal training. If employees are trained solely for handling technical aspects of ICT, they might lose their interest in training sessions. In such a situation, employees shall develop a negative perception of ICT, or they shall not be able to comprehend its benefits. Furthermore, in order to reduce personal learning gaps, the users of the ICT should be facilitated through an effective support system. An effective support system will help them to solve technical problems, pertaining to the use of hardware and software applications, in an efficient manner.

2.5.5 Establishing an effective support system

The support system in a construction firm can be shaped by coordination of senior managers, project managers, and training staff. The support system should be designed in a manner

that it motivates employees for exploring and using new technology. If employees feel demotivated, they will develop a negative attitude towards ICT implementation. It can be asserted that it is necessary to train employees so that they can acquire learning about exploiting ICT. Furthermore, employees should be offered adequate technical and organizational support (Xue, 2006). Hence, personal learning coupled with organizational support will encourage employees to interact with new technologies in an efficient manner.

2.5.6 Empowering a "champion."

Empowering a champion in an organization will smoothen transition towards ICT implementation (Shohet & Frydman, 2003). A 'champion' is a dominant member who supports weaker members either through his power and influence or by facilitating collaboration among employees. A champion will enable weak employees to overcome their hesitance towards ICT adoption. Furthermore, he will advocate ICT usage across project team; in this regard, a champion will facilitate project teams. Hence, a champion will direct efforts of employees towards achieving a common objective, i.e., implementing ICT, as suggested by Shohet and Frydman (2003).

2.5.7 Creating proximity

Since the nature of the construction industry is fragmented, partners of a construction project are geographically dispersed. Morton (2009) explains that physical distance among partners can obstruct sharing of knowledge, information, and experience. Therefore, considering this aspect of the industry, senior management should develop strategies for creating proximity among ICT users.

2.5.8 Investing in the right technology

ICT cannot be implemented without adequate financing. ICT implementation commences from hardware installation and includes purchasing appropriate applications like CAD and BIM,

investing in the training of employees and maneuvering organizational culture to facilitate new technology. Furthermore, investing in ICT requires time, and time is a precious asset in the construction industry, because of tight building and construction margins gave to project managers and contractors (Notari, Baumgartner, & Herzog, 2014).

Hence, ICT implementation requires time and money; it is a risky investment. Managers need to be selective regarding technology. Business automation and re-engineering require strategic insight. Therefore, top managers should scrutinize each and every detail of ICT installation in the organization (Jorgensen, 2004). Some of the questions that should be answered for implementing ICT are:

- Where does the organization stand in terms of its technology use?
- Where does it want to head in future?
- How much are the employees willing to adapt to new changes in the organization?
- Is the culture of an organization consistent for making new adjustments?
- How long will it take for an organization to adapt to technological modifications successfully?
- Are the employees amply trained to adopt new tools? (Rekha, 2012, pp. 101)

Once these questions are answered, the managers should devise appropriate timeline to review the effectiveness of ICT. For example, after every four weeks, the managers should carry out an assessment exercise. The assessment should measure the extent to which company's objectives are achieved (Jha & Iyer, 2006).

CHAPTER 3: METHODOLOGY

This section of the research provides the profound detail of not only the important features of this study but also the philosophical assumptions behind it, data collection tools, tools for analysis and validity and reliability of research.

3.1 Research purpose

It is necessary to define the purpose of research before designing its methodology. The purpose of this study is to identify barriers faced by construction professionals of a specific construction firm while implementing Information and Communication Technology across it. It identifies some strategies used by professionals of the specific firm for mitigating the factors that hinder implementing ICT in this firm. The scope of this study lies in the fact that much of the world's industries have gone through the process of automation but the construction industry lags behind in technology implementation, even in the 21st century, as mentioned by Amadi-Echendu, Brown, Willett, and Mathew (2012, pp. 62). The methodology has been designed to fulfill the above-mentioned objectives.

Through this study, the researcher obtained insight about factors that hold back the process of ICT diffusion. So, this research is divided into three parts. The first part deals with barriers which are present in the company that hinder the diffusion of ICT. The second part deals with identifying the scope of ICT applications in the selected firm. The third part is about identifying strategies used in the firm for facilitating diffusion of ICT. The model of innovation diffusion presented by Roger (1983) is used to structure the research undertaken. Thematic analysis was used to analyze classifications and present findings relating to the data; the data is further illustrated in great detail as thematic analysis gives an opportunity to understand the potential of

any issue in detail (Marks and Yardley 2004). The research revolves around the participant's level of technology diffusion in the firm. The study categorized the interviewees and observed whether they are early adopters, early majority, late majority or laggards. Some of the interview questions were designed to identify the likelihood of participants to adapt to new technologies. The interview questions can be viewed in Appendix-D.

3.2 Research approach

This research is qualitative in nature. Qualitative research allows for the generation of rich data and the exploration of 'real life' behavior, enabling the research participants to speak themselves. The aim of the qualitative research is to learn about *how* and *why* of behavior and phenomenon in question. It also gives the researcher a holistic perspective which can observe the complexities of human behavior (Stenbacka, 2001). Qualitative research can also contribute to the deep understanding of subject matter. Some subjects are better investigated using a qualitative approach, as it aims to increase researcher's understanding of what is going on (Golafshani, 2003).

The current research objectives and questions need a detailed understanding of barriers to ICT implementation and strategies for removing it. The researcher needs to explore participants' views to understand the barriers they face, therefore, it calls for a detailed understanding of their perceptions. As shown in the studies of Love, Li and Mandal (1999), Avgerou, Hayes, and La Rovere (2016) and Onyegiri and Nwachukwu (2011) most of the barriers cannot be measured on a scale. Hence, quantitative analysis cannot be applied to this study as the research calls for detailing, probing deeply into the matter and fair description of the environment in the firm that either inhibits or encourages the use of ICT.

3.3. Philosophical assumptions behind research

It is necessary to consider the philosophical assumptions and epistemologies of research. Epistemologies constitute one's view of the world, one's assumption about how to know the social phenomenon and apprehend its meaning (Fonow& Cook, 1991, p. 1). Qualitative research is a broad term that covers a range of diverse epistemological assumptions and approaches, from the classical to the postmodern, from the interpretive to the structural. Nevertheless, qualitative methods have been influenced by different sets of orientations and theoretical traditions (Denzin, 1992)

According to epistemological perspective, this research is based on social constructivism. The term constructivism and social constructivism can be used interchangeably (Kukla, 2000, pp. 07). It is an interpretive framework where the researchers seek to comprehend their world and develop their own particular meaning that relates to their experience (Creswell, 2013). Constructivism explains that through cognition, people figure their experiences (Tom, 2012). Social constructivists dig into realities and experiences of individuals, and the researcher depends on views of participants (Young, 2007, pp. 121). In this study of ICT's usage, its barriers to implementation and strategies, the philosophy of social constructivism is embedded, as participants will be describing their experiences and their interpretations of reality.

It should be noticed that most of the qualitative research theories and methodologies assume constructivist approach to the nature of knowledge. According to Yates and Leggett (2016), qualitative research makes the researchers aware of the socially constructed nature of reality. This reality is already embedded intimately in the context of the study. The circumstances of the research include research setting, participants, and the data being collected.

3.4. Method

3.4.1. In-depth interviews

For accomplishing the objectives of this study, data was collected through in-depth interviews. In-depth interviewing is a qualitative research technique, which involves conducting intensive individual interviews with a small number of respondents, in order to explore their perspective on a particular idea, program or situation (Boyce & Neale, 2006). In-depth interviews are appropriate when the researcher wants to have detailed information about a person's thought and behavior or wants to explore an issue with a comprehensive approach. In the case of this study, employees working in construction firm were questioned thoroughly, to assess their viewpoints regarding the use of ICT and its diffusion.

A major benefit of the interview is that respondents are more comfortable with the researcher as opposed to filling a survey. Other advantages of in-depth interviews include depth, disclosure, quality of data and short timelines. In-depth interviews can uncover valuable insights in terms of intensity. The quality of data can be attained in interviews when the interviewer probes for greater details. Questions can be added or changed in the real-time if needed; however, in this study, the researcher did not change questions during interviews. Data from interviews can also be collected faster, usually within a few weeks (Tong, Sainsbury, & Craig, 2007).

However, interviews also have limitations. Firstly, there is an existence of bias when the interview is conducted. Biases can result from the effect that the researcher can have on the respondent. Secondly, interviews are very time-consuming. Furthermore, researchers should carefully use qualitative research methodology. This is due to the occurrence of Hawthorne effect that can influence the overall research outcome (DiCicco-Bloom & Crabtree, 2006). This can be explained by assuming that the researcher influences the interviewee with respect to the detailed

and descriptive discussion of the topic. In such case, the entire discussion shall be inclined towards the opinion of the researcher than the interviewee. So, in this study, the researcher was careful not to influence the respondents to the extent that their opinions are altered, as suggested by Wolters (2016).

Since in-depth interviews are very time-consuming, researcher planned for the data collection effort so that the interviews should not take more time than necessary. In the study undertaken, the time has been saved by merging some questions into one question. Also, interviewees are asked to rate the importance of certain attributes, as rating questions are less time-consuming than open-ended questions. Interviewee questions can be viewed in Appendix-D.

3.5 Data source

The data was collected through an interview designed. To gain insights about *how's* and *what's* of interviewee mindset, the researcher developed open-ended questions. Open-ended questions have been used to get a detailed interview with the professionals so that the researcher may get a perspective on ICT usage, its barriers to implementation and subsequent strategies. Some rating questions were also developed, which asked interviewees to rate barriers they encounter. A total of 20 questions were formulated, out of which 5 questions made participants rate certain attributes on a scale of 1-5. These questions were characterized by the fact that they allow respondents to say, 'what the experience was like.' The word 'like' is important here as the investigator is implicitly asking questions so that the participants can make their own comparisons and distinctions. The questions also allowed the interviewees to tell more about their thinking. A well-asked open-ended question is often an inquiry into how a candidate makes classifications. It is an invitation to say what sort of things they experience and describes their 'perceptual judgment'(Lee & Cronin, 2016, p37).

It is important to mention that the interviews were conducted during the working hours of the company so that all the interviewees could be accessible to the researcher. In this study, interviews were recorded and transcribed. With respect to the privacy that needs to be maintained for every participant, the researcher did not use the name of participants in the study. Each respondent was given a numeric title so that the response remains anonymous.

3.6 Sampling

Qualitative research seeks to develop a deeper understanding of the subject. Unlike quantitative analysis, it focuses on depth rather than the breadth of research. It helps the researchers to analyze what participants are thinking, and make meaning of it, rather than focusing on what people do or believe on a large scale (Whitley, 2000). In this regard, it draws from a small sample and seeks to acquire in-depth and intimate information. Furthermore, qualitative research is entangled in the desire to get the accurate mindset of participants; a smaller sample can yield detailed mental facts. These essentials lie at the subconscious level and can only be accessed through prolonged discussion and analysis. Thereby, taking in-depth interviews and asking numerous 'what' questions can help the researchers to get a better understanding of the data (Lichtman, 2013).

There are two principal reasons underpinning the choice of a particular firm for this study. First of all, the selected firm operates in three sectors of construction, i.e., housing, commercial and industrial. Thereby, the researcher decided to interview three participants from each sector to get insight about their use of ICT in the firm. Secondly, CEO of this firm was willing to cooperate with the researcher. He encouraged employees of the firm to participate in this study, by sending them an email about the usefulness of this research one week prior to data collection. The researcher interviewed participants from different managerial levels, i.e., project manager, project

engineer and site superintendent, which helped the researcher to conduct analysis from different facets of the same organization, thereby, leading to higher-quality data collection. Nine participants, three from each sector, were enough to collect and analyze data, as in-depth information is required according to qualitative nature of the study. The sampling criteria for this study was that interviewees should be working in the selected firm.

3.7 Data analysis

The current research performed a thematic analysis of interview data. This also involves identifying important features of the data that would be relevant to answering the research questions (Thomas & Harden, 2008). In thematic analysis, the theme must "describe the bulk of data" (Joffe and Yardley 2004 p.67). The following technique of thematic analysis was used to convert raw data to meaningful information

3.7.1 Data reduction

The first step of thematic analysis was data reduction, as recommended by Miles and Huberman (1994). Data was reduced using Nvivo, which is a widely used software for qualitative analysis. Data reduction is a process that sorts, discards, focuses and organizes data in such a way that a valid conclusion can be verified and drawn (Miles & Huberman 1994, p.11). In this study, data was coded to integrate data connections; coding was derived from various responses of the interviews. There were three phases involved in data reduction of this particular study through Nvivo, an overview of them is stated below:

3.7.1.1 First phase for data reduction

Once the data was collected through interviews from all of the nine respondents, it was tabulated using Microsoft word. Data was reduced in this phase, as some irrelevant sentences that did not answer the interview questions were removed.

3.7.1.2 Second phase for data reduction

In this phase, specific sentences from every participant were highlighted, so that relevant data can be put into Nvivo. For making nodes, it was strictly confirmed that the relevant information regarding the research question was not ignored during data reduction at this phase.

