A CONCEPTUAL FRAMEWORK FOR PROJECT MANAGERS TO IMPROVE PROJECTS PERFORMANCE

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PhD Thesis 2013

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Submitted in Partial Fulfilment of the Requirements of the Degree of Doctor of Philosophy, July 2013

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Acknowledgments

This research is dedicated to those people who supported me in committing to writing up my research. In particular, I would like to specially thank my Family (Theodora, Theodoro and Angelina), my supervisors, Professor Terrence Fernando and Professor Mike Kagioglou, Professor Vian Ahmed and Jesus's Mother Maria (Zoodoxou Pigi) for their continuing support all these years. From the depth of my heart, God bless you all!

In addition I would like to thank my good friends and colleagues for their support all these years: Athanasio Bistola, Christo Papadopoulo, Chisto Anagnostopoulo, Professor Ari Syntheto, Dr Yianni Polychronaki, Dr Apostolo Antonacopoulo, Dr Georgio Papoulaki, Colin Piddington, Dr Elia Economou, Dr Ioanni Moraitaki, Matar Alzahmi, Andy Turner, Hanneke Van Dijk, Erika Kenyon, Professor Ghassan Aouad Dr Dimitrio Tsouka, Dr Athanasio Tsouka and Chetan Narsih. I wish you all every success.

Special thanks are due to the European funded CoSpaces project for supporting this PhD research and my mentors: Professor Georgio Giagli, Professor Christos Makri and Professor Antoni Simintira.

Declaration

I declare that the research contained in this thesis was solely carried out by me. It has not been previously submitted to this or any other institute for the award of a degree or any other qualification.

Abstract

The Architecture, Engineering and Construction (AEC) sector often encounters difficulties in attaining satisfactory project performance. The secondary data in this research (literature review) clearly shows that an inability to pre-identify problems leads to projects becoming ‘risky’. This can be due to a lack of meeting certain project targets, i.e., a lack of predicting ‘accurate’ project time and costs, a failure to raise the project’s quality issues and failures in predicting a project’s return on investment. In addition, it has been shown that a major lack of anticipating problems within a construction project can occur because of a lack of providing accurate data/information and a lack of team collaboration between project stakeholders. Much research has been conducted in order to anticipate construction project problems and to attempt to offer technological solutions, including information maturity models. However, in spite of all this, research projects still run into risks.

Therefore, this thesis aims to investigate a conceptual framework to support construction project managers in order to enhance project performance. This conceptual framework brings together three main entities: Integrated Collaborative Technologies, Team Collaboration and Proactive Behaviour. These three notable entities are used to support project managers’ strategies in order to successfully fulfil the project. In order for this to be achieved the researcher has met the following objectives: an investigation as to how proactive behaviour impacts on the progress of construction projects, an investigation into how team collaboration relates to proactive behaviour and an investigation into how team collaboration and integrated collaborative technologies can support proactive behaviour.

The research design includes primary mixed data analysis and secondary data analysis from the literature review. In order to gather data, semi-structured interviews and a questionnaire have been undertaken by the researcher. The proposed conceptual framework was tested by asking professional experts whether the proposed framework was applicable within a construction project environment. The research shows that there is a relationship between integrated collaborative technologies and team collaboration, and team collaboration and proactive behaviour, and hence these factors impact on project performance. Moreover it has been proved that, in order to

achieve a successful outcome, a project requires stakeholders to learn how to collaborate with the support of integrated collaborative technologies. Throughout this 'iterative process' construction project managers can enhance their proactive behaviour at an individual level and thus can enhance their ability to pre-identify construction related problems. Arguably, this behavioural change will impact positively on project performance indicators.

Chapter 1 – Introduction

1.1.Motivation

The Architecture, Engineering and Construction (AEC) sector often encounters difficulties in achieving satisfactory project performance. Atkinson et al. (1997) states that successful construction project performance is achieved when stakeholders meet their requirements, individually and collectively. Project performance consists of indicators that help to measure project and organisational performance.

The Chair of the Construction Task Force, Sir John Egan (1998), in his 'Rethinking Construction Report' to the then Deputy Prime Minister John Prescott, identifies 10 parameters for benchmarking projects in order to achieve a good performance: construction cost; construction time; defects; client satisfaction with the product and service; profitability and productivity; promotion of result-orientated thinking; predictability of both design and construction cost and time; and health and safety. Since the year 2000 records on construction project performance have existed in the Department of Business Innovation and Skills. In the latest report (2012 edition) it is noted that there has been a significant improvement in project performance, although profitability has fallen to 2.7% - in contrast to the 9.9% recorded in 2009. In addition the report shows that there are still difficulties in predicting time, cost and profits.

Despite the reality of the construction industry's performance during the last decade, researchers in the academic world are trying to analyse the relevant factors and to understand how this environment could be significantly improved. Koskela (2002) states that the deficiencies in a construction project are, amongst others, poor investigation of **customer requirements** at the outset; the process of **requirement clarification and change** leading to disruption in the progress of the project, which starts to drift from the plan; tasks begun **without all inputs and prerequisites at hand**, leading to decreased efficiency or task interruption and; the **performance** baseline becoming counterproductive. In addition to the above challenges, the National Audit Office and the Office of Government Commerce in the United Kingdom (2005) has identified common causes of project failure: lack of clear links between the project and the organisation's key strategic priorities; lack of effective engagement; lack of skills and proven approach to project management and risk management; too little attention paid to breaking development and implementation into manageable steps; evaluation of proposals driven by price rather than price and quality; lack of understanding of project and client requirement; lack of contact with the supply industry and lack of effective project team integration. More recently, the Frederic Deposit Insurance Cooperation mentioned that construction projects often fail because of one or more of the following five reasons: poor planning; lack of leadership; inadequate knowledge, people problems and lifecycle problems. The challenges, therefore, relate to the skills and behaviour of team stakeholders and their access to information.

During the last two decades software solutions have been introduced to construction stakeholders with the intention of eliminating and controlling all of the above challenges. The most recent is the development of Integrated Collaborative Technologies. In the construction sector the current state-of-the-art is Building Information Modelling (BIM). (BIM) is a process of generating and managing building data during the project life cycle (Lee et al., 2006). Eastman (2009) gave a better understanding of the philosophy of BIM:

> "*BIM involves representing a design as objects – vague and undefined, generic or product-specific, solid shapes or void-space oriented (like the shape of a room), that carry their geometry, relations and attributes. BIM design tools allow for extracting different views from a building model for drawing production and other uses. These different views are automatically consistent – in the sense that the objects are all of a consistent size, location, specification – since each object instance is defined only once, just as in reality. Drawing consistency eliminates many errors."*

Typically BIM uses three-dimensional, real-time dynamic building modelling software in order to increase productivity in building design and construction. In addition to this the process produces the Building Information Model, which includes *spatial relationships; building geometry; geographic information; and quantities as well as properties of building components.* Eastman (2009) believed that this method of management is more practical and efficient:

> "d*ue to elimination of many of the uncertainties found during the construction phase since they can be found during the design phase of the project and fixed so they do not occur during the actual construction phase. Also, any changes during construction will be automatically updated to BIM and those changes will be made in the model."*

Current pilot practices of BIM in construction projects in the United States of America (USA), France and Australia have shown competitive advantages for all project stakeholders in both project and organisational environments. The American Institute of Steel Construction (2012) found that, amongst others, the following are highly beneficial: improved visualisation, embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering, improved productivity due to easy retrieval of information, increased speed of delivery, increased coordination of construction documents and reduced project costs. Hence, in May 2011, the United Kingdom Government decided that all construction projects with a budget exceeding £5M must use BIM by 2016, with the aim of controlling and improving project performance. However, the biggest challenge according to the latest Key Performance Indicators (KPIs) report is the need to predict 'accurate' time and cost, to raise quality issues and to predict return on investment (ROI) where profit has significantly fallen (2012). These four sub-indicators impact the progress of the project life cycle and consequently reflect on companies' viability. The challenge, therefore, is not only to share and access information but also to understand how to gather this information in order to predict more "accurately" the project indicators that will impact on construction project progress.

Trends or facts from the manufacturing industry have been transferred and observed within the construction industry. Parker et al. (2006) believed that, in order to predict performance indicators, including uncertainties and consequences, in manufacturing projects, "proactive behaviour" should be enabled and developed for product/project managers, which would, in turn, impact on production progress. In the same research paper proactive behaviour antecedents were captured: flexible role orientation; co-worker trust; job autonomy; control appraisal, proactive personality; change orientation and supportive supervision. It was shown that the more product/project managers develop these antecedents, the more proactively they can behave.

Summing up from the above, it can be seen that integrated collaborative technologies, team collaboration and proactive behaviour can be instrumental in achieving better project performance KPIs. This research aims to explore the interrelationships between these elements and to investigate how integrated collaborative technologies can support team collaboration, how team collaboration relates to proactive behaviour; and how proactive behaviour impacts on the progress of construction projects. In order to illustrate these relationships a conceptual framework is proposed as presented in Figure 1.1.