3.7.1.3 Third phase for data reduction

In this phase, the highlighted nodes data was broken down into smaller segments or themes by Nvivo. Then the list of possible themes related to responses was made, and after the critical examination, researcher choose the nearest theme related to the data of responses. Afterwards, the content was proofread to compare, contrast and search for the information that might have been ignored in the first two steps.

3.7.2 Data display

The display of data provides the researcher with an opportunity to have an in-depth understanding of the analysis; the same technique was used in this study by organizing the data into order. Some displayed data can be seen in Appendix-E.

CHAPTER 4: ANALYSIS

This chapter studies the findings of interviews from the lens of Roger's model. It consists of an analysis of demographics, after which the findings are organized relevant to the research objectives. Factors affecting ICT implementation and strategies to mitigate those factors are analyzed using the findings from the interviews.

4.1 Analysis of demographics

For this study, qualitative interview data has been analyzed in light of Roger's model (1983) for technology diffusion. As explained earlier, Roger's model of diffusion of innovation mentions that according to the rate of adoption of innovation, there are five categories of adopters i.e. innovators, early adopters, early majority, late majority, and laggards. In this study, the first question that researcher asked from interviewees was about their likelihood of adopting a new technology in their daily life. Through the responses of this question, interviewees were placed into one of the categories of Roger's model of innovation adoption (1983). For example, interviewee 6 enthusiastically mentioned that she uses applications to manage tasks in her personal and professional life, because of which she was classified as an 'early adopter.' Table-1 shows the demographic characteristics of interviewees, along with their place in Roger's model of innovation adoption.

Table 1: Demographic characteristics of interviewees

Respondents	Age group	Self-assessed Roger's category	Managerial Level	Gender	Sector	Total Experience (years)	Experience with firm (years)
Interviewee 1	43-50	Early adaptor	Project Engineer	Female	Commercial and industrial	20	6
Interviewee 2	50+	Late majority	Superintendent	Male	Commercial	42	15
Interviewee 3	43-50	Early majority	Senior project manager	Male	Commercial and multi-family (housing)	26	4
Interviewee 4	43-50	Laggards	General Superintendent	Male	Commercial	35	16
Interviewee 5	43-50	Early adopter	Project Engineer	Female	Commercial and Industrial	16	5
Interviewee 6	31-36	Early adopter	Project Engineer	Female	Commercial	11	1.5
Interviewee 7	43-45	Early majority	general superintendent	Male	Commercial and Industrial	38	3
Interviewee 8	31-36	Innovator	Project Engineer	Male	Commercial	11	3
Interviewee 9	31-36	Early adopter	Project manager	Male	Commercial	13	4

In the second question, participants were asked to rate five attributes of their adoption to innovation, according to Rogers Model of diffusion (1983). These five attributes include relative advantage, compatibility, complexity, trialability and observability. It should be noticed that the purpose of the second question was not to place interviewees in a particular category of Roger's model. As mentioned earlier, the place of interviewees on Roger's model of diffusion (1983) was determined from the first question. The second question was designed to determine how interviewees rate themselves about the five attributes of innovation while they try to adopt it in their personal lives. The researcher explained the five attributes of innovation to the interviewees, as mentioned below:

Table-2 shows the rates that interviews gave to each attribute on a scale of 1-5.

Table 2: Ratings of attributes by interviewees

	Compatibility	Relative advantage	Complexity	Triability	Observability
Interviewee 1	1.5	2.5	2.5	3.5	3.5
Interviewee 2	4	4	4	4	4
Interviewee 3	2.5	2.5	3.5	4	4
Interviewee 4	4	4	3.5	3.5	3.5
Interviewee 5	3	5	3	3.5	3.5
Interviewee 6	4.5	4	2.5	4	4
Interviewee 7	2.5	4	2.5	2.5	2.5
Interviewee 8	2.5	5	2.5	4	4
Interviewee 9	3.5	4.5	4	4.5	4.5

Relative Advantage: a Relative advantage for the diffusion of innovation includes economics, social prestige, convenience and satisfaction (Yang & Leskovec, 2010). The researcher explained interviewees the meaning of relative advantage. Table-2 shows that two interviewees rated relative advantage as ‘5’ and four of them rated it as ‘4’. Interviewee 4 was a laggard, but he still rated relative

advantage as 4. The same rating was given by interviewee 2 who belonged to 'late majority' stage according to Roger's model of innovation adoption (1983). It shows that interviewees belonging to the later stages of technology adoption i.e. 'laggards' and 'late majority' viewed the software and hardware development positively.

Compatibility: An innovation is considered compatible if is consistent with the existing values, past experiences, and needs of potential adopters (Yang & Leskovec, 2010). The average rating given to this attribute is 3, as evident from Table-2. Most interviewees did not realize the importance of this attribute. Perhaps it happened because they did not have a clear understanding of this particular attribute, which is one of the limitations of this study.

Complexity: Complexity refers to the degree to which an innovation is perceived as difficult to understand and use (Yang & Leskovec, 2010). The more complex the innovation, the more time it will take to be adopted. It is evident from Table-2 that only interviewee 1, 5, 6, 7 and 8 clearly acknowledged this attribute. Other interviewees rated complexity as either 3.5 or 4, but not 5. Roger's model of innovation diffusion can be applied in this scenario. For instance, those interviewees who gave a low rating to this attribute belonged to early adopter and early majority stages; they did not perceive an innovation to be complex, which is consistent with Roger's model (1983). On the other hand, Interviewees 2 and 4 gave a high rating to this attribute because they were in the late majority and laggard stages, respectively; this finding is also consistent with Roger's (1983) model. However, the dataset proved inconsistent with Roger's model in the case of two interviewees. Interviewee 3 and 9 were early adopters, but they still gave a high rating to complexity.

Triability: This refers to the experimentation of innovation with a limited bias (Yang & Leskovec, 2010). The innovations that can be tried out are more likely to be adopted. As shown in Table-2, most interviewees gave this aspect a high rating. The highest rating given to triability was 4.5, and the lowest it received was 3.5. Nonetheless, the average rating given to this attribute was high.

Observability: This particular attribute measures the extent to which the results of innovation are visible to others (Yang & Leskovec, 2010). The easier it is for employees to see the positive results of innovation, the more likely they are to adopt it. Again, in this case, most of the interviewees gave this attribute a high score. The lowest rating it received was 2.5, and the highest rating given to it was 4.5.

4.2 Thematic analysis

The coding of data into Nvivo and its analysis presented nine themes. The themes are elaborated below:

4.2.1 Use of ICT in firms operations

The interviewees used ICT in their daily, weekly and monthly operations. The daily use pertained to emailing, phone calls, report production and software. Most of the interviewees stated that they use ICT daily via emails, phone calls, and software controls. Procore™ was the most used software package. Regarding Procore, an interviewee stated that *'we use it all day'*. This software package is used mainly for streamlined project communication and documentation. Interviewee 1 stated that he used Procore '*to communicate with the entire project team*' on a daily basis. Information about Procore can be seen in Appendix-C. Some of the interviewees stated that ICT had provided good tools for immediate communication. They can now connect with the

opposite field and sub-contractors as well. Interviewee 8 stated that he also uses Adobe and on-screen takeoff software every day. Moreover, Interviewee 9 said that he had used Microsoft Office and Timberline for accounting. ICT was used on weekly and monthly basis for billing, meeting management and report production.

4.2.2 Importance of ICT in selected firm

The thematic analysis showed that ICT was important in the particular firm because of its four features (1). It made communication easier (2). It encouraged competition (3). It saved time (4). It reduced workload.

All of the interviewees were consistent in their views about the importance of ICT for fostering communication. For example, Interviewee 6 mentioned that the particular firm had *'a lot of field employees and a lot of office employees, and the information is easily communicated through technology (among field employees and office employees)*.' Some interviewees focused entirely on the basic feature of ICT, which is that it allows communication, despite geographical distance. Correspondingly, some interviewees were able to relate ICT to the productive growth of the organization. It should be noticed that in regard to Rogers's model, the importance of ICT was influenced by their level of technological adaptability. For instance, Interviewee 1, who was an early adopter, reported the significance of ICT in a more complex way, as compared to others. To illustrate, this interviewee mentioned that '*if there are technical problems with ICT across the organizations, whole day at work is wasted,'* as in such case, Interviewee-1 fails to complete the desired tasks and achieve goals of that particular day. It was explained that once, the system went down, and the Interviewee 1 was unable even to check her emails and answer her phone calls. On that day, the interviewee felt *'stuck'* and explained that day as *'unproductive.'*

On the other hand, Interviewee-2 belonged to late majority stage of Roger's model. This particular interviewee reported that influence of ICT is mainly limited to effective communication across the organization. However, Interviewee-2 also reported that with the help of ICT, the organization could get hold of all members in the project. Another applicant, largely belonging to the laggard category, related the importance of ICT by comparing the past with the future. He commented that previously there used to be piles of paper, and it would take hours to go through the work. Now, with the facilitation of ICT, it takes only a few minutes to complete such tasks. Similarly, another interviewee belonging to a laggard category explained that ICT-enabled the firm to remain one-step ahead of the organization. Also, it was mentioned that ICT keeps the firm organized. So even though this applicant was the last one to implement technology in his professional life, he was aware of the strategic impact of ICT on the company.

Interviewees were asked about the usefulness of ICT in the firm according to information generation, information transmission, maintenance of information and re-using information through ICT. All interviewees gave a high rating to information generation and transmission of information. Information generation deals with developing and gaining information. On the other hand, transmission of information deals with sharing information between employees of the firm or with partners and suppliers outside the firm. With respect to time-saving, interviewees revealed that with ICT, they could do same work in a short period of time. It was also explained that by using ICT, interviewees, at some instances, achieved their target even before their deadline. Interviewee 1, an early adopter, stated that nonexistence of wireless technology can increase the lifecycle. She stated that "*I am working on three projects currently, out of which two sites have satellite WIFI connection and the other one has a just tethered hotspot. The project which doesn't have proper WIFI connection communicates with us at a slower pace, and people personally*

should drive down to get the required information. On the other hand, the sites that have satellite WIFI are easy to communicate with, and thus the work there moves fast compared to the third site." An important feature of utilizing Wi-Fi connections is that it does not require project managers to be physically present on the job site. With the help of an internet connection, they can communicate instantaneously. A problem at the site can be communicated easily, thereby leading to quicker resolution. One of the participants, interviewee 7 an early majority stated the wireless technology helps to save 50% of the time required for a project. Furthermore, ICT reduced workload, as an interviewee explained that *'Without ICT, there would be piles of papers'*.

4.2.3 ICT and cost-effectiveness of selected firm

The third theme was that ICT installation made the firm cost-effective through four ways: (1). Productivity is increased (2). Communication is made easier (3). ICT enables multitasking (4). The costs of operations and processes are reduced.

All the interviewees believed that ICT installation made the firm more cost-effective. Interviewee 8, belonging to innovator stage, stated that new technology could be used to save costs in the organization. It was explained that Blue Beam could create cost-effectiveness in the firm. For example, when the project is in its design stage, the blue beam can help to incorporate all the drawing revision, thereby, it will save a lot of time and energy. On the other hand, the late majority interviewee 2 answered this question stating *only* that 'time is money' without elaborating about the ways in which it saves time and cost for the company. Nonetheless, *time* is an important commodity in any construction organization.

The interview data also highlights that cost-effectiveness can be achieved by doing the same task in less time. For instance, if there is an issue on the job site, ICT helps to take

everybody's input to resolve that problem. With the help of instantaneous communication that particular matter can be resolved in a shortened time.

All of the interviewees agreed that the expenditure incurred on ICT results in productivity for the firm. With ICT in place, it is not necessary to visit the site for collecting data, which saves time and energy of members. It was also affirmed by interviewees 3 and 9, an early adopter and an early majority respectively, that expenditure is incurred in initial stages; however, with the passage of time, the cost incurred is earned back in terms of increased productivity. It was also established by the same participants that with the passage of time, cost of using technology is becoming less, so expenditure is reducing, thereby allowing the firm to gain returns on investment quickly. When asked about the relationship between ICT expenditure and ICT productivity interviewee 5, an early adopter, reported that ICT productivity is equal to ICT expenditure.

A factor that affects ICT expenditure is the choice of the program selected by the firm. Interviewee 7, revealed that sometimes, a costly project might not be as effective as the cheaper ones. For instance, if a costly program does not synchronize with company's need, then it may not reap benefits. As a result, the productivity of the company will go down. It was also affirmed by interviewee 9, an early adopter, that the benefit from ICT implementation cannot always be expected in the short run. The same participant also stated that, in the beginning, stages, ICT installation takes a lot of time and money. But, in the long run, it may not cost that much, as people will start using ICT efficiently and thus saving their time, bring the costs down and make profits eventually. Thereby, the company and its managers have to wait until ICT is diffused in the firm and starts to benefit everyone.

4.2.4 Role of top management for ICT adoption

The fourth theme showed that top management can influence ICT diffusion in the firm. The two main benefits of top-management support included boosting employee morale and training of employees. Interviewee 7, an early majority, implied that if top management is not willing to use ICT procedures, then the employees will not consider it as well. This interviewee stated that *'If they (top management) are not going to believe in it (ICT innovation), the employees will not believe in it.'* Additionally, interviewee 8 stated that encouragement from top management could produce '*technological depth*' in the company. Interviewee 9, an early adopter, mentioned that support of top management is *'critical*' as *'people don't buy the new concept easily'* and explained that the role of higher management is critical because employees look up to their leadership before they agree to a new concept. This statement reveals that when a new technology is introduced in the firm, top management's role becomes critical in its overall adoption. However, interviewee 6, an early adopter, was not a strong advocate of the role of top management. According to her, employee's comfortability is more important. She stated that ICT diffusion could take place only *'when the employees have become comfortable with the new system.'* Overall, these responses show that employees of selected firm considered that top management could support diffusion of new innovation in the firm, by believing in it and supporting employees to learn its use.

4.2.5 Change of SOPs for ICT adoption

Nvivo analysis showed two subthemes under this theme. The first sub-theme suggested that SOPs don't need to be changed for ICT implementation. For example, interviewee 1 stated that ICT diffusion does not necessarily require a change in SOP. Similarly, interviewee 2 stated that a significant change is not a necessity. Companies should adjust only to an alteration in ICT

as they go along instead of changing the complete SOPs. Diffusion also depends on the existing SOPs of the firm. According to interviewee 5, the selected organization had already established SOPs in a manner that when new technology is introduced, no change in SOPs is required. However, this interviewee did not give an explanation of the manner in which the firm under study has established its SOPs.

The second sub-theme indicated that SOPs need to be changed for ICT innovation diffusion. Nonetheless, some interviewees supported the change in SOP for the adoption of ICT. For instance, interviewee 3 stated that to bring everyone on the same front, SOPs needed to be changed in his organization. According to interviewee 9, SOPs are important, but the organization should not be too strict in their implementation. Stern adherence to SOPs can also demotivate the use of new programs.

4.2.6 Employees comfort for ICT usage

Employee acceptance is critical for ICT diffusion. Interviewee 5, an early adopter, stated that all employees should be on the '*same page*' to adopt ICT. He also pointed that ICT can never be enforced on an individual. Likewise, interviewee 9, an early adopter, held that those employees, who may not approve ICT, show resistance by not making efficient use of the software or programs introduced by the management. Overall, it can be asserted that employees comfort is necessary for ICT innovation diffusion, as employees are users of new technology and without their comfort and support, ICT cannot be diffused completely.

All the interviewees gave similar opinion regarding employee acceptance and comfort for ICT usage in the company. Interviewee 1 described the implementation process as 'consuming.' She said that nobody likes to change as people are already comfortable with their existing practices. She stated that when employees are told to change their work practices, a state of unrest is created

in the organization. Interviewee 2 opined that new generation does not need to worry about technological alterations in the firm, as this generation is at home with technological advancements. Moreover, interviewee 4 stated that 90% of the employees in his organization are grasping ICT, whereas 10% are struggling with the new technology on a daily basis. These percentages infer that in the opinion of interviewee 4, most of the employees in a selected firm are using ICT comfortably. Interviewee 4 pointed out the concept of realization among employees. In his opinion, employees have to realize the importance of using ICT in the company at an individual level. If they are not willing to accept new technology, then they are never going to change their traditional practices. Ten percent of the employees do not adopt technology because they don't like using a computer and they are not comfortable with the new software. Hence, they 'blind' themselves from seeing the useful applications of ICT. This might be because new technology brings risks for employees, as they are already comfortable with existing technology; however, further research is needed to support this assumption.

4.2.7 Opinion leader for ICT diffusion

An opinion leader, in this study, is an early adopter who can help to undertake new technology in the organization. Regarding the importance of an opinion leader for ICT diffusion in the firm, interviewees gave very different responses. Interviewee 1 states that an opinion leader can help the organization to make a better decision for new technology. She argued that a leader can conduct research for top management to choose among the options available to the firm. It can be implied that according to interviewee 1, an early adopter, selection of wrong technology, which might not suit needs of the firm, can become a barrier to ICT innovation diffusion.

According to interviewee 3, an opinion leader should belong to the executive management of an organization. It can lead to the easy dissolution of problems because employees can easily

share their concerns when opinion leader is from their organization and an acquaintance. However, interviewee 5 stated that an opinion leader could not influence the technology diffusion in the system, and explained that before ICT implementation, four to five programs are tested. Interviewee 5 illustrated that in the selected firm, managers take a lot of factors into consideration and if a program works well for the company, then they make a final decision. In the same way, interviewee 6, an early adopter stated that before implementing a new technology, managers create a team to see and evaluate whether it will work for the company or not. For instance, before installing Procure software, a team of experts from Procore and selected firm's employees conducted sample runs. It is noteworthy that this task was not performed by an opinion leader, rather it was a team effort.

According to interviewee 7, an early majority, if a person is excited about a new ICT development and he comes up with supporting facts, then the management can work together for getting it implemented in the system. This statement implied that in the firm under study, employees are recognized for taking on the risk of finding and implementing new software. Interviewee 8 said that approval, money, and changes come later; first of all, the leader needs to sell his idea. However, interviewee 9, an early adopter, was a proponent of an opinion leader. In his view, bigger companies need them because initiating a change in a large company takes a lot of time.

4.2.8 Discussion among employees for ICT adoption

Most of the respondents agreed that discussion among employees leads to positivity in the organization. The majority responded that their firm is very open to new ideas. If a staff member needs to discuss an idea, they all get together and talk about it. Interviewee 3, an early adopter explained how rumors could affect the company. In his view, positive rumors will inculcate

positive dialogue which can make people lean towards such discussions. Moreover, interviewee 4, a laggard, stated that all employees like to '*work as a team.'* He affirmed that his firm encourages people to put forward their ideas as a team for the benefit of the organization. Interviewee 7 strongly supported team effort in adopting ICT. He explained that he was a part of a team where he asked other team members how they were doing with Procore and if they had any issues regarding it. If a staff member had any queries related to Procure, then interviewee 7 helped them in sorting it out.

4.2.9 Overcoming barriers through training, top management support and follow up

The thematic analysis showed three strategies to reduce barriers that hinder ICT implementation including employee's training, following-up with employees and leading employees by example/top management support; however, these strategies were those that have already been identified in the literature. For example, according to interviewee 1, training is very important for the employees. With proper training, employees are able to realize the potential advantages of technology. Interviewee 3 proposed another strategy. He stated that employees need to be led by example. This particular strategy works even better when the exemplary person belongs to upper management and knows how to use specific software.

According to interviewee 7, a follow-up strategy can also be helpful. By employing this strategy, managers can direct employees to use ICT in the workplace and then they can cross-check whether they employees adopt ICT or not. Interviewees 8 and 9 state the importance of creating an interest in employees for ICT adoption. According to interviewee 8, members of the staff should be made enthusiastic about the use of technology. Explaining the benefits of ICT to individual employees can make them more comfortable and productive at work. Interviewee 9 also stated that benefits of ICT should be explained to employees when they are asked to adopt ICT in

their professional lifestyle. Therefore, hands-on learning is also very important to reduce barriers to ICT implementation.

4.3 Ranking of factors that hinder ICT implementation

Interviewees were asked to rate factors that hinder ICT implementation across the firm. They were asked to rate different factors like financial constraints, time constraints, lack of encouragement from top management, lack of training, the reluctance of employees to learning new technologies and lack of technical support. The ratings are given in Table-3

Table-3: Ranking of factors that inhibit ICT implementation

Factors hindering ICT implementation in firm	INT-1	INT-2	INT-3	INT-4	INT-5	INT-6	INT-7	INT-8	INT-9	Average
1.Time constraints	5	4	3.5	4	3.5	3.5	3.5	0.5	3.5	3.4
2.Reluctance of employees to learn new technologies	1	4	1.5	3.5	1.5	4	4	2	1	2.5
3.Financial constraints	1.5	4	0.5	1	0.5	3.5	3.5	3	1.5	2.1
4.Lack of training given to employees	3	4	4	3	0.5	1	1	1.5	1	2.1
5.Lack of encouragement from top management	0.5	3	1	1.5	0.5	3	1	2.5	1	1.6
6.Lack of technical support	0.5	2.5	1	2.5	1.5	1	1	2.5	1	1.5

Listing down the barriers for ICT implementation, almost all of the interviewees held the opinion that their firm did not face any financial constraint to implement ICT. The lowest rating given to this barrier was 0.5, and the highest was 4. Interviewees 2 and 4 rated

this barrier as 4. They either identified this barrier generally for the overall construction industry or judged the investment in ICT as too costly. Interviewees 3 and 5, who rated financial constraint as 0.5, affirmed that their firms did not have any such limitations. One of the interviewees commented his firm as a 'robust firm' which can undertake the investment of ICT.

Most of the interviewees opined that time is a big barrier to the successful implementation of ICT. Only interviewee 8 gave it a low rating; a possible explanation of this response is that he belonged to the 'innovator' category. One of the participants, interviewee 9 stated that each employee has different ways of learning new technology. They learn at their own pace. Some employees require more time for learning while other may require lesser time. On the other hand, some interviewees related time constraint to project deadlines.

Regarding lack of top management support, most interviewees gave it a low rating. All of them were aware of the importance of top management for ICT implementation. Interviewee 7 said that if top management does not 'buy' the idea of new technology, most employees will not accept it as well. According to interviewee-7, managers belonging to executive management are very supportive for ICT diffusion in his respective firm.

As far as lack of training is concerned, interviewee 1 and interviewee 6 gave the highest rating to this constraint. According to them, lack of training was the biggest barrier faced by the construction industry for ICT implementation. But, they both were aware of the training practices that their company helps for employees. On the other hand, interviewees 7, 8 and 9 gave a low rating to this barrier for their firms. They were aware of its importance, but they also knew that their organizations holds frequent training programs for staff members. Highest rating given to this barrier was 5, and the lowest rating was 0.5.

Employees' comfort and acceptance are essential for making the diffusion of ICT successful. Four interviewees gave a high rating to employees' reluctance barrier as they were aware of employees' unwillingness existing in their organizations. For instance, interviewee 2 and 4 rated this particular barrier high because they were reluctant to adopt new technology. Both of them belonged to older age groups. On the other hand, five interviewees gave a low rating to this barrier, as they believed that the staff members of their organizations were not reluctant to adopt new technology.

The average rating given to 'lack of technical support' is 1.5; all the interviewees gave a low rating to this barrier. Only interviewees 2, 4 and 8 gave it a rating of 3. Interviewee 2 and 4 belonged to late majority and laggard, respectively. They insisted that they should be given more technical support for ICT implementation. Interviewee 8 was an innovator. He also proposed that their company should provide technical support for its staff members. Interviewee 8 stated that training should be 'mandatory' for employees so that they can fully utilize the features of an ICT program.

4.4 Ranking of strategies for fostering ICT implementation

Interviewees were asked to rate the strategies that are most useful for mitigating barriers that hinder ICT implementation in the firm. All interviewees gave high ratings to 'top management support' and 'training of the employees', as shown in Table-4.

Table-4: Ranking of strategies for ICT implementation

	Top Management support	Training employees	Learning by observation	Motivating employees	Empowering a champion	Giving employee time
Interviewee 1	5	5	5	5	3.5	4
Interviewee 2	5	4	4	4	4	2.5
Interviewee 3	4.5	4.5	4	2.5	4	3
Interviewee 4	5	5	4.5	4.5	4.5	4.5
Interviewee 5	4.5	5	4.5	4.5	4	4
Interviewee 6	4	5	4.5	4	3.5	4.5
Interviewee 7	5	4	5	5	4	4
Interviewee 8	4	4	2.5	2.5	4.5	5
Interviewee 9	5	4	5	5	4.5	3
Average	4.7	4.5	4.3	4.1	4.1	3.8

They were also asked to rate the importance of empowering a champion or opinion leader in the firm. Highest rating given to this strategy was 4.5, and the lowest was 3.5. Interviewees gave it an average rating of 3.9. They were not well aware of the impact that an opinion leader can have on the firm. Similarly, they were asked about motivating employees for using ICT, learning by observation and giving employees sufficient time to learn the use of ICT. As evident from

Table-4, most interviewees gave high ratings to strategies like motivating employees for using ICT, learning by observation and giving employees sufficient time to learn to use new technologies.

All respondents were strong advocates of training sessions for adopting ICT in a company. According to interviewee 1, effective training of employees is important. For instance, she noticed that the software may not always have the feature to be fully utilized on a mobile phone. However, one can fully utilize this software on a computer. Training sessions teach the employees how to use that software on a mobile phone as well as on the computer. Interviewee 3 stated that effectiveness of training could be reflected in terms of future productivity of the employees. According to interviewee 4, learning is essential, and if a company does not adopt latest technologies, it will be out of business soon. Therefore, employees' training for adopting new technology is important for the survival of the firm in the long run.

4.5 Findings according to Roger's model of innovation diffusion

All of the interviewees were convinced about the importance of ICT in the selected firm. Even the interviewees who belonged to laggard and late majority mentioned that ICT played a major role in facilitating operations of the selected firm. However, the extent to which interviewees realized the importance of ICT in the selected firm was a reflection of their place in Rogers Model of Innovation Adoption. For example, interviewee 8, who termed himself as 'technology freak' mentioned that *'If something happens to the internet, the whole working day is lost, and a lot (of work) is dependent on ICT now.'* Similarly, interviewee 1, who belonged to early majority, stated that '*Workday is wasted,'* if there are technical problems with ICT in the selected firm. Interviewee-8 was the only innovator among these interviewees, and interviewee 1 was an early adopter. The early majority, laggards, and the late majority did not show as much dependency of their work on

ICT as reported by early adopters and innovators. Overall, in the light of Roger's Model of Innovation Diffusion (1983), it can be said that innovators and early adopters are more dependent on ICT for completing their daily tasks in the selected firm.