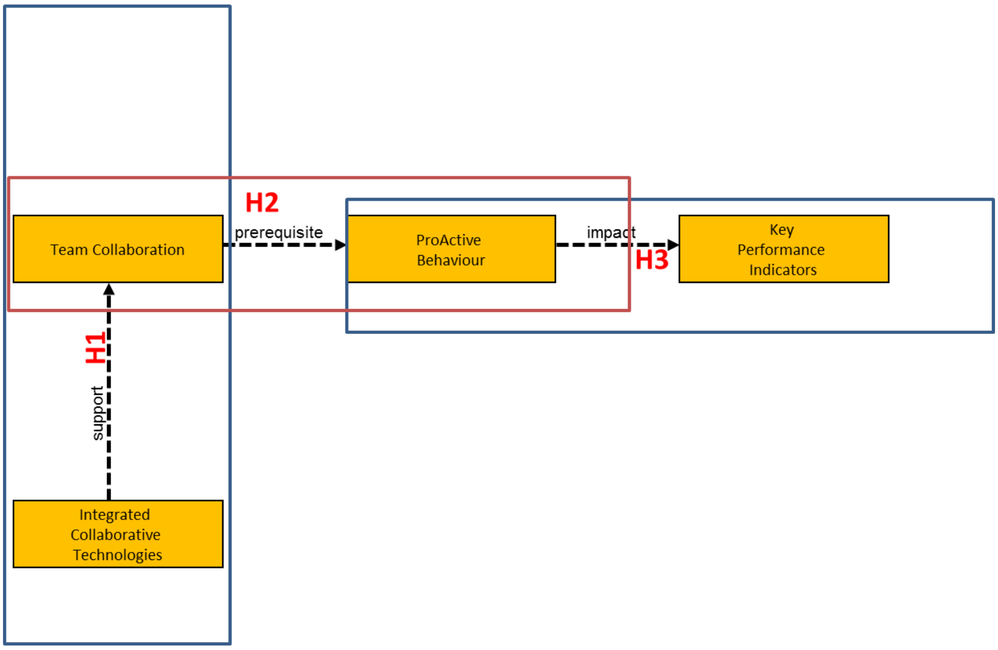


Figure 1.1. Illustration of research relationships

1.2. Research Aim and Objectives

The **aim** of this research is to test the relationships is illustrated in the conceptual framework as is presented in figure 1.1. Specifically, this research aims to investigate whether team collaboration and integrated collaborative technologies support proactive behaviour which subsequently leads to increased efficiency and effectiveness in construction project performance.

The research **objectives** are listed below:

- To investigate if integrated collaborative technologies impact on team collaboration
- To investigate how team collaboration could impact on proactive behaviour
- To investigate if proactive behaviour impacts on project performance

The scope of the research within the broad project management life cycle (PMLC) focuses on the design, schedule and construction phase of a project.

1.3. Contribution to Knowledge

The main contribution of this research is in enhancing the understanding of the relationships between integrated collaborative technologies, team collaboration, proactive behaviour and project performance. This research has made assumptions that integrated collaborative technologies can enhance team collaboration, that team collaboration can enhance proactive behaviour and that proactive behaviour can consequently enhance project performance. It has tested these assumptions and elaborated the fundamental characteristics of team collaboration, proactive behaviour and project performance to explain their impact on project performance.

Elaboration of the basic features of collaboration, proactive behaviour and project performance provided the author with a conceptual framework that illustrates how various features could lead to the enhancement of project performance. The research conducted also validated the "strength of influence" of these characteristics as well as answered the question of "how" these features could lead to proactive behaviour and project performance. This research captures the subjective view of many experienced project managers and provides a conceptual framework that can be used by project managers to deploy the various key characteristics, identified, enhancing their proactive behaviour and leading to improved project performance.

Moreover, the development of a collaborative culture in a construction project is a further contribution to knowledge. This culture presents the main features of integrated collaborative technologies, collaboration, proactive behaviour and performance indicators, including the interrelationships between them. Hence, the developed collaborative culture could be incorporated in existing construction projects with the aim of enhancing their project performance.

1.4.Thesis Structure

The thesis is organised into 7 chapters, as illustrated in Figure 1.2. **Chapter 1** explains the research problem, and gives the research questions, aim and objectives, including the PhD thesis structure. **Chapter 2** discusses the secondary data of this research: construction project managers, team collaboration in construction projects, proactive project managers and the state-of-the-art in integrated collaborative technologies. **Chapter 3** contains the research design and methodology to be followed in order for the data to be scientifically correct. **Chapters 4, 5 and 6** consist of the primary and secondary research data analysis. In particular, in Chapter 4 the strength of integrated collaborative technologies in supporting construction project team collaboration is tested. In **Chapter 5** the strength of team collaboration and proactive behaviour is tested. In **Chapter 6** the strength of integrated collaborative technologies in construction project team collaboration is tested. **Chapter 7** includes the research assessment, the contribution to knowledge, impact and future work. References and appendices relevant to the research can be found at the end of this chapter.

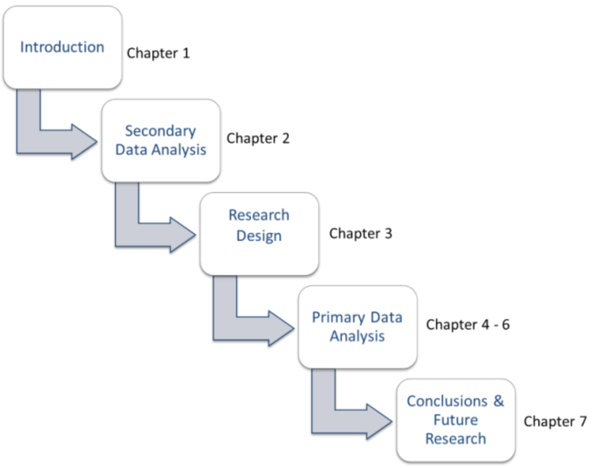


Figure 1.2. Research Structure

1.5.Summary

This chapter introduces the foundation and motivation (research problem) for this PhD research, as well as the aim and objectives of the research. In addition, the structure of the thesis is outlined. In the next chapter, the discussion of the secondary data will be outlined in detail.

Chapter 2 - Literature Review

2.1. Management of Construction Projects

Academics and industry experts attempt to define what project management is from different points of view. Meredith et al. (2012, 2006) defined Project Management from a managerial approach, whilst Kerzner (2006) identified project management as oriented processes similar to the traditional project management methods such as PMBoK introduced by the Project Management Institute. Another opinion comes from Morris (1994) who argued that if a manager wants to manage a project efficiently and effectively, a human centric approach should be adopted, while Shenhar (2004) and Stacey (2007) saw project management as a strategic approach. At the same time Koskela (2002) believed that the current definitions of project management are obsolete, while Morris et al. (2006) believed that there is not yet an adequate definition (Morris et al., 2006). It would appear from the above that, at the very least, the definition is incomplete.

According to Kerzner (2006) and Egbu (1999) a project manager should bring together three principles: *responsibility, accountability and authority*. They argue that the project manager has the responsibility to collect specific resources (capital, materials, equipment, facilities, information, and personnel) as inputs in order to achieve the outputs effectively and efficiently (Morris et al., 2006). The weak link, as identified by Baron and Besanko (1984), is between information, control and organisational management, with this weak link acting as a barrier to the achievement of set objectives. As a result a project manager cannot be accountable, which leads to the lack of trust between team members. Arguably, the communication link between team members (stakeholders) is not efficient and effective, and consequently this affects the decision making and management (process) control within a project and an organisation (Williams et al., 2004).

Foucault (1980:154) states that, *'control is the power exercised by the virtue of things being known and people being seen'*. In the construction sector project management operates under the same principle, i.e., the need of a project manager to control a project or a process due to the thirst for power. Thomas (2006:92) suggested that project management increases process control during the progress of a work/task (Project Life Cycle – PLC) and subsequently over the people who are involved as a part of the project life cycle. Henceforth, this situation affects how the group of people work together collaboratively. This team collaboration impacts on internal communication and thus on the project life cycle performance or project performance (the key performance indicators, introduced by the United Kingdom Government in 2000).

Team collaboration aims to bridge communication gaps within a team. Communication requires access to data, information and knowledge in order to assist humans in making efficient decisions. These are the principles of the hierarchy of human understanding as required by Tuomi (2000). As a result a team has to have access to data, information and knowledge. This access to data and information mainly helps project managers to enhance their knowledge in terms of pre–identifying, understanding and dealing with problems. For this reason, project managers focus on and invest in capital and time in the conceptual phase of a project (Dinsmore, 2006; Morris 2005). As a result construction companies estimate that a problem solution in the later phases of a project can cost 10 times more to rectify than when identified earlier (KPI, 2011). Therefore, the need to pre-identify problems is a major priority in the construction sector.

During the last two decades information and communication technologies (ICTs) have played a significant role in helping construction project managers to pre-identify construction projects. The state-of-the-art is collaborative technologies that allow team members to enhance team collaboration by sharing data and information between construction project stakeholders. Building information modelling (BIM) is collaborative technology that can support sharing documentation, files, and drawings in 3D/4D/5D dimensions interactively between the stakeholders (Kiviniemi, 2010). The biggest challenge, however, is to use integrated collaborative technologies to fulfil the need of project managers to gather data and information from other systems, e.g. Enterprise Resource Planning Systems (ERPs). In these systems the following records can be saved and gathered at any time: project management accounting, project human resources, project financial resources, project information flow, project supply chain, etc. (Hosein, 2004). This is the aim of the BIM Strategy, Level 3, published by the BIM Task Group in March 2011, which helps all stakeholder members to be involved at an early stage so as to design the project according to the client's requirements with the project manager being in control.

Arguably, there is a need to identify a model/framework that could support construction project managers to enhance project performance by using these integrated collaborative technologies. However, before this can be discussed further, it is vital to understand the role of a construction project manager and what he/she requires in order to satisfy project performance.

2.2. Construction Project Managers' Roles

In order to focus on successful project management a number of key behavioural factors have emerged. Slevin & Pinto (2008) identify 12 factors that are crucial in impacting on the behavioural issues relating to project management. These state-of-the-art factors range from micro (individual) issues to more macro (organisational) issues and, due to the increasing needs of new businesses, create a challenging environment. As a result of the state-of-the-art analysis of project management, it is evident that there is no activity which addresses the impact of globalisation, which has little control over the lower levels of resources and relies on inter-organisational trust. The 12 factors mentioned above are listed in table 2.1. For further information see Appendix I.