Though all interviewees opined that ICT implementation was cost-effective, their opinions were strongly aligned with their place on Roger's Model. To illustrate, interviewee 6, an early adopter, mentioned that ICT is like an *'Electronic filing database,'* which allows saving records that can be accessed by '*everyone*' working on the project. On the other hand, in response to a question that asked about the cost-effectiveness of ICT in the selected firm, interviewee 2 limited his response to saying that '*time is money.'* Similarly, interviewee 4, who belonged to laggards, focused on the attribute of ICT that it leads to *'shortened time'* for completing work. Interviewee 5, who was an early majority, stated that *'work is done faster'* through ICT. In the light of Roger's Model, innovators and early adopters related cost-effectiveness of ICT to record keeping, communication effectiveness, and time effectiveness; while the other three categories majorly mentioned time effectiveness of ICT. Hence it can be asserted that interviewee's realization of the cost-effectiveness of ICT was aligned with their category in Rogers Model of Innovation Diffusion.

All interviewees, with the exception of interviewee 6, regarded support of top management as an important factor that can facilitate ICT innovation diffusion in the selected firm. However, except interviewee 6, all of the interviewees showed a consistent pattern in response to this question. To illustrate, innovators, early adopters, and the early majority reported higher effectiveness of top management's support as compared to other two categories. For example, they emphasized that *'encouragement creates a trickle-down effect,' 'if they (top management) are not going to believe in it (ICT), employees will not believe in it.'* On the other hand, late majority and

laggards gave less powerful statements as compared to other three categories. Their responses stressed that top management should *'communicate'* benefits of ICT. Conclusively, it can be implied that late majority and laggards perceived a limited effectiveness of support from top management.

Regarding the change in SOP's for facilitating ICT innovation, early adopters and innovators expressed that these needed not to be changed in the selected firm. For example, when inquired if SOP's needed to be changed for facilitating ICT in the firm, interviewee 1 and interviewee 5 responded *'not at all'* and *'not much'* respectively. Likewise, interviewee 8, an innovator, also expressed *'no need'* to change SOPs. As far as other three categories are concerned, their responses varied.

Innovator, early majority and early adopters mentioned that having an opinion leader can positively influence ICT innovation diffusion in the selected firm. Interviewee 3 mentioned that opinion leader should be from *'top management,'* and interviewee 9 stated that an opinion leader should be an *'early adopter.'*

Regarding strategies that can help the selected firm to facilitate ICT innovation diffusion, Roger's model of innovation diffusion (1983) can be applied to explain the varying importance of training from employee-to-employee. According to this model, some employees may need little training as they are early adopters of technology. Some members of staff may need more training as they are at late majority or laggards' stage. For example, interviewee 7, a laggard used the term *'imperative'* for training and learning. Hence, training is an important task for an organization. Interviewee 7 stated that all programs could not be easily adopted by early adopters. Some programs need employees to be fully trained before they start working on these projects. In this case, employees have to take acceptance tests before they start using that program. Acceptance

test basically evaluates whether the employee has undertaken proper training or not. Additionally, interviewee 9 stated that training is critical because learning process of all employees is different. Some people learn through watching; some like to learn through booklets, while some need hands-on learning. Interviewee 8, an innovator, mentioned that the selected firm needs to focus on training and learning by observation. It can be argued that training needs of employees are in accordance with their place at Roger's Model of innovation diffusion to some extent.

CHAPTER 5: DISCUSSION AND CONCLUSION

The purpose of this chapter is to discuss the interview findings. This discussion mainly analyzes literature and interviewees' response in regards to three research objectives, i.e. 1) to identify of commonly used ICT tools in the construction industry 2) to identify significant factors viewed by construction professionals of selected construction firm as hindering the application of ICT in this firm, and determine the extent to which these factors are consistent with barriers mentioned in literature and 3) to analyze strategies used by professionals of selected firm for mitigating the hindrances they have encountered while attempting to implement ICT. The detailed answers to these questions are discussed in this chapter

5.1 Similarities with previous studies

Some findings of this study are consistent with previous studies, which are explained below:

5.1.1 ICT fosters communication in construction firms

To begin with, the role of ICT in providing immediate communication was elaborated by interviewees. One of the interviewees related his experience as his firm has a number of field employees and office employees. With the help of ICT, information is now easily communicated within his firm. It also helped employees to share and access information with their subcontractors and clients regarding the progress of the project without any delay. Another interviewee said that ICT had created effective communication system which has kept everyone on the same page. This particular finding is aligned with previous studies, as ICT has developed instantaneous communication system in construction firms (Moeiem, 2002). Hosseini et al. (2013) explained that ICT has enabled fostering coordination and communication in the construction sector.

Another finding that is consistent with previous research pertains to the importance of communication because of the nature of construction industry. According to Moniem (2002) construction projects are complex, dynamic and involve parties that are geographically dispersed. On a similar note, one of the interviewees explained the importance of ICT in dealing with the difficulties of complex projects and highlighted that if there is an issue on the job site, ICT helps to take everybody's input to resolve that problem. Thereby, ICT helps to minimize the complexity and brings geographically dispersed stakeholders together, who are directly involved in the construction process. Onyegiri and Nwachukwu (2011) mentioned that the major benefit of using ICT is that employees do not need to be present at the same venue; computer and internet allow them to coordinate from different locations. When asked about the importance of ICT from the interviewees, they were of the same opinion. They narrated that they don't have to be physically present on the job site. Moreover, their work is not delayed when the owner is not present on the construction venue. With limited communication barriers, they can coordinate with the clients, subcontractors, contractors, architects, and engineers. Hence, this study, in compliance with previous studies shows that instantaneous communication is valuable in construction sector because of its complex and fragmented nature.

5.1.2 The role of ICT for information management

The importance of ICT for information management has been stressed by this study and previous studies as well. To illustrate, ICT has not only helped in decreasing communication gap among stakeholders, but it has also helped in information management. Effective information management can help the firms to stay ahead of the competition through constant innovation and improved decision making. Davenport and Prusak (2000) reported that Information Management System (IMS) had been used to facilitate storing, sharing, integrating and utilization of data.

Through IMS, firms have become more flexible, and they can respond to environmental changes quickly. Furthermore, this system has resulted in quick access to information, increased innovation and improved decision making (Davenport & Prusak, 2000). The interviewees supported this stance; one interviewee stated that information management could help the firm to be one step ahead of the competition.

5.1.3 Top management support for facilitating ICT innovation diffusion

As established in the literature review, lack of support from top management can become a barrier for implementing ICT in construction firms. Correspondingly, support from top management facilitates ICT diffusion in firms. The findings of this study showed that top management provided ample support to employees for facilitating ICT innovation diffusion. An average rating of 1.6 was given to the *lack of top management support*. Top managers encouraged employees to learn the use of new technologies. Employees were given training sessions to facilitate their learning. Hence, as recommended by researchers (Bakshy, Rosenn, Marlow, & Adamic, 2012; Regan and O'Connor, 2000), the selected firm provided support to employees for implementing ICT.

5.1.4 Barriers to ICT implementation

Literature suggests that certain factors like financial constraints, time constraints, user reluctance and lack of training hinder ICT implementation in construction firms. In the selected firm, the reluctance of project partners to use in-house technology and time constraints were major barriers that obstructed ICT implementation. The usage of new technology may lead to user-reluctance for other stakeholders in the construction industry. Adriaanse et al. (2010) stated that some role-players in construction companies have different documentation standards and they may not be comfortable in adapting in-house technology for the organization. In the case of the

researched firm, this particular aspect holds true. One of the interviewees also wished that company's subcontractors also would understand in-house technology. He contended that much of employees' energy gets wasted when they try to explain processes to partners who are not aware of in-house technology. Conclusively, the reluctance of partners to use technologies that are used in-house was a barrier hindering ICT diffusion in selected firm.

Another barrier prevalent in the selected firm was 'time constraints.' Explaining another barrier to ICT implementation, Ofori (2012) stated that employees spend less time in learning new technology as they fear that they will have to compromise their work. Interviewees rated this constraint as high.

Most of the interviewees opined that time poses a big barrier to the successful implementation of ICT. Only interviewee 8 gave it a low rating because he belonged to an 'Innovator' category. It was also mentioned that some employees require more time for learning while other may require lesser time. On the other hand, some interviewees related time constraint to project deadlines. The schedule of construction industry managers is tough which leads to time constriction for learning new technology. Hence, lack of sufficient time to learn a new technology is a barrier for ICT implementation in selected firm, and this finding is congruent with literature.

5.1.5 Facilitating ICT innovation diffusion

The culture of an organization can either obstruct or facilitate innovation diffusion in a firm. Onyegiri and Nwachukwu (2011) stated that culture helps to foster a positive attitude and seriousness towards technology adoptions. In the case of selected firm, its culture did not hinder ICT diffusion; rather it fostered the diffusion of ICT. Interviews with company's personnel revealed that they actively shared ideas and discussed latest technologies. This was shown in the ratings that they gave to 'motivating employees for using ICT.' An average rating of 4 was given

to motivation of employees. Interviewees knew that creating a culture of motivation is important, and they expressed that their company's culture motivated them to use new technologies. Hence, positive and motivating culture facilitated ICT implementation in the selected firm.

Literature asserts that training employees for using new technology are a strategy that facilitates ICT implementation in construction firms (Peansupap & Walker, 2005; Thamhain, 2013). In the selected firm, adequate training was given to employees, so that they can use technology comfortably. To illustrate, interviewees gave higher ratings to 'training employees for ICT tools.' Most of them were highly optimistic about the training strategy for employees. According to interviewee 9, training is critical because all the employees like to learn differently. Some people learn by watching; some like to work with the booklet and some needs hand on learning. These ratings and responses show that in this particular firm, training was used as a strategy for implementing ICT.

Another strategy is given by Olander (2007) mentions that cause and effect of 'learning through observation' play a key role in knowledge transfer. According to interviewee 8, showing the benefits of ICT and how it will help him individually can make an employee more comfortable and productive at work. Therefore, hands-on learning is also very important to reduce barriers to ICT implementation. Overall, it can be seen that the selected firm focuses on training employees for using ICT, motivating them for learning its use and creating a culture that supports employees for facilitating ICT innovation diffusion.

5.2. Differences from previous studies

Some findings of this study were different from the conclusions drawn by previous researchers, as explained below:

5.2.1 Applications of ICT in the selected firm

A significant difference was found in applications of ICT in the selected firm. ICT has been subject to constant innovation in the form of communication system up gradation. For instance, Duyshart, Sherif, Keith, & Hampson (2006) stated that through video conferencing and shared servers, ICT has not only facilitated document sharing but also reduced the transaction costs of the construction industry. However, in the selected firm, video conferencing was not used frequently. For instance, one of the interviewee stated that he used video conferencing only to communicate with the upper management. Most of the time audio conferencing are used by managers. This shows that although ICT has advanced in last few years, yet managers tends to use this medium only when they think it is necessary for the selected firm.

There is a diverse use of ICT in construction firms. Emmit and Gorse (2003) argued that ICT in the building industry is concerned with information exchange, drawings, specifications, cost data, programs, and designs. Though literature mentions usage of a number of software in construction sector like BIM, video conferencing, etc., the selected firm highly relies on Procore. According to the interviewees, the use of Procore has changed the way business is conducted in this firm. The early adopters were strong advocates of Procore. To illustrate, early adopters stated that before the installation of Procore software, they had to do everything through different programs. With Procore, all of those tasks are now done at one place. Interviewees' ratings for this software were very high as compared to all other programs.

Almost all of the interviewees gave Procore a high rating. With respect to the programs used in construction companies, Emmit and Gorse (2003) stated that Building Information Modelling (BIM) aids in building a project from the beginning till the end. It can also virtually detect indistinguishable mistakes in the building. Even though this software had immense

advantages, it was recently introduced in the company. The average rating given to BIM was 1.17. It should be noticed that four of the interviewees did not even rate this program because they were not aware of its usage and benefits for the company. As for the other interviewees, only interviewee 9 gave this program a rating of 4.5.

Hence, the applications of ICT that were used in the selected firm were different from those identified in the literature. To conclude, the literature shows a great significance of Video conferencing and BIM in construction firms, but in the selected firm, Procore held high significance.

5.2.2 The role of ICT in shortening lifecycle of projects in construction firms

Another finding that contrasted previous studies relates to the role of ICT in shortening the lifecycle of construction projects. ICT has shortened the lifecycle of construction projects (Murray, Nkado, & Lai, 2001). According to World Economic Forum (2016), the construction industry has observed that by incorporating effective information management and sound communication technologies, the life cycle of the construction process can be shortened. Conversely, one of the interviewees stated that wireless technology does not really shorten the lifecycle of the project. However, its non-existence can increase the lifecycle. For instance, one interviewee stated that on those projects which did not have a Wi-Fi connection, she could not scan images and send them from job site which slowed down the progress of these projects. Another interviewee said that through Wi-Fi connections, project managers or superintendents do not need to be physically present on the job site; thereby, Wi-Fi connections have helped in saving *'50% of their time'*. Describing the limitations of ICT in shortening project's life cycle, an interviewee said that although ICT has shortened project's life-cycle, yet it does not let the managers focus on the job altogether. He said that despite the fact the internet has aided in saving some hours for the

organization, ICT cannot entirely shorten the lifecycle as actual construction work will take the same time as before. Overall, the finding of shortening of the lifecycle of projects pertaining to ICT in the selected firm is not aligned with literature.

5.2.3 Barriers in ICT implementation

Literature suggests that financial constraints are a significant barrier that hinders ICT implementation in construction firms (Hosseini et al., 2013; Akinbile and Oni, 2016). However, it was not the case in the selected firm. As for financial constraints, interviewees gave an average rating of 2.4. According to interviewees, the selected organization was robust enough to invest in new technologies.

Brynjolfsson & Hitt (1994) stated that when technology-based projects are financed, construction managers should make sure that productivity paradox doesn't exist. Interviewees had mixed views regarding ICT expenditure and its productivity in their firm. One of the interviewees affirmed the existence of productivity-paradox in the firm. According to him, the use of ICT is in the form of an inverted C-shaped curve. After a certain time, ICT tools become less effective. For instance, when emails were introduced, they were very effective, but now that they are overly used, they have become less useful. Nonetheless, in the case of Procore and BIM, he stated that the more this software would be used, the more they will become cost effective. Hence, productivity-paradox seems to be diminished with the use of the efficient software. On the other hand, some interviewees said that productivity paradox could not be measured in short run. According to them, investment in new technologies is always tough in the beginning. However, productivity increases over a period of time, with the help of training and guidance. Overall, interviewees gave mixed opinions about productivity paradox, and in this regard, a theme consistent with literature was not found from the thematic analysis.

Research indicates that for implementing ICT, SOP's need to be changed, which can become a barrier. Since new ICT tools change the way of doing business, SOPs need to be changed as well. Kasim (2011) stated that introducing a technological change in an organization and re-engineering methods are time-consuming processes which can hinder the growth of ICT. However, in the selected firm, mixed views were reported regarding the change in SOP's for ICT implementation. While some interviewees opined that SOP's had to be changed for ICT implementation, others mentioned the opposite. However, early adopter and innovators perceived that SOPs don't need to be changed for ICT diffusion in the selected firm. This attribute can be investigated further in future studies.

Rauf (2014) stated that bandwidth limitation a constraint to ICT implementation. According to the author, bandwidth limitation can slow down the work of ICT users, which can directly affect the productivity of an organization. In the researched firm, there wasn't any bandwidth limitation, but storage limitation occurred when a server went down. For instance, interviewee 1 stated that once her system went down, she was unable to check her emails and answer her phone calls. Her whole working day was wasted as she was 'stuck.' Similarly, before the firm used Procore, its storage space was limited. With Procore, interviewees can save as much data as they want since this program secures their information in a *cloud*. Therefore, Procore has given unlimited space and saved firm's costs as well.

5.3. Relation of findings to stated objectives

The first research objective was to determine the scope of ICT in the selected firm. In this regards, the role of ICT in providing immediate communication was elaborated by interviewees. One of the interviewees related his experience as his firm has a lot of departments, office employees and with the help of ICT, information is now easily communicated within his firm. It

also helped employees to share and access information with their subcontractors and clients regarding the progress of the project without any delay. Another interviewee said that ICT had created effective communication system which has kept everyone on the same page. It was explained that instantaneous communication helps to manage complex construction projects. According to Moniem (2002) construction projects are complex, dynamic and involve parties that are geographically dispersed. One of the interviewees explained the importance of ICT in dealing with the difficulties of complex projects and highlighted that if there is an issue on the job site, ICT helps to take everybody's input to resolve that problem. Thereby, ICT helps to minimize the complexity and brings geographically dispersed stakeholders together, who are directly involved in the construction process.

A major application of ICT in the selected firm was 'Procore.' According to the interviewees, the use of Procore has changed the way operations are conducted in this firm. Early adopters stated that before the installation of Procore software, they had to do everything through different programs. With Procore, several tasks can be performed through one software. Interviewees' ratings for this software were very high as compared to all other programs. As far as BIM is concerned, even though it had immense advantages, it was recently introduced in the company.

The second objective of this study was to identify barriers that hinder ICT implementation in the selected firm. In the selected firm, financial constraints did not hinder ICT implementation. Furthermore, adequate support from top management was available to foster ICT adoption. Regan and O'Connor (2000) mentioned that top managers are the key players, who are responsible for the diffusion of ICT in an organization. The same was found true for the selected firm, where top management encouraged and motivated employees for using ICT.

The usage of new technology may lead to user-reluctance for other stakeholders in the construction industry. For instance, Adriaanse et al., (2010) stated that some role-players in construction companies have different documentation standards and they may not be comfortable in adapting in-house technology for the organization . In the case of the researched firm, one of the interviewees also wished that company's subcontractors would understand in-house technology. He contended that much of employees' energy gets wasted when they try to explain the same the use of ICT software to other partners. Time constraints were the primary barrier that this firm faced, while it implemented ICT. Bandwidth limitation was also regarded as a constraint that hindered ICT adoption; specifically, early adopters reported higher dependence on the internet and for completing their daily works.

The third research objective was to analyze the strategies that are used in the selected firm to facilitate ICT implementation. The selected firm had implemented different techniques to foster ICT implementation. Support from top management enabled employees to learn ICT swiftly. Furthermore, top management not only supported employees but also motivated and encouraged them to learn the use of new technologies. Nonetheless, the employees expressed that ICT adoption could have been better if employees had more time to explore new technologies. Another strategy that the selected firm practiced was to train employees for using ICT tools. To conclude, training and support from top management facilitated ICT innovation in the selected firm.

5.4. Implications of findings and recommendations

The findings have certain implications for the selected firm and for other firms operating in the construction sector, which is discussed in this section.

5.4.1. Implications and recommendations for construction industry

It has been seen that though all interviewees were aware of the scope of ICT in the selected firm, their awareness was in accordance with their place at Roger's model of technology adaptation. For example, early adopters and innovators were highly aware of numerous ways in which ICT implementation made the selected firm cost effective. This implies that when a construction firm wants to implement ICT across its operations, it needs to empower early adopters and innovators, as they are the ones who realize the importance of ICT to the maximum level. These people should be asked to advocate the use of ICT and convey its benefits to other members of the firm. Hence, as innovators and early adopters are highly dependent on ICT, they are the ones who should be 'empowered as a champion' by management.

The selected firm facilitated ICT implementation through training and support for top management. Support from top management was related to benefits like producing technological depth in the firm. This implies that firms in construction sector can facilitate ICT diffusion by supporting employees, encouraging them. Interviewee 7 stated that *'If they (top management) are not going to believe in it (ICT innovation) and the employees will not believe in it.'* This statement implies that the belief and conviction of top management in ICT and its benefits can make it easier for employees to believe in the system as well. Other firms in construction sector can also learn from this finding; it is recommended that executives in other construction firms should be convinced on benefits of ICT before they start implementing it.

Another finding was that employee's acceptance and comfort with ICT usage could make its diffusion easier. It is recommended that other construction firms develop strategies to make employees comfortable with ICT. Training employees for using new technologies can increase their comfort level. Empowering an opinion leader or a champion can also facilitate ICT

innovation diffusion, as evident from the findings. It might also help employees accept new technologies easily.

Among all the barriers faced by employees for ICT implementation, time constraint had the higher rank. This implies that in construction firms, top management needs to give employees some spare time to explore and learn new technologies. Giving employees time to explore new technology is one of the strategies that can help them to adopt ICT.

5.4.2. Implications and recommendations for the selected firm

Though the selected firm uses several software like Microsoft Word, Adobe Reader, Blue Beam, etc., a high dependency on Procore has been observed for commencing daily, weekly and monthly operations have been observed, which implies that the selected firm needs to emphasize on training employees for using this software. Though the selected firm already emphasizes on conducting training workshops, training for Procore should be given priority, so that employees can feel easy when they perform their daily operations.

A major finding is that all the interviewees, except one, regarded ‘time constraints’ as a significant barrier that hinders ICT implementation in the selected firm. Most of the interviewees rated it at ‘3.5’ on a scale of 1-5 in terms of difficulty. It should be noticed that time was given a high rating, irrespective of places of interviewees on Roger’s model. To illustrate, both early adopters and laggards, despite being at opposite ends of a spectrum, viewed time as a barrier. Henceforth, it can be affirmed that time is a major barrier that hinders ICT implementation in the selected firm. It can be implied that in this firm, ICT can be diffused further if employees are given more time to test and explore new technologies.

5.5. The validity of findings

To explore the validity of findings, comments from participants were sought about the specific issues and conclusions reached by this study. Participant 1 agreed with most findings of the research like time constraint as a barrier to ICT implementation and training as an effective strategy to adopt ICT tools in the construction industry. However, this participant mentioned that other software besides Procore might be high-rated. He commented that Procore has its limitations, which is why the employees of his company complement it with Bluebeam, Nuance, or old-fashioned hand takeoffs. When asked to comment on the findings of the research, Participant 2 also agreed that ICT tools are beneficial for the construction industry at large. However, he stated that the staff of his company encounter difficulties whenever Procore updates the website features. He argued that although tutorials are available on the website to assist the employees yet the website is not so productive with resolving tasks at hand. In much the same manner, participant 2 agreed with most findings of the research, but he recommended that the research could have been more strengthened if it considered how proactive Procore is in meeting the specific needs of a firm.

5.6. Conclusions

The construction industry has not been quick in adopting ICT. Therefore, it has not been benefitted from the advances of ICT as compared to other industries. The current study has focused on a particular construction firm operating in Las Vegas, Nevada. The first research objective of this research was to identify the scope of ICT the in the selected firm. It can be concluded from the themes of interviews that the applications of ICT in selected firm included means for facilitating communication, Adobe Reader, Microsoft Word, Blue Beam and Procore. A high reliance on Procore was seen, which enabled the firm to complete daily, weekly and monthly operations. Employees were aware of benefits of ICT in terms of its cost-effectiveness and time-

effectiveness; however, their awareness was in accordance with their place at Roger's Model of Technology Adaptability. To conclude, innovators and early adopters were more aware of the scope of ICT in the selected firm, as compared to another early majority, late majority, and laggards.

The second research objective was to identify factors that inhibit the growth of ICT in the selected organization. The researcher asked questions about barriers related to financial constraints, time constraints, lack of encouragement from top management, lack of training given to employees, the reluctance of employees to learn new technologies and lack of technical support. However, the financial constraint was not a barrier in the selected firm, as it had the financial muscle to implement ICT. As for encouragement from top management, firm's upper management was open to new technologies and encouraged its employees to share ideas and discuss their views on new technology. There was less user reluctance in the firm. The researched firm also had a culture to adopt new technologies. In a selected firm, 'time constraint' was a major barrier to ICT innovation implementation, as different employees take varying time periods to learn new technology. The tight schedule of construction industry also made time a barrier in for ICT implementation. It was also mentioned that schedule of the construction industry is very complex, which leads to time constraint. Another barrier to ICT implementation was SOPs of the firm, as some interviewees expressed that whenever new technologies are implemented, SOPs need to be changed. Another constraint that was recognized is 'bandwidth limitation,' as a disruption in the bandwidth can waste a whole working day of employees of the firm. This barrier is relatively new, and it has not been studied in the literature. Further research is needed to validate it. Conclusively, three barriers hindered ICT implementation in the selected firm, i.e. time constraints, change in SOPs and bandwidth limitation.

The third research objective of this paper was to identify strategies that facilitated the adoption of ICT in the selected firm. It was seen that in the selected firm, support from top management and training employees were major strategies that enabled ICT implementation. The interviewees expressed that giving employee's sufficient time to learn new technologies, making them learn through observation and empowering an opinion leader can diffuse ICT further in the selected firm. It can be concluded that in the selected firm support from top management and training employees are practiced as strategies for diffusing ICT and other strategies that can be used include giving employees time to adopt new technologies, learning by observation and making an opinion leader who advocates ICT use.

5.7. Limitations of study and suggestions for future studies

This paper holds some limitations with respect to the research conducted. Firstly, the researcher has only focused on one company. To illustrate, when studying the barriers to ICT implementation in construction firms, the researcher chose to have only one organization as the center of research. During analysis, the researcher found out that some barriers which may have been applicable to a lot of firms haven't been observed in the researched company. For instance, the financial constraint was considered to be the most important barrier to ICT implementation in the construction industry. But this barrier was not persistent in the firm studied. Another example is the presence of top management support. Again, unlike other laid-back construction firms with autonomous management structures, this particular firm's structure supported new ideas and promoted the use of new technology. If there would be more than one firm in the picture, then the researcher would also be able to compare and contrast research findings.

Secondly, the research was conducted by questioning only nine interviewees. Nine interviewees were not enough for the researcher to observe all the barriers in ICT implementation.