KEY BEHAVIOURAL FACTORS			
		Twelve Key Behavioural Factors for Successful Projects	Definitions
MICRO	1.	Personal Characteristics	It has been suggested for some time that project management skills are closely related to key general management skills. The 12 dimensions are: planning and organising, technical and professional knowledge, oral communications, listening, written communication, sensitivity, group leadership, job motivation, analysis, judgments, and initiative.
	2.	Self–Motivation	The project manager must be a motivational genius. He/she must have a high level of self-motivation and also be quite skilful at motivating the project team, often under situations of inefficient resources, low team member commitment and morale, and formal authority.
	3.	Leadership	Leadership is crucial for effective project management in terms of team building and its control across the varying phases of the project life cycle.
	4.	Communication	Every time information is exchanged, time is expended and project resources are consumed. Communication of a project vision to all affected stakeholders can be a tremendously important step in the process.
	5.	Staffing	Careful staffing of an organisation has long been known as a secret to success.
	6.	Cross–functional Cooperation	Most projects require a team that includes members of different functional groups with diverse backgrounds. Cultural barriers, both geographical and disciplinary, make it extremely difficult to achieve cross–

			functional cooperation.
MACRO	7.	Project Teams	Organisations of the future will increasingly rely on project teams for business success.
	8.	Virtual Teams	Project management is utilising distributed teams comprising individuals who may directly interact with each other.
	9.	Human Resources Policies	The human resource function is being designed more carefully to expedite project team development and for staffing major processes concerning project human resources management: a) organisational planning b) staff acquisition, and c) team development
	10.	Conflict and Negotiation	Project management is a constant environment of conflict and negotiations. Examples of conflicts happen in organisations that are run on a project base within structures where functional departmental heads retain all control over project resources, requiring project managers to negotiate for their team resources.

Table 2.1. Key Behavioural Factors captured from Pinto and Morris (2009)

What is observed so far is the importance of human contribution to the excellence of a project. Human involvement is the enabler of the successful completion of projects. What makes the difference in enhancing the success of a project is the interaction between humans. This interaction between the project manager and his/her team members is known as team collaboration. According to Montiel-Overall (2005), team collaboration is defined as a repeated process where two or more people or organisations work together in pursuit of joint common goals, i.e., creation in nature by sharing knowledge, learning and building consensus. Most collaboration requires leadership, although the form of leadership can be social within a decentralised and democratic group. In particular, teams that work collaboratively can achieve respect and recompense with different types of resources (i.e., financial). Successful teams are those where collaboration is engaged not only to solve a problem (Greene, 2004) but which is capable of anticipating a problem and thus making efficient decisions (Voiklis, 2009). This engagement is the biggest challenge. In order to validate the above an in-depth analysis of managing construction project challenges will be discussed in the following section.

2.3. Challenges of Managing Construction Projects

The researcher has been influenced by the '*Eye of Competence*', introduced by the International Project Management Association (IPMA) (1999, 2001 and 2006), to analyse construction project management challenges. These challenges are listed below:

- **Technical Challenges (Technological Challenges):** the unstructured process and the transformation of the information among the tasks into the project management life cycle.

- **Human Behavioural Challenges (Social Challenges):** acting as barriers between people communicating during the project management life cycle.

- **Contextual Environment Challenges (Knowledge Challenges):** the non-constructive structure of a project during the design phase of the project - before entering into the project management life cycle.

2.3.1. Analysis of Technological Challenges

So far the importance of linking human skills and technology with the intention of benefitting the management of projects within the organisational context has been widely observed. As a result, at organisational level, the orientation of information needs to be highlighted. Marchand et al. (2001, 2007) suggests that a way to achieve this is with strong **IT practices**, **competent management of information** and good information behaviours and **values**. These three elements must be well-built and function well together in order to achieve business goals and to address information maturity.

2.3.1.1. Information Maturity

Information maturity leads to making more effective and efficient decisions. As regards the hierarchy of human understanding (from Data to Information then to Knowledge and finally Wisdom) learning is enabled as the catalyst for the transfer from information to knowledge and to wisdom and, arguably, to making decisions. Nonaka and Von Krogh (2002) illustrate what is known as the SECI Model (figure 2.1). This model could be useful in enhancing the technical challenges in managing projects more effectively and efficiently as, by resolving and using technical challenges, human behaviour changes.

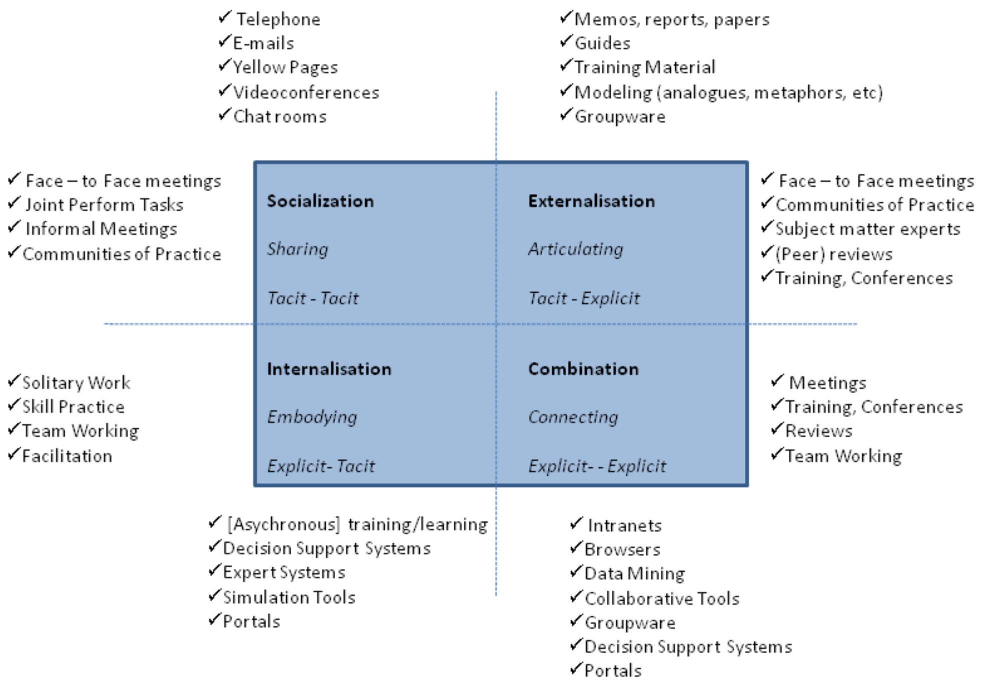


Figure 2.1 Learning and support mechanisms by Nonaka and Von Krogh et al. (2002)

By using this model concept, ideas and facts are easier to be understood by project managers and their clients, stakeholders, suppliers and shareholders during the project and process life cycle. This gives an understanding of knowledge creation, reuse and innovation. As a direct result, the need arises to develop a space in which stakeholders, including the project manager and clients, can share their intellectual capital. ***In this scenario the team's intellectual bandwidth should work as a function not only of the members' capacity to transfer data into wisdom but of their ability to collaborate.***

Considering all the above, with the combination of the five mentioned elements, data, information, knowledge, integrated collaborative technologies and human understanding, changes will occur at both organisational and operational (project) level which reflect interactively all these elements. In particular, collaborative environments work as enablers in order to enhance the information, the human behaviour and the context of a project. At this stage it should be mentioned that the context relates to information. Information is a term with many meanings depending on context (Liu et al., 2004). Thus three elements - information maturity, human behaviour and integrated collaborative technologies – have been used up to this stage. The following figure (2.2) illustrates how these 3 elements interrelate in order to establish an innovative interactive project information maturity "model".

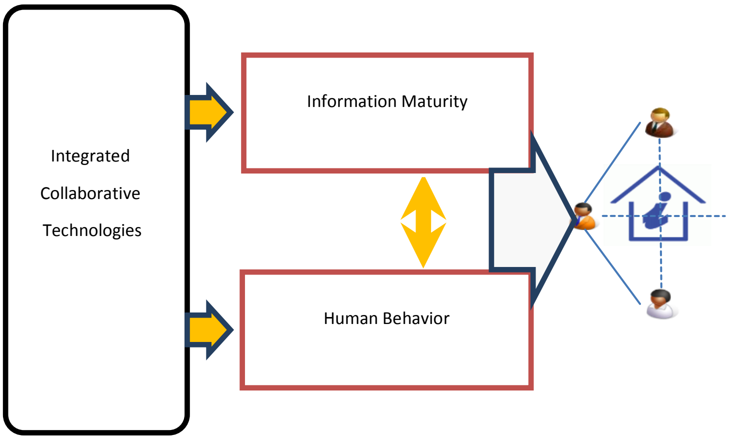


Figure 2.2. Innovative Interactive Project Information Maturity

By using the above interaction the above mentioned changes are taking place in team members' behaviour. This occurs as learning processes are activated so that humans will understand information in a better manner. When humans feel more confident with information and can understand in detail a task of a project, they develop skills such as anticipation, change-orientation and self-initiative (Grant and Ashford, 2008);

these skills enable the team member and the project manager to behave in a more proactive mode (Grant and Ashford, 2008). More will be discussed on the subject of human (social) challenges later.