More research participants are needed to get a holistic view of an organization. Therefore, future studies should include more interviewees at different levels. Another limitation of the study was that interviewees did not have a deep understanding of attributes of innovation like compatibility.

Nonetheless, this study has a scope for future research as it opens avenues for further investigation on the use of ICT tools in the construction industry. For future studies, researchers can analyze the influence of factors that inhibit ICT innovation diffusion in the construction sector of America by employing an approach where data is collected from multiple firms. Data from a number of firms will be richer in terms of its versatility. It is also recommended that researchers analyze strategies that are used to facilitate ICT innovation diffusion in different firms of the construction sector.

BIBLIOGRAPHY

1. Adenfelt, M., &Lagerstrom, K. (2006). Enabling knowledge creation and sharing in transnational projects. *International Journal of Project Management, 24* (3), 191-8.
2. Ahuja, V., Yang, J., & Shankar, R. (2009). Study of ICT adoption for building project management in the Indian construction industry. *Automation in Construction, 18* (4), 415-423.
3. Akinbile, B., Oni, O., (2016). Assessment Of The Challenges And Benefits Of Information Communication Technology (Ict) On Construction Industry In Oyo State Nigeria. *Annals of the Faculty of Engineering Hunedoara-International Journal of Engineering*. 14.
4. Aladag, H., Demirdögen, G., Isık, Z., (2016). Building Information Modeling (BIM) Use in Turkish Construction Industry. *Procedia Engineering*. 161, 174–179.
5. Alkalbani, S., Rezgui, Y., Vorakulpipat, C., & Wilson, I. E. (2013). ICT adoption and diffusion in the construction industry of a developing economy: The case of the sultanate of Oman. *Architectural Engineering And Design Management* , 62-75.
6. Amadi-Echendu, J., Brown, K., Willett, R., & Mathew, J. (2012). *Asset Condition, Information Systems and Decision Models.* Springer.
7. Andreas P., Michael H., 2008. Role of Information Flow Management in the Design and Construction of Exterior Wall Systems. AEI 2008, Proceedings. doi:10.1061/41002(328)13
8. Arditi, D., Kale, S., &Tangkar, M. (1997). Innovation in construction equipment and its flow into te construction industry. *Journal of Construction Engineering and Management*, 371-378.

9. Atalah, A., Seymour, A., (2013). The Current State Of Wireless Information Technology In The Construction Industry. *The Journal of Technology Studies*. 14–27.

10. Avgerou, C., Hayes, N., & La Rovere, R. (2016). Growth in ICT uptake in developing countries: new users, new uses, new challenges. *Journal of Information Technology*, 329-333.

11. Bakshy, E., Rosenn, I., Marlow, C., & Adamic, L. (2012). The Role of Social Networks in Information Diffusion. In *Proceedings of the 21st International Conference on World Wide Web* (pp. 519–528). New York, NY, USA: ACM. https://doi.org/10.1145/2187836.2187907

12. Blessing, M., 2012. *E-Agriculture and Rural Development: Global Innovations and Future Prospects: Global Innovations and Future Prospects*. IGI Global.

13. Bower, D.J., Hinks, J., Wright, H., Hardcastle, C., Cuckow, H.,(2001). ICTs, videoconferencing and the construction industry: opportunity or threat? *American Journal of Scientific and Industrial Research.* 1, 129–144.

14. Bowden, S. (2005). *Application of mobile IT in construction (Doctoral dissertation).* Leicestershire, UK: Sarah Louise Bowden.

15. Boyce, C., & Neale, P. (2006). Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input. *Pathfinder International*, 2–12.

16. Brandon, P., & Lu, S.-L. (2008). *Clients Driving Innovation.* West Sussex, Chichester. : Wiley-Blackwell.

17. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

18. Brynjolfsson, E., & Hitt. (1994). *Paradox Lost? Firm-level evidence of hig returns to information systems spending*. Retrieved from ccs.mit.edu: http://css.mit.edu/CCSWP162/ccswp162.html

19. Brynjolfsson, E., & Hitt. (1994). *Productivity without profit? Three measures of information technology*. Retrieved from ccs.mit.edu: http://ccs.mit.edu/CCSWP190.html.

20. Cherian, T.M., AravindhKumaran, L., (2016). E-Business in Construction Industry: Opportunities and Challenges. *Indian Journal of Science and Technology* 9.

21. Christopher, G. R. (2009).*Handbook of Research on Strategies for Local E-Government Adoption and Implementation: Comparative Studies*. IGI Global

22. Conrad, C., Poole, M.S., 2011. *Strategic Organizational Communication: In a Global Economy*. John Wiley & Sons.

23. Creswell, J. W. (2013). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. SAGE.

24. Dace, A. C. (2007). *Building Information Modeling: The web3d application for aec*. Perugia, Italy: ACM.

25. Davenport, T., &Prusak, L. (2000). *Working Knowledge: How Organizations Manage What they know*. Boston: Harvard Business School Press.

26. Davies, K. (2008). Barriers Or Constraints? A Review Of Development Issues As They Apply To Construction It.*International Conference on Information Technology in Construction* (pp. 1-7). Santiago, Chile: School of the Built Environment, Unitec New Zealand.

27. Denzin, N. K. (1992). *Symbolic Interactionism and Cultural Studies: The Politics of Interpretation*. Blackwell.

28. DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, *40*(4), 314–321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

29. Dubois, A., & Gadde, L.-E. (2002). The Construction Industry as a Loosely Coupled System:Implications for Productivity and Innovation. *Construction Management and Economics*, *20* (7), 621-631.

30. Duyshart, B. D., Sherif, W., Keith, M., &Hampson. (2006). An example of developing a business model for information and communication (ICT) adoption on construction projects-the National Museum of Australia project. *Engineering, Construction and Architectural Management, 13* (4), 364-379.

31. Duyshart, B. (1997). *The Digital Document.* Oxford: Butterworth Heinemann.

32. Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2008). *Bim handbook: a guide to building information modeling for owners, managers designers, engineers, and contractors.* Hoboken, New Jersey: John Wiley and Sons.

33. Ekholm, A., Andersson, R., Molnar, M., 2007. Benefits of ICT in the construction industry - characterization of the present situation in house-building processes. Proceedings of the W78 Conference, pp. 423–428.

34. Emmitt, S., & Gorse, C. (2003). *Construction communication.* Oxford: Blackwell.

35. Emuze, F.A., Saurin, T.A., 2015. *Value and Waste in Lean Construction*. Routledge.

36. Fonow, M. M., & Cook, J. A. (1991). *Beyond Methodology: Feminist Scholarship as Lived Research*. Indiana University Press.

37. Gibbons, D. E. (2007). Interorganizational Network Structures and Diffusion of Information Through a Health System. *American Journal of Public Health*, *97*(9), 1684–1692. https://doi.org/10.2105/AJPH.2005.063669

38. Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report*, *8*(4), 597–606.

39. Hore, A., & West, R. (2005). Attitudes towards Electronic Purchasing in the IrishConstruction Industry. *2005 CIB W92/T23/W107 International Symposium onProcurement Systems*. Las Vegas, USA.

40. Hosseini, R., Chileshe, N., Zou, J., Baroudi, B., (2013). Approaches of Implementing ICT Technologies within the Construction Industry. *Australasian Journal of Construction Economics and Building-Conference Series* 1, 1–12.

41. Jacobsson, M., Linderoth, H.C.J., (2012). User perceptions of ICT impacts in Swedish construction companies: "it"s fine, just as it is'. *Construction Management and Economics*. 30, 339–357.

42. Jha, K. N., &Iyer, K. C. (2006). Critical determinants of project coordination. *International Journal of Project Management, 24* (4), 314-322.

43. Jorgensen, B. (2004). Individual and organisational learning: a model for reform for public organisations. *Foresight, 6* (2), 91-103.

44. Kasarda, J., &Rondinelli, D. (1998). Innovative infrastructure for agile manufacturers. *Sloan Management Review, 39* (2), 73-82.

45. Klinc, R., Turk, Ž.,Dolenc, M., (2016). A service-oriented framework for interpersonal communication in architecture, engineering and construction. *Tehnicki vjesnik - Technical Gazette.* 23, 1855–1862.

46. Kling, R. (1980). Social analysis of Computing:Theoritical Perspective in Recent Empirical Research. *Computing Survey, 12* (1), 61-110.

47. Kocarev, L., 2012. *ICT Innovations 2011.* Springer Science & Business Media.

48. Kodama, M., 2012. *Competing Through ICT Capability: Innovation in Image Communication*. Palgrave Macmillan.

49. Kramer, W. J., Jenkins, B., & Katz, R. S. (2007). *The Role of the Information and Communications Technology Sector in Expanding Economic Opportunity.* Harvard.

50. Krogh, V. (2002). The communal resource and information systems. *Journal of Strategic Information Systems, 11* (2), 85-107.

51. Kukla, A., 2000. *Social Constructivism and the Philosophy of Science.* Psychology Press.

52. Kuper, A., Reeves, S., & Levinson, W. (2008). Qualitative Research: An Introduction to Reading and Appraising Qualitative Research. *BMJ: British Medical Journal*, *337*(7666), 404–407.

53. Lee, T. L. F. S., & Cronin, B. (2016). *Handbook of Research Methods and Applications in Heterodox Economics*. Edward Elgar Publishing.

54. Lenny, K., S.C., 2009. *Information and Communication Technologies Management in Turbulent Business Environments*. IGI Global.

55. Leon, A., 2008. *ERP Demystified.* Tata McGraw-Hill Education.

56. Levy, S. M. (2007). Project Management in construction 5th Edition. McGraw Hill companies.

57. Lichtman, M. (2013). *Qualitative Research for the Social Sciences*. SAGE Publications.

58. Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills, CA: Sage.

59. Love, P., Li, H., &Mandal, P. (1999). Rework: a symptom of a dysfunctional supply-chain. *European Journal of Purchasing and Supply Management*, 1-11.

60. Melville, N., & Ramirez, R. (2008). Information technology innovation diffusion: an information requirements paradigm. *Information Systems Journal*, *18*(3), 247–273. https://doi.org/10.1111/j.1365-2575.2007.00260.x

61. Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook.* Sage Publications.

62. M. Sarshar, U. I. (2004). A Survey of ICT Use in the Turkish Construction Industry. *Engineering, Construction and Architectural Management, 11* (4), 238-247.

63. Moniem, A. H. (2000). *The Role of Project Control Systems in the Integration of the construction Site Processes.* Leicestershire, UK: Loughborough University.

64. Morton, C. (2009). *Evaluating collaborative planning: A case study of the morice land and resource management plan [online].Masterresearch project thesis subject to SimonFraser University.* Retrieved 2017, from :http://www.silverhillinstitute.ca: :http://www.silverhillinstitute.ca/pdf/cedar_morton_final_paper.pdf

65. Murray, M., Nkado, R., & Lai, A. (2001). The integrated use of information technology in the construction industry. *Proceedings of the CIB 78 Conference: IT in Construction in Africa,* (pp. 39-1 to 39-13). Pretoria: South Africa.

66. Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evid Based Nurs, 18 (*2), 34-35.

67. Notari, M., Baumgartner, A., & Herzog, W. (2014). Social skills as predictors of communication, performance and quality of collaboration in project-based learning. *Journal of Computer Assisted Learning, 30* (2), 132-147.

68. Obaide, A., &Alshawi, M. (2005). The need for an effective knowledge management models in engineering organizations. *Proceedings of CIB W102 Conference on "Information and and knowledge management in a global economy* (pp. 405-13). Lisbon.

69. Olander, S. (2007). Stakeholder impact analysis in construction project management. *Construction Management and Economics, 25* (3), 277-287.

70. Onyegiri, I., Nwachukwu, C., (2011). Information and communication technology in the construction industry. Am. J. Sci. Ind. Res. 2, 461–468.

71. Pace, C. (1999). Defining a Research Agenda for AEC Process/product Development in 2000 and Beyond. *Berkeley-Stanford CE&M Workshop*, Retreived from: http://www.ce.berkeley.edu/~tommelein/CEMworkshop/Pace.pdf

72. Patton, M. Q. (2002). Qualitative evaluation and research methods (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

73. Payne, G., & Williams, M. (2005). Generalization in qualitative research. *Sociology*, *39*(2), 295–314.

74. Peansupap, Vachara, Walker, D. H., Goldsmith, P. W., & Wilson, A. (2003). Developing within-company information and communication technologies (ICT) innovation diffusion networks: a study of three Australian major contractors. Retrieved from http://digitalcollections.qut.edu.au/1974/

75. Peansupap, V., & Walker, D. H. T. (2004). Understanding the ICT Innovation Diffusion Process of Large Australian Construction Contractors. In *First SCRI International Research Symposium, Salford UK* (pp. 30–31). Retrieved from http://www.irbnet.de/daten/iconda/CIB14620.pdf

76. Peansupap, V., Walker, D., (2005). Factors affecting ICT diffusion: A case study of three large Australian construction contractors. *Engineering, Construction and Architectural Management*, *12*, 21–37.

77. Peansupap, V., Walker, D.H.T. (2006) Information communication technology (ICT) implementation constraints: A construction industry perspective. *Engineering, Construction and Architectural Management*, *13*, 364–379.