2.3.1.2. Integrated Collaborative Technologies

In 2002 Wainhouse Research & First Virtual Communication Inc stated that, '*integrated collaboration environments allow enterprises to realise a number of competitive advantages by using their existing computers and network infrastructure for group and personal collaboration. These new fully-featured environments take the best features of both traditional videoconferencing and web collaboration and combine them to enable teams to work together interactively through a browser-based interface'.*

Ibrahim (2011), Steven et al. (2009) and Kiviniemi (2009) mention that integrated collaborative technologies (ICTs) consist of:

- **Collaborative software** designed to improve the performance of teams by supporting the sharing and flow of information. It allows for real-time collaboration and conferencing but also asynchronous collaboration.
- **Workflow systems** facilitate the automation and management of business processes.
- **Documentation management systems** manage a document through all the stages of its processing.
- **Peer-to-peer collaboration software** permits users to communicate in real time and share files without going through a central server.
- **Knowledge management systems** are information technology (IT) systems that support the capture, organization, and distribution of knowledge (know-how).
- **Social network systems** are IT systems that link people to others they know and, from there, to the people their contacts know. They are a way to leverage personal and professional contacts.
- **Collaborative Design** allows project stakeholders to design construction projects either collocated or distributed.

Collaborative tools help facilitate action-oriented teams working together over geographic distances by providing tools that aid communication, collaboration and the process of problem solving. Technology Integration is the use of technology tools in general content areas in businesses in order to allow stakeholders to apply computer and technology skills to learning and problem-solving. Collaboration requires individuals working together in a coordinated fashion, towards a common goal. Arguably Integrated Collaborative Technologies are those tools that can help stakeholders work collectively towards problem solving without considering geographical distance. These technologies could work either in a synchronous (real time) or asynchronous (not real time) manner, so allowing the stakeholders or the team members to share documents or files from anywhere at any time (figure: 2.3.).

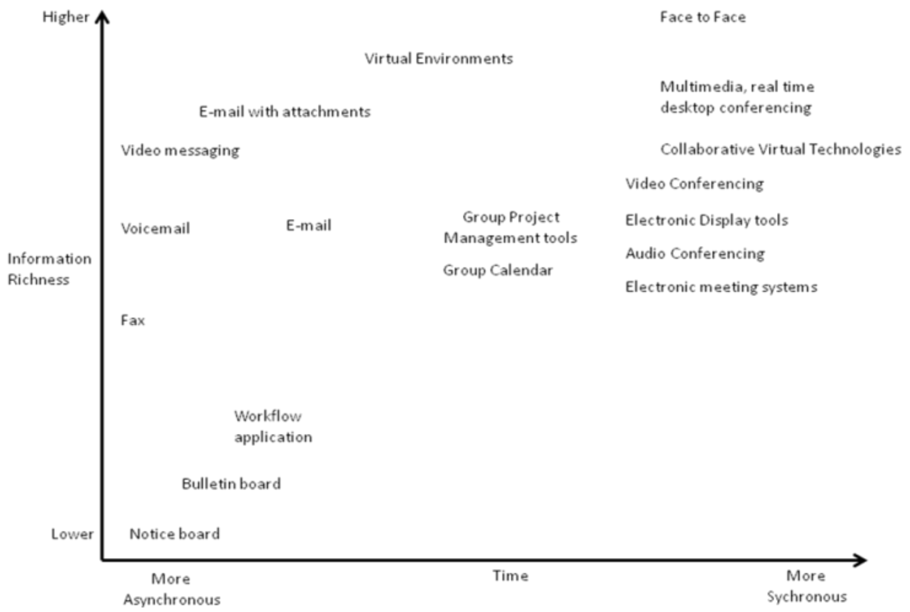


Figure 2.3: Comparing Technologies adapted from D70 (CoSpaces Project, 2010)

There is a great demand to design and deploy integrated collaborative environments within the construction industry and, based on the UK Government Building Information Roadmap (figure 2.4), the implementation of BIM in national industry is “almost” at level 2 and requires to be implemented by 2016 (Philips, 2012). At this level there is a need to use construction commercial data managed by an ERP (Enterprise Resource Planning Systems) and this is where the need for the development of Integrated Collaborative Environments is compulsory.

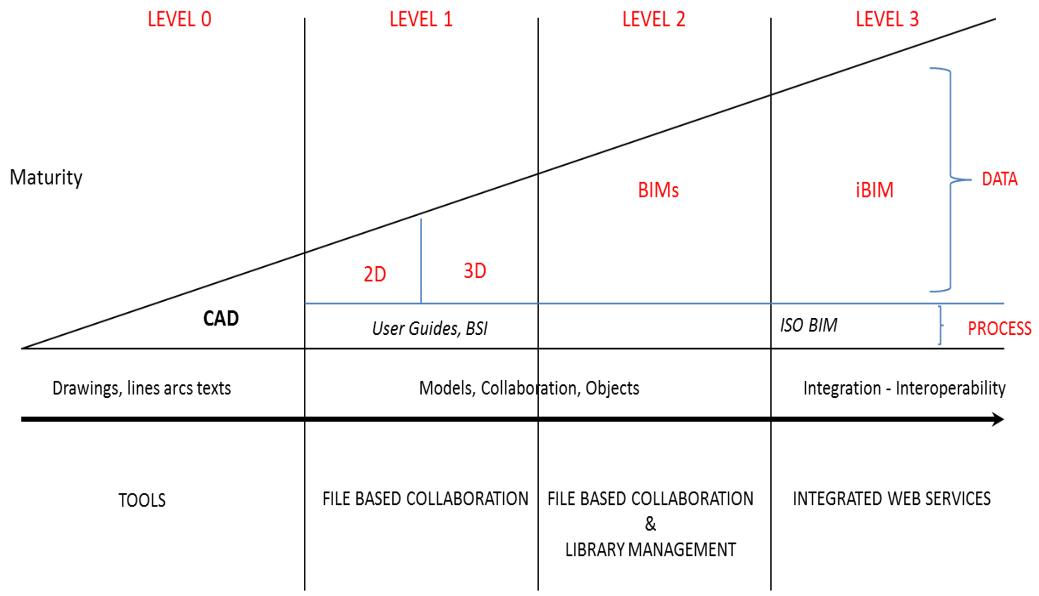


Figure 2.4. Building Information Modelling (BIM) Roadmap adapted by BIM Task Group (2011)

Furthermore, in order to be implemented successfully, BIM requires transition from the traditional management theory to lean management theory.

The statements made by Winch in both his books (2001 and 2010) on Lean Management and BIM in the context of managing construction projects were refuted by Ballard and Koskela (2011) who have the opinion that:

- *Lean construction is a form of bureaucracy, as opposed to the professionalism Winch advocates.*
- *Lean construction has its roots in high-volume lean manufacturing and is thus constrained to "high volume construction", rather than one-off projects.*
- *Lean construction is limited to site construction, and separates designing and making (implementation).*
- *Lean construction is applicable only to slow, simple and certain projects.*
- *Lean construction is limited to the production of standard products.*

Therefore BIM and Lean Management could cooperate when a project manager sees the task as a project and thus will be in a position to reduce the bureaucracy, to separate the design and the implementation stage of a project and to control the project. An additional competitive advantage of BIM and Lean, used in an integrated collaborative environment, are the mechanisms that are developed to focus on trust and relationships between team members (stakeholders).

At this stage the author brings forward some principles and understanding of how BIM and Lean Management benefit a construction project. In particular, Dave (2013) stated primarily that it is at the early project design stage where a project manager can define project value(s) to the client, quickly evaluate alternative solutions, identify procurement strategy and target value design. An additional benefit is to be found in detailed design where team collaboration plays a significant role in supporting collaborative design, constructive feedback, intellectual property rights and clash detection. Nevertheless, a significant consideration is the validation of information from a trusted resource. Construction benefits from the use of Lean and BIM tools and processes lie in the co-location of the supply chain, collaborative production planning using 4D and 5D, and model based prefabrication that helps to achieve the goals of waste minimisation and value retention (and generation). Moreover, the main focus is in avoiding the creation of conflicts and duplication of processes. During construction, it is important to monitor the progress of construction work to compare planned activities with work completed to allow the stakeholders to focus on tasks that have fallen behind schedule (Harty et al., 2010). Facilities and Operation Management benefits are that the BIM process workflow enables the recording and delivery of as-built information which can be linked with facilities management systems and processes. Therefore, two main principles of the above analysis are the deployment of trust and information management.

Suppa (2008) states that development of trust is an integral component of effective teams, successful partnering and implementing new technology. Building and maintaining trust between contracting parties can lower costs, improve performance and minimize disputes. According to Nikas et al., (2007) the construction industry is entering a new era where using technologies can improve collaboration on construction projects. Collaboration is an intended process that creates value beyond communication and is dependent on the trust of the collaborators (Vangen and Huxham, 2003). It is driven by a desire to solve problems, create solutions, or to discover new methods of completing work (Peters and Manz, 2007), as confirmed by primary research. Moreover Nikas et al. (2007) found that collaborative technologies foster collaboration in the construction industry with the intention of improving project management, information management, transaction time, transparency of project information, relationships between partners, communication, schedule, costs and profitability. However, collaborative technologies are not widely used and are perceived as ineffective due to the lack of trust in the technologies and/or the lack of trust between the collaborators (Brown et al., 2004; Panteli and Duncan, 2004; Peters and Manz, 2007). As a result there is a need to change the mind-set of stakeholders in construction projects in a manner which supports and enhances trust between the team members. The following table 2.2. illustrates the factors that could be enhanced through Integrated Collaborative Technologies.

SUCCESS FACTORS USING INTEGRATED COLLABORATIVE TECHNOLOGIES					
	Trust	**Commitment**	**Shared Culture and Language**	**Shared Vision**	**Information Sharing**
Uden and Naaranojia, 2007	X				X
Requi, 2007	X	X			X
Chiu et al., 2006	X	X	X	X	X
Nuntasunti and Bernold, 2006	X				X
Chinowsky and Rojas, 2003	X	X	X	X	X
Davy et al., 2001	X				X
Thorpe and Mead, 2001		X			X

Table 2.2: Success Factors using Integrated Collaborative Technologies

Uden and Naaranojia (2007) state that trust is defined as the willingness of a party to be vulnerable to the action of another party based on the expectation of a favourable outcome. Moreover Chinowsky and Rojas (2003) stated that collaboration is defined as synchronous discussion with the ability to exchange project information and real time data manipulation and exchange. Commitment is defined as the participation and follow-through of a project team (Thorpe and Mead, 2001) where the shared language and culture is the common understanding between team members, allowing them to gain access to the information they require (Chiu et al., 2006). The same authors in the same article state that shared vision is a bonding mechanism that helps different team members focus their resources on common goals. Thus integrated collaborative technologies assist project stakeholders in achieving the above features towards attaining a common goal.

Hence it is clear that the use of integrated collaborative technologies in construction projects could potentially benefit all project stakeholders in encouraging sharing and trust by being collaborative and consequently proactive.

2.3.2. Analysis of Behavioural Challenges

This section discusses the two main behavioural challenges that arose in the previous section 2.3.1: team collaboration and proactive behaviour within the construction sector.

2.3.2.1. Team Collaboration in construction projects

Research into collaboration spans a number of disparate fields such as organisational and social psychology, human factors, computer science, management science, education, and healthcare. In March 2009 the University of Nottingham, a partner in the European Funded project CoSpaces, published the attributes which influence and form part of collaborative work as well as developing an explanatory, descriptive model in order to enable a unified understanding of what it is to collaborate, and how best to communicate this to industry and to support collaborative work based on this understanding.

The technique/method followed to check the validity of this research was semi-structured interviews with the CoSpaces user partners, and through drawing on the broad experience of working with a range of industrial organisations. The main factors (individuals, teams, interaction processes, tasks, support, context and overarching factors) and sub-factors (with supporting references) give an overview of their relevance and importance to collaborative work. In addition, in order to assess how meaningful the factors in the model are, a series of card sorting exercises with human factors experts took place. This study showed that there was general agreement on the main factors proposed for the model of collaboration. Moreover, groups of human factors experts were also asked to review the 27 different representational styles for a model of collaborative work which incorporated the factors that had been considered during the card sort. The outcome of this research is illustrated in figure 2.5.

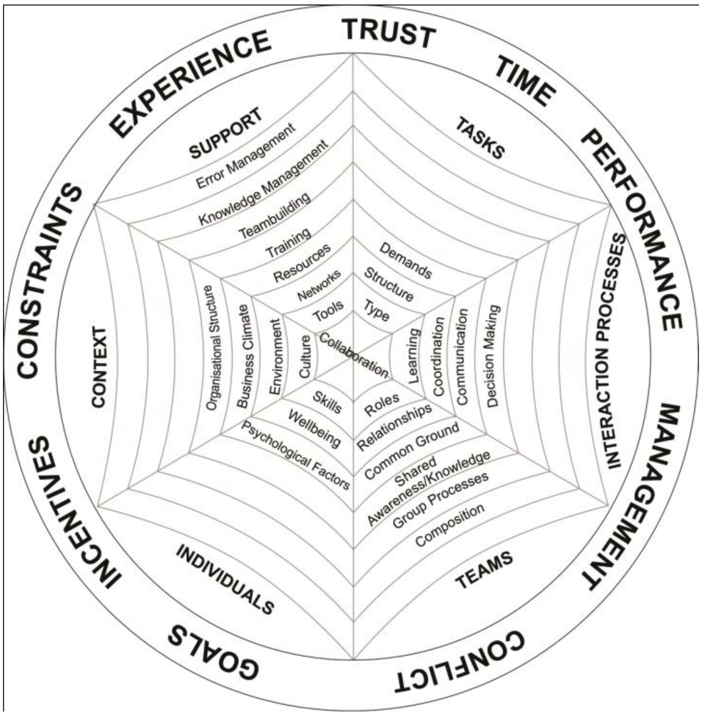


Figure 2.5.: Team collaboration model adopted by Patelli et al. (2012)

In particular, the external factors that influence building collaboration in a business environment and in a project are: trust, time, performance, management, conflict, goals, incentives, constraints and experience (Table 2.3).

EXTERNAL FACTORS OF TEAM COLLABORATION	
FACTORS	**DESCRIPTION**
Trust	Trust aims to engage and enable people in business with each other. Trust and willingness to communicate and share information openly indicate collaboration. Face to face communication is most important in building and boosting trust amongst colleagues, including social interactions and regular communication.
Time	In a business environment time is crucial due to the nature of helping to organise and structure how teams work, its influence on the team climate (motivation) and the quality of individuals' experiences. Deadlines exist in order to help to structure work and time pressure and make employees work effectively. In addition, real time contribution to a team process can lead to team prosperity.
Performance	Within the performance factor the following activities should be included: perspective including keeping to project budgets and deadlines, profits, time saved, meeting or improving the required quantity and quality of product/service, improving work processes, innovation, achieving goals, meeting requirements, improving relationships, extending professional networks, generating new business, learning, individual and team satisfaction and wellbeing, improving trust and commitment, reducing errors, high level of safety, absenteeism and staff turnover.

Management	Management requires improved work productivity, team effectiveness, employee satisfaction, clear direction and guidance to individuals and teams, and communication of any necessary constraints on team behaviour. In the project management world management consists of setting communication goals and objectives, forming and maintaining teams, planning tasks, assigning tasks, setting deadlines, monitoring status of tasks and resources, ensuring that the work delivered is of the required quality and performance and within the allotted budget and timeframe, monitoring and reviewing changes in the environment and adapting the team, objectives, tasks, processes and strategies as necessary, setting performance expectations, providing feedback on individual and team performance, coaching the team, creating a positive working atmosphere, and managing conflict.
Conflict	Conflict results when there is an incompatibility between people's values. However, conflict may have a positive impact due to the nature of causing people to be creative due to the wider discussion and understanding of issues and alternatives as well as increasing participation in work and effective decision making.
Goals	Goals aim to present a clear understanding of task and organisational objectives. and employees should be aware of any changes in priorities over time. In a modern business environment it is key for a group of people to work collaboratively in order to satisfy company objectives and aims.
Incentives	The benefit of developing incentives in a

	business/project environment may include financial rewards, recognition of contributions to work, enhancing visibility or improving status within the workplace, more/shared responsibility, shared risks, interesting work, reduction of workload, building professional and personal relationships with others, and the satisfaction of having achieved something.
Constraints	Constraints in a business or project can be: at an individual and team level; at a process and task level; resources including finance, personnel and materials; culture and barriers such as hierarchy.
Experience	Experience involves individual, team and organisational familiarity with the business and with project process, tasks and technologies. Experience matters in making effective and efficient decisions as well as in helping employees to predict each other's behaviour with the intention of reducing the demand in communication and workload.

Table 2.3: External factors of collaboration at work

The internal factors influencing the building of collaboration in a business are: teams, individuals, context, support, tasks and interaction processes (Table 2.4). In order for external and internal factors to be applied during the project management life cycle a number of different activities, behaviours and skills have to be developed.

INTERNAL FACTORS OF TEAM COLLABORATION	
FACTORS	**DESCRIPTION**
Tasks	Types of task must be identified in term of scope, demands, strategies and communication. Task structure involving collective activities require input from multiple individuals simultaneously or frequent interaction between individuals or teams. There are tasks which require input coordination and communication, the effectiveness of which will impact on productivity. Tasks differ in the demand they make on individuals, teams and processes which, in turn, impact on employee wellbeing and productivity.
Interaction process	The key actions and behaviours across the interaction process lead to the learning that incorporates the development and improvement of new skills, to new knowledge to satisfy team task performance, to being flexible and dynamic, and to improving the quality of working life. In addition to this, coordination assists in meeting goal settings, managing and integrating people and information, setting and managing time schedules and planning and managing divisions. Communication as an additional behaviour enables people to understand the nature of a problem coherently and to share information synchronously or asynchronously. Furthermore, the decision making process as an action involves both intellectual and judgmental tasks influencing team outcomes.
Teams	Team relationships refer to group dynamics, interpersonal cohesion, task cohesion, professional, social and personal relationships within the team where effective collaboration

	is facilitated in part by teams. Knowledge/shared awareness is held in common across a group, allowing team members to work together effectively. The common ground of interest or values, shared cultures and a shared understanding of practices impact on setting a team. Group process incorporates the understanding of group behaviour in terms of communication, influence, effectiveness and decision making. Moreover the composition of a team plays a vital role in establishing collaboration by considering heterogeneity (age, gender, ethnicity, background, etc) and size (the optimum number of team members is 6-8).
Individuals	The individual factor requires the contribution of people's skills, knowledge and experiences. In addition, wellbeing (physical and mental) is both an input and an output for collaborative work success. Moreover the psychological factors of individuals (i.e., needs, biases, perception, mood, motivation, attitudes) impact on collaboration.
Context	Context-wise culture can be that of the team, organisation or both. It comprises the beliefs and values shared by employees which impact on employee behaviour and morale. The environment constitutes the physical space in which individuals and teams work, including the socio-cultural aspects of the workplace. The business stability affects the business opportunities available and thus the team's and organisation's effectiveness. The organisational structure impacts on the foundation, structure and boundaries of formal and informal roles, tasks, processes, policies, culture and norms, power, trust and learning.

Support	Support for collaboration requires the involvement of tools that will support synchronous and asynchronous communication between the team members. These tools can reduce the social distances between distributed team members. Tools enhance the role of the control of communication in a task and help the message flow, while personal and professional networks can provide a forum for the discussion ofan idea/ideas. Indeed, e- resources and the management of them add value to collaboration due to the nature of better task performance. In addition to this, as part of the collaboration process, training is vital due to the enhancement of productivity and employment satisfaction. Team building activities can help team members to develop skills, boost morale, improve motivation, improve cohesiveness and increase commitment. In order to secure the enormous collaboration process between team members, knowledge capture, structure, transfer, storage, availability and utilisation is required as necessary.