78. Peansupap, Vachara, & Walker, D. (2005). Exploratory factors influencing information and communication technology diffusion and adoption within Australian construction organizations: a micro analysis. *Construction Innovation*, *5*(3), 135–157.

79. Peansupap, Vachara, & Walker, D. H. (2006). Innovation diffusion at the implementation stage of a construction project: a case study of information communication technology. *Construction Management and Economics*, *24*(3), 321–332.

80. Porter. (2001). Strategy and the internet. *Harvard Business Review, 79* (3), 63-78.

81. Regan, E., & O'Connor, B. (2000). *End-user Information Systems: Implementing Individual and Work Group Technologies, 2nd ed.* Upper Saddle River, NJ: Prentice Hall.

82. Rekha, P., 2012. *Globalization, Technology Diffusion and Gender Disparity: Social Impacts of ICTs: Social Impacts of ICTs*. IGI Global.

83. Ribeiro, F. L. (2009). Enhancing knowledge management in construction firms. *Construction innovation*, 268 - 284.

84. Rogers, E. M. (1983). *Diffusion of innovations* (3rd ed). New York : London: Free Press ; Collier Macmillan.

85. Rogers, M. (2003). *Diffusion of Innovations*. New York: Free Press.

86. Samad, M. E., Loosemore, S. M., & Davis, S. R. (2016). Conceptualising Information and Equipment Technology Adoption in Construction A Critical Review of Existing Research. *Engineering, Construction and Architectural Management, 23* (2), 158 - 176.

87. Sarshar, M. & Isikdag, U. (2004). A Survey of Use of ICT in Turksih Construction Industry. *Engineering, Construction and Architectural Management, 11 (4), 238-247*

88. Sarshar, M., Betts, M., Abbott, C., & Aouad, G. (2000). A Vision for Construction IT 2005-2010: Two Case Studies. *Engineering, Construction and Architectural Management, 9* (2), 152 – 160

89. Sarshar, M., Isikdag, U., (2004). A survey of ICT use in the Turkish construction industry. Eng. Constr. Archit. Manag. 11.

90. Satapathy, S.C., Avadhani, P.S., Udgata, S.K., Lakshminarayana, S., 2013. *ICT and Critical Infrastructure: Proceedings of the 48th Annual Convention of Computer Society of India- Vol II: Hosted by CSI Vishakapatnam Chapter*. Springer Science & Business Media.

91. Schein, E. (2004). *Organisational Culture and Leadership, 3rd ed.* San Fransisco, CA: Jossey Bass.

92. Sekou, E.A., (2012). Promoting the use of ICT in the construction industry. Retrieved 2017, from: http://dspace.knust.edu.gh/bitstream/123456789/5583/1/Final%20Thesis.pdf

93. Sexton, M., & Barrett, P. (2003). Appropriate Innovation in Small Construction Firms. *Construction Management and Economics*, 21 (6), 623-633.

94. Shibeika, A., & Harty, C. (2015). Diffusion of digital innovation in construction: a case study of a UK engineering firm. *Construction Management and Economics*, *33*(5–6), 453–466. https://doi.org/10.1080/01446193.2015.1077982

95. Shohet, I., &Frydman, S. (2003). Communication patterns in construction at construction manager level. *Journal of Construction Engineering and Management-Asce; J.Constr.Eng. Manage.-ASCE, 129* (5), 570-577.

96. Slaughter, E. (2000). Implementation of Construction Innovations. *Building Research & information, 28* (1), 2-17.

97. Smith, J., & Love, P. E. (2004). Stakeholder management during project inception: strategic need analysis. *Journal of architectural engineering, 10* (1), 22-33.

98. Statistics, A. B. (1999). *Business Use of Information Technology-Preliminary, Australia 1997-98.* Canberra: Australian Bureau of Statistics.

99. Story, L., Walls, D., 2010. *Microsoft Office 2010 Fundamentals*. Cengage Learning.

100. Strader, T., Ramaswami, S., &Houle, P. (2007). Persieved network externalties and communication technology accpetance. *European jornal of information systems*, 54-65.

101. Stenbacka, C. (2001). Qualitative research requires quality concepts of its own. *Management Decision*, *39* (7), 551–556. https://doi.org/10.1108/EUM0000000005801

102. Sun, M., & Howard, R. (2004). *Understanding IT in construction.* London: Spoon Press.

103. Theodosios, T., 2014. *Approaches and Processes for Managing the Economics of Information Systems.* IGI Global.

104. Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45.

105. Thamhain, H. (2013). Changing Dynamics of Team Leadership in Global Project Environments. *American Journal of Industrial and Business Management, 3* (2), 146-156.

106. Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, *19*(6), 349–357. https://doi.org/10.1093/intqhc/mzm042

107. Tseng, S. (2008). The effects of information technology on knowledge management systems. *Expert Systems with Applications*, 150-160.

108. UNESCO (2002). *Information and Communication Technology in Education*. Retrieved from http://unesdoc.unesco.org/images/0012/001295/129538e.pdf.

109. Van der Vlist, A.J., Vrolijk, M.H., Dewulf, G.P.M.R., (2014). On information and communication technology and production cost in construction industry: evidence from the Netherlands. *Constr. Construction Management and Economics*. 32, 641–651.

110. Verburg, R., Bosch-Sijtsema, P., &Vartiainen, M. (2013). Getting it done: Critical success factors for project managers in virtual work settings. *International Journal of Project Management., 31*, 68-79.

111. Weippert, A., Kajewski, S. L., & Tilley, P. A. (2003). The implementation of online information and communication technology (ict) on remote construction projects. *Logistics information management*, 327-340.

112. Whitley, R. (2000). *The Intellectual and Social Organization of the Sciences*. Oxford University Press.

113. Wolters, M. K. (2016). Capsule Commentary on Reese et al., Two Randomized Controlled Pilot Trials of Social Forces to Improve Statin Adherence Among Patients with Diabetes. *Journal of General Internal Medicine*, *31*(4), 416. https://doi.org/10.1007/s11606-016-3599-0

114. Wong, C. H., & Sloan, B. (2004). Use of ICT for e-procurement in the UK Construction Industry: a Survey of SMES Readiness. *ARCOM Proceedings Twentieth Annual Conference*, (pp. 1-3).

115. Wong, F.W., Lam, P.T., (2010). Difficulties and hindrances facing end users of electronic information exchange systems in design and construction. *Journal of Management in Engineering*. 27, 28–39.

116. Xue, X. S. (2006). Critical review of collaborative working in construction projects: business environment and human behaviors. *Journal of Management in Engineering, 26* (4), 196-208.

117. Yang, J., & Leskovec, J. (2010). Modeling Information Diffusion in Implicit Networks. In *2010 IEEE International Conference on Data Mining* (pp. 599–608). https://doi.org/10.1109/ICDM.2010.22

118. Yates, J., & Leggett, T. (2016). Qualitative Research: An Introduction. *Radiologic Technology*, *88*(2), 225–231.

119. Young, M., 2007. *Bringing Knowledge Back In: From Social Constructivism to Social Realism in the Sociology of Education.* Routledge.

APPENDIX A: RATINGS GIVEN TO IMPORTANCE OF VIDEO CONFERENCING, PROCORE AND BIM

Interviewees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Video Conferencing	0.5	2.5	3	2.5	5	0	1	1.5	3

Interviewees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Procore	5	4	5	5	5	5	5	5	5

Interviewees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
BIM	0.5	0	1.5	0	3	0	0	1	4.5

APPENDIX B: RATINGS GIVEN TO IMPORTANCE OF ICT FOR COMMUNICATION

	Interviewees								
Usefulness of Information	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Information generation	5	5	5	4.5	4	4	4.5	4.5	3.5
Transmission of information	5	5	3.5	4.5	5	4.5	4.5	5	4.5
Maintenance of information	5	5	4	4.5	5	4	4.5	3	5
Re-use of information	4	4	3	4	5	4.5	4.5	4.5	4

APPENDIX C: PROCORE

Procore is a cloud-based construction management software application that helps firms increase their project efficiency and accountability. This software helps by providing streamlined project communication and documentation. Interviewees could manage their projects from any web-connected mobile device, tablet, and laptops. Procore provided them a way to collaborate on projects and view documents, such as submittals, RFIs, contracts, schedules, and drawings. Everyone from general contractors and architects to engineers and construction management firms could edit and share project data from the job site, while facility owners can view the progress of each project in their portfolios. This firm leveraged Procore to manage construction projects, field communications, drawings, documents, and more. Procore operates under the Software-as-a-Service (SaaS) model, allowing general contractors and project managers to buy the software on a subscription basis.

APPENDIX D: QUESTIONS FOR INTERVIEW

Information about Interviewee

*Sector (encircle the sector):

Housing Commercial Industrial

*Describe your position in the company in one sentence.

*Gender: Male/Female

*Age: (encircle)

18-24 years 25-30 years 31-36 years 37-42 years 43-50 years

50+ years

*Experience in construction sector: _____ Years (approximately)

*Experience in selected company: _____ Years (approximately)

1. How do you identify yourself among the following in terms of adopting a new technology?
    a. Innovators
    b. Early adopters
    c. Early Majority
    d. Late Majority
    e. Laggards

2. How would you rate the importance of the following factors on a scale of 1-5, as you think they influence you while adopting a new technology with 1 being the least and 5 being the highest?

FACTORS	Rate (1-5)
Relative Advantage	
Compatibility	
Complexity	
Trialability	
Observability	

3. How do you use Information and Communication Technology in your daily operations? Kindly give some examples of your use
4. How do you use Information and Communication Technology in your weekly operations? Kindly give some examples of your use
5. How do you use Information and Communication Technology in your monthly operations? Kindly give some examples of your use

   (Taken from: Hosseini, R., Chileshe, N., Zou, J., Baroudi, B., (2013). Approaches of Implementing ICT Technologies within the Construction Industry. *Australasian Journal of Construction Economics and Building-Conference Series* 1, 1–12.)
6. **Please rate the following software/applications according to the extent of their usage in your organization on a scale of 1-5, with 1 being least and 5 being highest.**

Software/Application	Rate (1-5)
On screen take off	
Procore	
Blue beam	
Adobe pdf reader	
CAD/Revit	
BIM	
Video conferencing	
Primavera	
Others(if any)	

(Taken from: Bowden, S. (2005). *Application of mobile IT in construction (Doctoral dissertation).* Leicestershire, UK; Sarshar, M., Isikdag, U., (2004). A survey of ICT use in the Turkish construction industry. Eng. Constr. Archit. Manag. 11.)

7. In your opinion why is ICT important in your company?

(Taken from: Murray, M., Nkado, R., & Lai, A. (2001). The integrated use of information technology in the construction industry. *Proceedings of the CIB 78 Conference: IT in Construction in Africa,* (pp. 39-1 to 39-13). Pretoria: South Africa.)

8. In your opinion, to what extent ICT installation can lead to cost effectiveness in your firm?

(Derived from: Van der Vlist, A.J., Vrolijk, M.H., Dewulf, G.P.M.R., (2014). On information and communication technology and production cost in construction industry: evidence from the Netherlands. *Constr. Construction Management and Economics.* 32, 641–651.)

9. Please rate the usefulness of ICT for accomplishing following processes effectively in your firm on a scale of 1-10, with 1 being least and 10 being highest.

Processes in firm(Submittals, contracts, documents)	**Rate (1-5) of ICT usefulness for completing process in an effective manner**
Information generation (Developing and gaining information)	
Transmission of information (for example, sharing information between employees of firm or with partners, suppliers outside firm)	
Maintenance of information (storing information)	
Re-use of information (for example, referring to stored information again)	

(Derived from: Weippert, A., Kajewski, S. L., & Tilley, P. A. (2003). The implementation of online information and communication technology (ict) on remote construction projects. *Logistics information management*, 327-340.)

10. In what ways can ICT help to improve customer service and client satisfaction of your firm?

(Derived from: Duyshart, B. D., Sherif, W., Keith, M., &Hampson. (2006). An example of developing a business model for information and communication (ICT) adoption on construction projects-the National Museum of Australia project. *Engineering, Construction and Architectural Management, 13* (4), 364-379.)

11. Has wireless technology shortened the life-cycle of projects in your firm?

(Derived from: Atalah, A., Seymour, A., (2013). The Current State Of Wireless Information Technology In The Construction Industry. *The Journal of Technology Studies*. 14–27.)

Second Research Objective: To identify significant factors viewed by construction professionals of selected construction firm as hindering the application of ICT in this firm, and determine the extent to which these factors are consistent with barriers mentioned in literature.

12. How do you think that ICT expenditure and ICT productivity are related to each other in your firm?

(Derived from: Brynjolfsson, E., & Hitt. (1994). *Productivity without profit? Three measures of information technology.* Retrieved from ccs.mit.edu: http://ccs.mit.edu/CCSWP190.html.)

13. In what ways top management can help employees to adopt ICT in your firm?

(Taken from: Regan, E., & O'Connor, B. (2000). *End-user Information Systems: Implementing Individual and Work Group Technologies, 2nd ed.* Upper Saddle River, NJ: Prentice Hall;

Strader, T., Ramaswami, S., & Houle, P. (2007). Perceived network externalities and communication technology acceptance. *European journal of information systems*, 54-65.)