Table 2.4: Internal factors of collaboration at work

The above analysis was based on an examination of the literature available on this topic. A further discussion on this is presented below.

INDIVIDUALS

Collaboration is fundamentally a social activity, requiring interaction between two or more individuals. However, it is inevitable that some degree of effort remains at the level of the individual. Individual performance – social and technical – is crucial in the performance of teams (Brna, 1998; Fischer et al., 2005; Fasel, 2001; Harvey and Koubek, 2000). The first factor in this study's model of collaboration is, therefore, individuals. Skills (Hockey, 1996; Stammers 1996; Bornemann et al., 2003; Johnson and Hyde, 2003; Salas et al., 2005a.), wellbeing (Hockey 1996; O'Driscoll and Cooper 1996; Warr 1996a; Tyndale 2003; Van Fenema, 2005; Kyzlinková et al., 2007) and psychological factors (Steiner, 1972; Norman 1980; Folkard, 1996; Harvey and Koubek, 2000; Fasel, 2001; Marttiin et al., 2002, Wilson et al., 2003, Montiel-Overall, 2005, Salas et al., 2005a; Beddoes-Jones and Miller, 2007) play a significant role in the deployment of making someone work individually, efficiently and effectively. Due to the nature of individuals, they bring their own set of skills, knowledge (declarative, procedural, explicit and tacit) and experiences to the working environment. Wellbeing includes physical and mental aspects, where both input and output are useful for collaborative success. Teamwork has been associated with improved employee wellbeing as well as motivating and encouraging hard work. The psychological characteristics of individuals include needs, biases, confidence, motivation, information processing, thinking style, culture, mental workload and behaviour.

TEAMS

Collaboration involves interaction between two or more individuals. Teams have a specified organisational function and contribute to organisational objectives. Teams are made up of individuals engaging in shared tasks with a common goal. For this study's purposes, team work covers individuals involved in collective tasks and also individuals involved in interdependent tasks which are subsequently integrated, both as part of intra- and inter-group collaboration (Bratman, 1992; McNeese et al., 2000; Roger and Ellis, 1994; Schrage, 1990; Shea and Guzzo, 1987; Sundstrom, 1999; Unsworth and West, 2000; Warner et al., 2003; West, 1996). Katzenbach and Smith (1994) defined teams as 'a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable'. Therefore, a team consists of roles (where each team member has specific responsibilities); relationships (this refers to group dynamics, interpersonal cohesion, task cohesion including respect and trust between members); shared knowledge (allowing team members to work together effectively, adjusting their activities as necessary through an understanding of colleagues' roles, responsibilities, expertise, skills, limitations, preferences etc.); common ground (refers to the extent to which team members have a shared culture, vocabulary, values or interests, and a shared understanding of working practices and group norms and share information in common); group processes (refers to understanding the behaviour of groups – their patterns of communication, patterns of influence, how they make decisions and their effectiveness); team composition (this refers to team heterogeneity and size).

INTERACTION PROCESSES

Individuals and teams are part of a collaborative state, or working environment, within which they engage in collaborative, interaction processes, e.g. learning, coordination, communication, decision making and so on, in order to complete their tasks and achieve their goals, i.e., the processes by which teams convert their resources into a product or service (Brna, 1998; Steiner, 1972; Weiseth et al., 2006). Steiner (1972) defined process as consisting of "the individual or collective actions of the people who have been assigned a task". Interaction processes consist of: learning (the team-working process inevitably results in learning as individuals within a team can learn from each other and develop new skills, improve existing skills, and increase knowledge simply from team task performance); coordination (refers to setting, managing and integrating people and information, setting and managing time schedules, planning and managing the division of labour across different tasks etc.); team communication (refers to how people understand each other and how information is transferred in organisations) and decision making (involves both intellectual and judgement tasks and influencing team outcomes).

TASKS

Individuals and teams engage in collaborative processes in order to complete tasks to meet defined goals. Task characteristics are identified as a main category of attributes affecting collaboration (Harvey and Koubek, 2000; Warne et al., 2003). Tasks consist of the type of task (routine or non-routine, predictable or unpredictable, complex or simple in nature) and task structure (which should engage all team members, ensure clear, measurable boundaries for the tasks for which the team members are individually and collectively responsible, and avoid unnecessary duplication of work).

SUPPORT

Collaboration within organisations requires effective and appropriate support/organisational support which could make the difference between a successful and an unsuccessful collaboration. Even well designed and managed teams with good people can perform poorly if they are not provided with the management support and resources they require in order to meet their goals, and collaborate with internal and external colleagues and clients as necessary (Hackman,1990; McNeese and Rentsch, 2001; Weiseth et al., 2006). The support factors consist of tools (technologies, e.g., email, conferencing, scheduling tools, information management tools, etc); networks (personal and professional networks can provide a forum for the discussion of ideas and generate awareness of possible collaborations); resources (refers to individuals and teams needing access to adequate resources, i.e., finances, time, physical space, materials, equipment, tools, appropriately skilled personnel, etc.); training (personal and professional development training opportunities are associated with improved productivity and employee satisfaction), team building (refers to those activities that can help individuals and teams to develop team-related skills, boost morale, improve motivation, improve cohesiveness, and increase commitment); knowledge management (refers to individuals and teams requiring access to the knowledge required in order to perform their task) and error management (identification and management of errors and violations which may influence collaboration, productivity and costs).

CONTEXT

Context usually dictates the types of individuals and teams involved in the work and the types of tasks that need to be carried out. It will also influence the type of support that is provided for collaborative work and can have an impact on the actual process of collaboration itself and on team effectiveness. Amongst other contextual factors that impact on the deployment of team collaboration is the organisational structure that relies on the organisational breakdown structure (who is involved) and the work breakdown structure (what is the activity/task to be done, by whom and by when).

The factors and sub-factors of team collaboration within a construction project are listed in the table below:

TEAM COLLABORATION	FACTORS
Individuals	
	Skills
Teams	
	Roles
	Relationships
	Shared Awareness/ Knowledge
	Common ground
	Group processes
	Composition
Interaction Processes	
	Learning
	Coordination
	Communication
	Decision making
Support	
	Tools
	Networks
	Resources
	Knowledge management
	Error Management
Context	
	Organisational structure

Table 2.5. Team Collaboration Factors within the Construction Environment

The above table was used in the research to design the interface of the conceptual framework and to design the survey and the structured interviews.

2.3.2.2. Proactive Construction Project Managers

The social behaviour of employees has a great impact on an organisation's effectiveness within the construction sector. Many aspects of social behaviour are manifested in project managers in interaction with team members. Moreover, working in teams magnifies and intensifies behavioural characteristics as a result of the close encounters that members have with each other, in terms of both formal and informal attitudes, where rapid responses/decisions are required for problem resolution. Proactive behaviour as a social behaviour impacts on project and organisational effectiveness (Bindl, in press) but this research intends to explore and explain how project managers' proactive behaviour could be enhanced in a project.

Crant (2000, p.436) referred to proactive behaviour as, "taking initiative in improving current circumstances; it involves challenging the status quo rather than passively adapting present conditions". Parker, Williams & Turner (2006, p. 636) defined proactive behaviour as "self-initiated and future-oriented action that aims to change and improve the situation or oneself". As it is a relatively new field, there is no precise definition of proactive behaviour and current definitions are somewhat unclear and even contentious. Nevertheless, in recent times, a consensus appears to be emerging as to the definition of proactive behaviour, as suggested in Parker & Collins (2010). Dictionary definitions typically highlight two key elements of proactivity. Firstly, they identify an anticipatory element involving acting in advance of a future situation, such as acting in anticipation of future problems, needs, or changes (Miriam Webster Online Dictionary). Secondly, the definitions emphasize taking control and causing change, for example: "controlling a situation by causing something to happen rather than waiting to respond to it after it happens" (WordNet® 2.0 Princeton University, 2003). Grant & Ashford (2008, p. 13) defined proactive behaviour as "anticipatory action that employees take to impact on themselves and/or their environments". In particular proactive behaviour has three key features:

- It is anticipatory - it involves acting in advance of a future situation, rather than just reacting.
- It is change-oriented - being proactive means taking control and causing something to happen, rather than just adapting to a situation or waiting for something to happen.
- It is self-initiated - the individual does not need to be asked to act, nor do they require detailed instructions.

The dynamic view of managing projects successfully is through enhancing the skills of the project manager in the manner of controlling and making more accurate decisions. What is mainly needed in order to advance the project manager's skills is the capability to interact with the other participants or members of the organisation or project. This interaction enhances the communication and the collaboration and develops the building of trust among the project manager and the participants. What is more, in enhancing and developing the above key elements, the outcome will efficiently and effectively capture partnerships. The result of this attempt is to assist in reducing the degree of complexity in projects. Specifically, regarding trust, Estrin (2008:272) stated that, “innovators must trust themselves, trust the people with whom they work, and trust the people with whom they partner, balancing their progress in an environment that demands both self-doubt and self-confidence”. Communication constitutes conceptualising the processes by which people navigate and assign meaning. Communication is also understood as the exchanging of understanding. Montiel-Overall (2005) defined collaboration as “a trusting relationship between two or more equal participants involved in sharing thinking, shared planning and shared creation”.

Grant and Ashford (2007) supported the belief that, in order to enhance trust, communication and collaboration, the construction of the following skills is required: anticipatory skills, change orientation and self-initiation skills. Henceforth, these skills will lead to the development of proactive behaviour. Therefore, a successful project manager/managers need(s) to be self-initiated, future oriented and anticipative. This behavioural situation will be used as the driving force that will initiate change in the operational and organisational system of a company. **This approach will give an added value to the current state-of-the-art in project management**. The proactivity concept assists project managers to think and act before, during and after a meeting takes place.

Parker et al. (2006) captured and analysed the proactive cognitive model (Figure 2.6). It consists of proactive personality, job autonomy, co-worker trust, supportive supervision, self-efficacy, flexible role orientation (organisational commitment) and control appraisal.

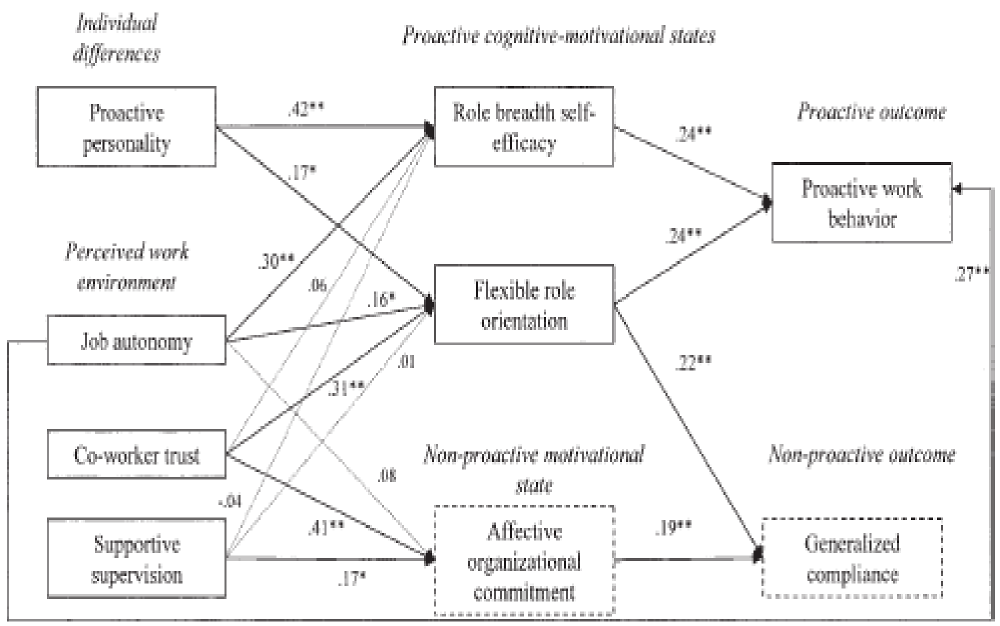


Figure 2.6. Proactive Model illustrated by Parker et al. (2006)

The definition of each of the model's elements is listed below:

- **Flexible role orientation** indicates the extent to which various problems affecting the longer term goals of projects would be of personal concern to an individual rather than to someone else.

- **Co-worker trust** refers to trust among the members of a project team.

- **Self-efficacy** refers to how confident a project manager feels in carrying out a range of proactive, interpersonal and integrative project tasks.

- **Control appraisal** refers to a belief that a project manager can control and have an impact on project outcomes.

- **Change orientation** refers to those project managers that have the intention of initiating/proposing changes in a project/task so as to optimise projects/tasks procedures and or performance(s).

- **Job autonomy** refers to the extent to which the project manager is involved in making decisions within the team.

- **Proactive personality** refers to the relatively stable tendency to identify problems in advance.

- **Supportive supervision** refers to the enhancement of leader effectiveness in a self-management context.

What can be gathered from the above is the need to focus on low project information maturity in order to enhance the progress of a project. The proactive project manager's behaviour aids in developing project information maturity during a meeting. This added value will afford a higher quality of decisions and better control of operational processes before the project start and during the project progress across the Project Life Cycle (PLC). As a result, proactive model antecedents will be used to support the design of the interface of the conceptual framework as well as to design the survey and the structured interviews.

2.3.3. Analysis of Contextual Challenges

Sir John Egan's report, Rethinking Construction, challenged the industry to measure its performance over a range of its activities and to meet a set of ambitious improvement targets. Moreover, the purpose of Key Performance Indicators (KPIs) is to enable the measurement of project and organisational performance throughout the construction industry. Latham (1994) and The Construction Industry Board (1998) introduced the following key performance indicators (Figure 2.7.):

Latham (1994)	**Egan (1998)**	**Construction Productivity Network (1998)**	**Construction Industry Board (1998)**
Client satisfaction	Construction cost	People	Capital cost
Public interest	Construction time	Processes	Construction time
Productivity	Defects	Partners	Time Predictability
Project performance	Client satisfaction (product)	Products	Cost Predictability
Quality	Client satisfaction (service)		Defects
Research & development	Profitability		Safety
Training and recruitment	Productivity		Productivity
Financial	Safety		Turnover & profitability
	Cost predictability (const.)		Client satisfaction
	Time predictability (const.)		
	Cost predictability (design)		
	Time predictability (design)		

Figure 2.7. Key Performance Indicators' Resource, adopted from Mbgua et al. (1999).

Clients of the construction industry want their projects delivered: on time, on budget, free from defects, efficiently, right first time, safely, by profitable companies (contractors' inability to make a profit was identified as a major reason for project cost and time over-runs in Sir Michael Latham's report 'Constructing the Team' (1998)). Moreover, regular clients expect continuous improvement from their construction team to achieve year-on-year reductions in project costs and reductions in project times.

The KPI Pack (2000), with the support of The Department of the Environment, Transport and the Regions, the Construction Industry Board, and the Movement for Innovation, through the Construction Best Practice Programme, presents the construction industry's range of performance using seven groups, but omits the more detailed elements of performance. These seven are listed in table 2.6 below, including their objectives and sub-objectives:

PERFORMANCE GROUP	OBJECTIVES	SUB - OBJECTIVES
Time	Provide a suite of KPIs which facilitate measures of time performance improvement on a project by project basis, either within a single company or within a market sector.	1. Time for Construction 2. Time Predictability – Design 3. Time Predictability – Construction 4. Time Predictability – Design & Construction 5. Time Predictability – Construction 6. (Client Change Orders) 7. Time Predictability – Construction 8. (Project Leader Change Orders) 9. Time to Rectify Defects
Cost	Provide a suite of KPIs which facilitate measures of cost performance improvement on a project by project basis, either within a single company or within a market sector	1. Time for Construction 2. Time Predictability – Design 3. Time Predictability – Construction 4. Time Predictability – Design & Construction 5. Time Predictability – Construction 6. (Client Change Orders) 7. Time Predictability – Construction 8. (Project Leader Change Orders) 9. Time to Rectify Defects
Quality	Provide a suite of KPIs which can be used to measure quality improvements from the start of a project by measuring the number of ‘quality issues’.	1. Defects Headline 2. Quality Issues at Available for Use Operational Period? 3. Quality Issues at End of Defect Rectification

		Period
Client Satisfaction	Provide a suite of KPIs which measure client satisfaction on a project by project basis which can be used throughout the supply chain. Use surveys to assess whether projects meet clients' expectations and whether they are satisfied with the results.	1. Client Satisfaction Product – Standard Criteria 2. Client Satisfaction Service – Standard Criteria 3. Client Satisfaction – Client-Specified Criteria
Client Changes	Provide a suite of KPIs which facilitate measures of the extent to which a project has been affected by changing specifications during the construction phase, either within a single company or within a market sector.	1. Change Orders – Client Diagnostic 2. Change Orders – Project Manager
Business Performance	Provide a suite of KPIs which facilitate measures of business performance on a project or company basis along the supply chain, either within a single company or within a market sector.	1. Profitability (company) 2. Performance 3. Productivity (company) 4. Return on Capital employed (company) 5. Return on Value Added (company) 6. Interest Cover (company) 7. Return on Investment (client) 8. Profit Predictability (project)l 9. Ratio of Value Added (company) Repeat Business (company) 10. Outstanding Money (project) 11. Time taken to reach Final Account (project)
Health and Safety	Provide a suite of KPIs which facilitate measures of the frequency of lost time and reportable accidents and	1. Reportable Accidents (inc fatalities) 2. Reportable Accidents (non-fatal)

	fatalities.	3. Lost Time Accidents Operational 4. Fatalities

Table 2.6. Key Performance Indicators published by the UK Government (2000**)**

The above factors have been used since 2000 and reports from 2010, 2011 and 2012 show a significant input in the development of construction experience in the last 13 years. The Minister of the Department of Business, Innovation and Skills has mentioned the importance of project performance indicators in maintaining and building project performance but the timely delivery of projects has declined over the last year. A survey conducted by the Ministry shows that 79% of contractors' turnover was attributable to repeat clients. Therefore, the message disseminated within the construction environment is the need to strengthen ties with existing clients and secure profitable repeat business. In particular, according to the same report (KPIs, 2012), clients had a higher level of satisfaction on projects where KPIs have been deployed to monitor their project. Therefore, it is vital to sustain project managers' interest on how to maintain their project performance at high levels. Due to the complexity of evaluating all the above key performance indicators, the researcher focused on testing the following four KPI sub-objectives (table 2.7).

KEY PERFORMANCE INDICATORS	SUB - OBJECTIVES
Time	Accurate Time Prediction – Design & Construction
Cost	Accurate Cost Prediction – Design & Construction
Quality	

Business Performance	Raise quality issues
	Return on Investment (client).

Table 2.7: KPIs used for the current research purposes

The above table was used in the research to design the interface of the conceptual framework and to design the survey and the structured interviews.

2.4. Summary

Thus, inefficiencies in the technical, human behavioural and contextual skills of any project need to be improved and developed by enhancing the project manager's main roles – accountable, authoritative and responsible – into a more interactive role engaging with people 'on demand'. This interactive role will provide project managers with the ability to enhance problem solving and decisional quality, before and during the project life cycle, and with the ability to predict a problem in advance, or to react to a problem by having facts and/or data and expertise of what is required. This lies in a proactive behaviour whose antecedents are: having a flexible role, co–worker trust, self–efficacy, being change oriented, control appraisal, job autonomy, proactive personality and supportive supervision.