14. Research studies suggest that certain factors hinder implementation of ICT in construction firms. These factors include financial constraints of adopting ICT, time constraints for learning use of technology, lack of training, etc. Please rate the following factors on a scale of 1-5, with 1 being least and 5 being highest.

Factors hindering ICT implementation in firm	**Rating in general (1-5)**
a. Financial constraints	
b. Time constraints	
c. Lack of encouragement from top management	
d. Lack of training given to employees	

e. Reluctance of employees to learn new technologies	
f. Lack of technical support	
g. Others (if any)	

(Derived from: Hua, G. B. (Ed.). (2013). *Implementing IT business strategy in the construction industry*. IGI Global; Strader, T., Ramaswami, S., & Houle, P. (2007). Perceived network externalities and communication technology acceptance. *European journal of information systems*, 54-65; Ofori, G. (Ed.). (2012). *Contemporary Issues in Construction in Developing Countries*. Routledge.)

15. How do you think Standard Operating Procedures (SOPs) and business processes need to be changed for ICT's diffusion/adoption in your organization?

(Derived from: Kasim, N. (2011). ICT implementation for materials management in construction projects: case studies. *Journal of Construction Engineering and Project Management*, *1*(1), 31-36.)

16. In what ways do you think employee acceptance and comfort for ICT usage is important for implementing ICT in your company?

(Derived from: Davies, K. (2008). Barriers or Constraints? A Review Of Development Issues As They Apply To Construction It. *International Conference on Information Technology in Construction* (pp. 1-7). Santiago, Chile: School of the Built Environment, United New Zealand.)

17. **How do you think that an opinion leader in your firm can influence diffusion of ICT throughout your firm?**
18. **How do you think that discussion among employees about ICT implementation and usage can affect its implementation?**

(Derived from Peansupap, Walker, Goldsmith and Wilson (2003)

<u>Third Research Objective: To analyze strategies used by professionals of selected firm for mitigating the hindrances they have encountered while attempting to implement ICT</u>

19. **How has your firm developed strategies for reducing barriers that hinder ICT implementation? (Ex: Strategies like weekly training sessions)**

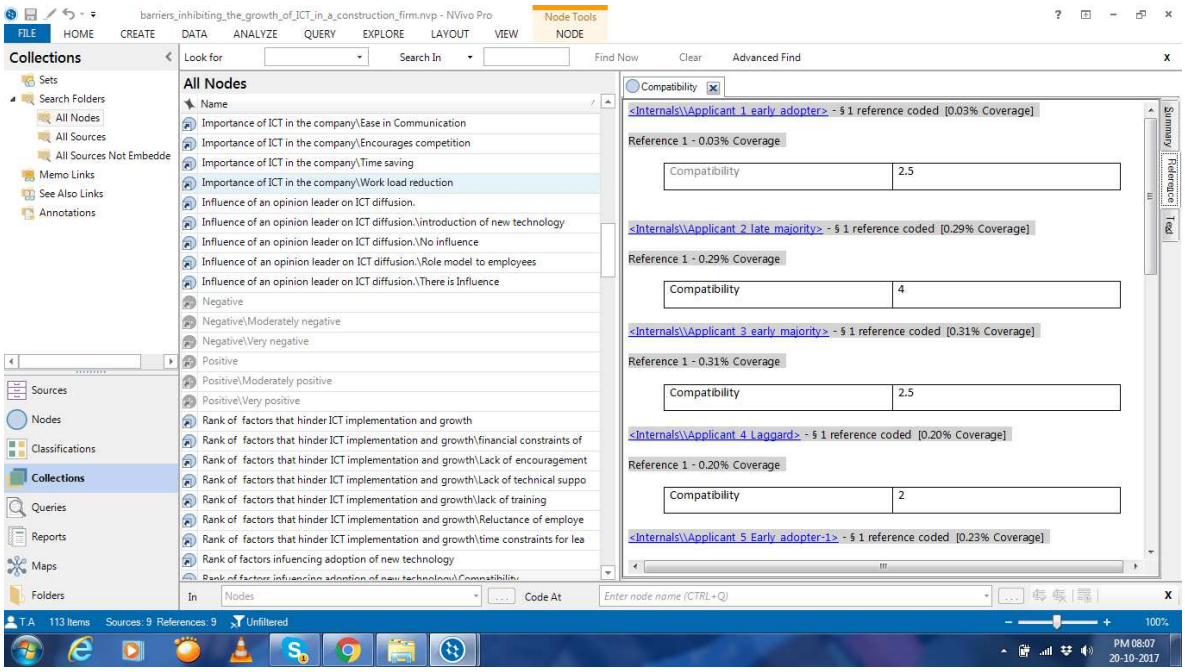
    [Taken from: Morton, C. (2009). *Evaluating collaborative planning: A case study of the morice land and resource management plan [online].Masterresearch project thesis subject to SimonFraser University.* Retrieved 2017, from: http://www.silverhillinstitute.ca/pdf/cedar_morton_final_paper.pdf;

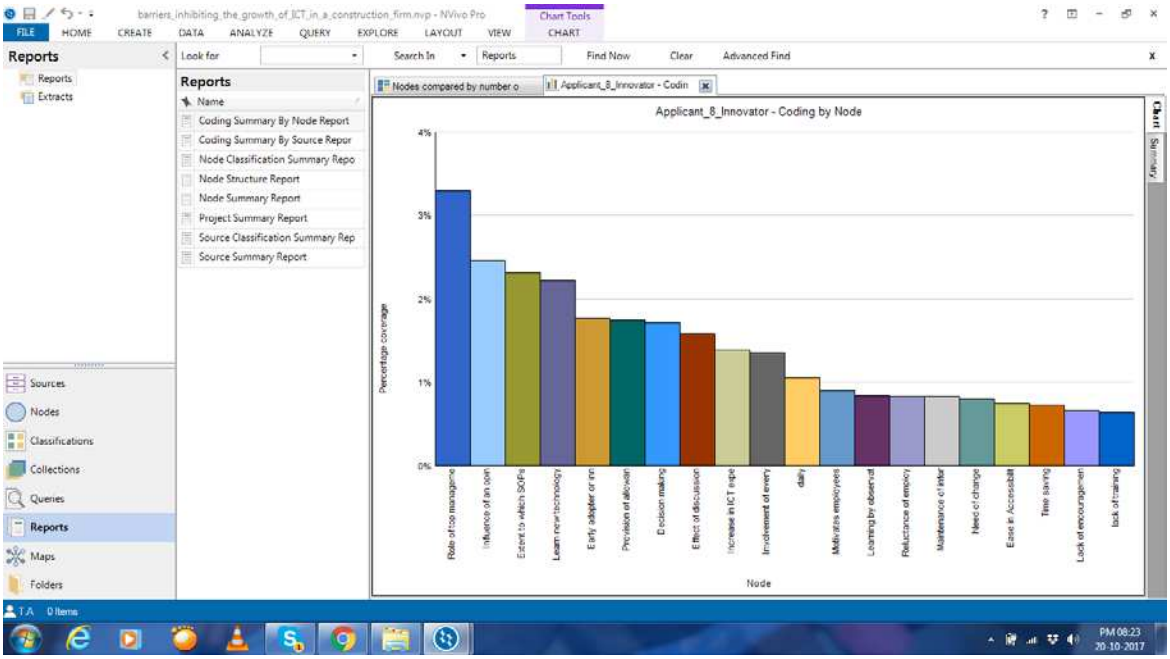
    Shohet, I., & Frydman, S. (2003). Communication patterns in construction at construction manager level. *Journal of Construction Engineering and Management-Asce; J.Constr.Eng. Manage.-ASCE, 129* (5), 570-577]
20. **On a scale of 1-5, please rate following strategies according to their effectiveness for fostering ICT diffusion in your organization?**

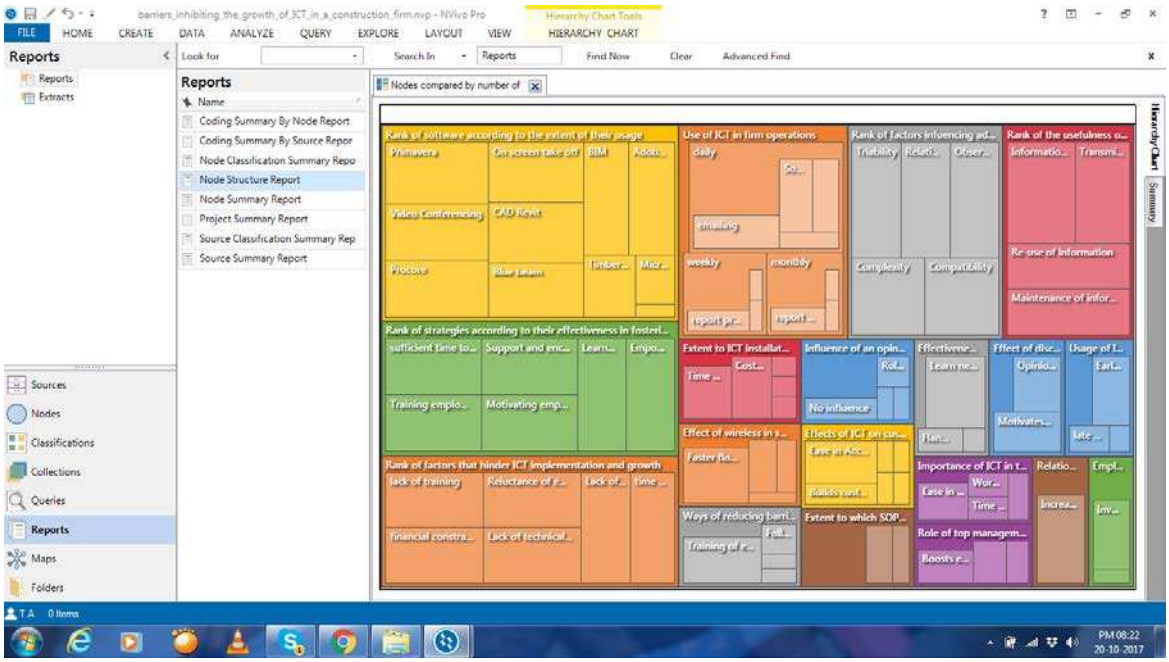
STRATEGIES	Rate (1-5)
Support and encouragement from top management	
Training employees for using ICT tools	
Motivating employees for using ICT tools	
Empowering a champion or opinion leader, who advocates use of ICT in firm and helps staff member overcome their resistance	
Learning by observation (Showing employees how to do it, rather than telling them)	
Giving employees sufficient time to learn using new technologies	

[Taken from: Peansupap, Vachara, & Walker, D. (2005). Exploratory factors influencing information and communication technology diffusion and adoption within Australian construction organizations: a micro analysis. *Construction Innovation*, *5*(3), 135–157; Verburg, R., Bosch-Sijtsema, P., &Vartiainen, M. (2013). Getting it done: Critical success factors for project managers in virtual work settings. *International Journal of Project Management., 31*, 68-79]

APPENDIX E: DATA DISPLAY IN NVIVO






barriers_inhibiting_the_growth_of_ICT_in_a_construction_firm.nvp - NVivo Pro
Hierarchy Chart Tools
FILE
HOME
CREATE
DATA
ANALYZE
QUERY
EXPLORE
LAYOUT
VIEW
HIERARCHY CHART
Reports
Look for
Search In
Reports
Find Now
Clear
Advanced Find
Reports
Extracts
Reports
Name
Coding Summary By Node Report
Coding Summary By Source Repor
Node Classification Summary Repo
Node Structure Report
Node Summary Report
Project Summary Report
Source Classification Summary Rep
Source Summary Report
Nodes compared by number of
Rank of software according to the extent of their usage
Primavera
On-screen take off
BIM
Adobe...
Video Conferencing
CAD Revit
Procore
Raw Learn
Timber...
Micr...
Use of ICT in firm operations
daily
So...
emailing
weekly
monthly
report pr...
report ...
Rank of factors influencing ad...
Triability
Relati...
Obser...
Complexity
Compatibility
Rank of the usefulness o...
Informatio...
Transmi...
Re-use of information
Maintenance of infor...
Rank of strategies according to their effectiveness in fosterl...
sufficient time to...
Support and enc...
Learn...
Empo...
Training emplo...
Motivating emp...
Extent to ICT installat...
Time ...
Cost...
Influence of an opin...
Rol...
No influence
Effectivene...
Learn ne...
Effect of disc...
Opinio...
Motivates...
Usage of I...
Earl...
late ...
Effect of wireless in t...
Faster flo...
Effects of ICT on cus...
Ease in Acc...
Builds cust...
Rank of factors that hinder ICT implementation and growth
lack of training
Reluctance of e...
Lack of...
Time ...
financial constra...
Lack of technical...
Ways of reducing barri...
Fail...
Training of e...
Extent to which SOP...
Importance of ICT in t...
Wor...
Ease in ...
Time ...
Role of top managem...
Boosts e...
Relatio...
Increa...
Empl...
Inv...
Sources
Nodes
Classifications
Collections
Queries
Reports
Maps
Folders
T A
0 Items
HierarchyChart
Summary
PM 08:22
20-10-2017