The enabling relationship is defined as team collaboration. The key identified characteristics of team collaboration according to the secondary data are: individuals (skills), teams (roles, relationships, shared awareness/knowledge and common ground), tasks (structure), support (tools, networks, resources, training, knowledge management and error management) and context (organisational structure). Subsequently, in order to support collaboration, integrated collaborative technologies need to be used.

Chapter 3 – Research Design

3.1. The Importance of Planning a Research Design Framework

The contribution to knowledge from any study/research could be either the research framework or the research design. As a young researcher the author has been influenced by a number of Greek philosophers starting from Socrates (469 BC–399 BC), Plato (428/427 BC – 348/347 BC), Aristotle (384 BC – 322 BC), Pythagoras (570 BC. 495 BC), Euclides (300 BC) through to recent times, eg, Compte, Mill, Drkheim, Newton and Locke (Smithe, 1983). Planning a research design framework is needed in order to secure the validity of the scientific process which will lead to valid results. Creswell (2009, p3) defined research design as:

"....plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and methods."

Therefore, based upon the research aim and objectives (section 1.1), as a researcher it helps to consider how to organise the research (the research planning phase) and, consequently, how to prepare the steps (procedures) in order to conduct the research. The biggest challenge in research design is the assumptions which have to be made and then listed under the condition of identifying and clarifying the research aim and objectives (Saunders 2009). Therefore, in order to design the research planning phase, answers to the following questions (table 3.1.) have to be given (Sexton, 2002). Each question refers to a definition.

QUESTION	DEFINITION
What knowledge is?	Ontology
How we know knowledge?	Epistemology
What values go into knowledge?	Axiology
The process of studying knowledge	Methodology

Table 3.1: Questions which have to be answered, adapted by Sexton (2002)

In order to understand how the researcher moves towards new knowledge - contribution to knowledge – the journey is visually presented in section 3.2.

3.2. Developing the Research Design Framework

As mentioned in the previous section, and according to Creswell (2009), research designs are defined as the plans and procedures for research that span the decisions from broad to detailed methods of data collection and analysis. Therefore, the researcher's worldview and hypothesis will be presented in the following two sections.

3.2.1. Philosophical Worldview

A philosophical worldview is defined as *"......a basic set of beliefs that guide action"* (Creswell, 2009; Guba, 1990, p.17). Other researchers have referred to the term 'Worldview' as paradigm (Lincoln & Guba, 2000; Mertens, 1998); epistemology and ontology (Crotty, 1998). Creswell (2009, p 6) referred to 'Worldview' as "*a general orientation about the world and the nature of research that a researcher holds"*. Within the research world four different positions - referred to as "*...types of Worldview"* (Creswell, 2009, p.6) - have been distinguished, specifically: a) postpossitivism; b) constructivism/intepretivism; c) advocacy/participatory/idealism; and d) pragmatism/realism (Creswell 2009; Saunders et al., 2009; Sexton, 2002). Each of these positions gains a different sense of research assumptions. The following table 3.1 presents the major elements of each position:

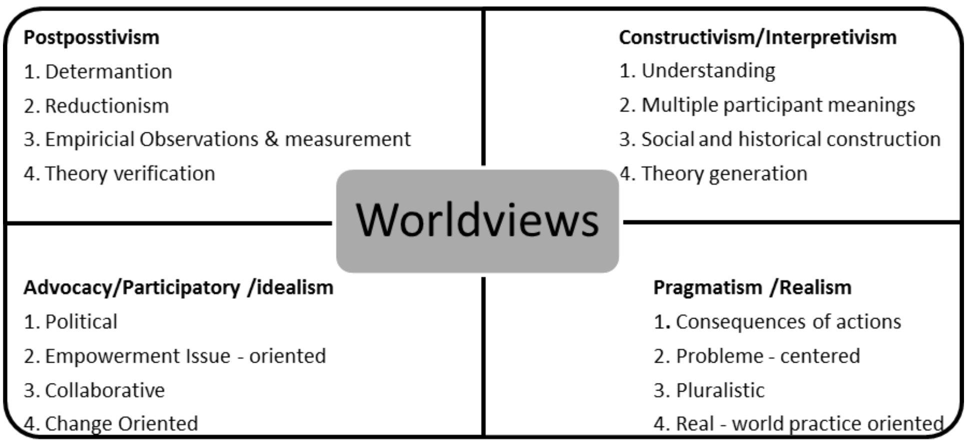


Figure 3.1. The Four Worldviews adapted by Creswell (2009), Saunders et al. (2009) & Sexton (2002)

A research problem through a **postpositivist** lens is based on careful observation and measurement of the **objective** reality that exists "out there" in the world (ontological). Therefore the assumption(s) are validated as true more for **quantitative research** than for qualitative research. **Pragmatism/Realism** for most of the philosophers (Creswell, 2009, p. 10) is seen as a worldview arising out of actions, situations and consequences rather than antecedent conditions as in postpossitivism. Therefore, the assumption(s) are validated as true more by both **quantitative and qualitative research sequentially**.

Constructivism, often combined with **interpetivism**, (Mertens, 1998) drives researchers to seek an understanding of the world in which they live and work. Therefore, researchers should ontologically be **subjectivist** due to the capability to understand the meanings that individuals attach to social phenomena. Within this worldview the researcher is looking for the meaning of a situation. Another key element is that constructivist researchers often address the processes of interaction among individuals. Within the constructivism worldview the **qualitative** approach is followed (Creswell, 2009; Saunders et al., 2009). The **Advocacy/ Participatory/Idealism** worldview is held by those researchers whose assumptions are imposed by structural laws and theories which do not fit marginalised individuals in our society or the issues of social justice that needed to be addressed. Arguably in such a case, **qualitative** data should be collected but occasionally could be a foundation for **quantitative** research as well (Creswell, 2009; Saunders et al., 2009).

The term paradigm came into popular usage with Kuhn's (1962) *The structure of scientific revolutions* and can generally be taken as referring to the commonly shared set of assumptions, values and concepts within a community, which constitutes a way of viewing reality. Koskela (2002) mentioned the underplaying theory of project management as obsolete, due to scientific weakness in the understanding of what a project is about. Attempts have been made by great scientists in the domain of project management, such as Turner (1993), Morris (1994), Starr (1996), and Koskela (2000), to try to distinguish a project as a process in which people/experts are involved; they have to complete what has been requested; to formalise when the actions should be in place; to capture the total cost and the actual cost. In addition, it has been mentioned that, during the project execution, stage two elements, *decision* and communication, are mandatory in order for tasks/projects to be completed successfully (Koskela, 2002). In project management literature reviews the terms 'hard' and 'soft' are broadly used. 'Hard' indicates a vague focus on tangibles or tasks and 'soft' indicates a vague focus on people or intangibles (Crawford, 2004; p.645). Pollak (2006; p.3) added that the 'hard' paradigm is associated with a positivist epistemology, deductive reasoning and quantitative techniques, while the 'soft' paradigm is associated with an intepretivist epistemology, inductive reasoning and qualitative techniques. However, since this research investigates 'soft' and 'hard' aspects (tasks, people and decisions) in the management of construction projects, the **researcher's worldview is pragmatism.** Therefore the mixed method will be used for the data collection and analysis (Creswell, 2009) provided that the data are validated true by both **quantitative and qualitative research.**

Considering the researcher's worldview of what knowledge is and how knowledge is known the next stage is to identify the value of knowledge or, in simple terms, to identify the credibility of the results. Value observation is defined as **axiology** and derives from the Greek word αξία - axiā, "value, worth"; and λόγος -logos. Values can be either neutral (free and objective) or biased (value laden and subjective) based upon the work undertaken by Lapie (1902) and Von Hartman (1908). In this research the value is neutral (objective).

Within the project management research area an indication of the adequacy of a particular foundation is usually provided (Koskela, 2002), and thus the results of this research will provide adequate outcomes. Adequate does not mean that the results will be weak but that they will be valid and measurable (Creswell, 2009). The success of this research will be derived when there is a continuous dialogue between the scientific and practitioner community; being in the scientific community, the researcher is seeking answers from the practitioner community (construction project managers).

3.2.2. Testing the inter–relationships

According to what has been analysed and discussed in section 1.1 of the dissertation, the following three inter–relationships will be tested.

1. **Integrated collaborative technologies can impact on team collaboration (H1)**

H1a: *Integrated collaborative technologies can enhance the understanding of roles within a team.*

H1b: *Integrated collaborative technologies can enhance the relationships between the project partners (stakeholders)*

H1c: *Integrated collaborative technologies can enhance the knowledge sharing and awareness between the project partners (stakeholders)*

H1d: *Integrated collaborative technologies can enhance the common ground / understanding of the project brief (scope, aim, objectives, budget, timeline, stakeholders)*

H1e: *Integrated collaborative technologies can enhance group processes (group effectiveness and performance)*

H1f: *Integrated collaborative technologies can enhance collaboration in terms of the heterogeneity and the size of a team*

H1g: *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of learning*

H1h: *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of coordination*

H1i: *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of communication*

H1j: *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of decision making*

H1k: *Integrated collaborative technologies can enhance the structure of a project: Organisational Breakdown Structure*

H1l: *Integrated collaborative technologies can enhance the structure of a project: Work Breakdown Structure*

H1m: *Integrated collaborative technologies can enhance the accessibility of projects' stakeholders to information*

H1n: *Integrated collaborative technologies can enhance the networking accessibility and capability between the projects' stakeholders*

H1o: *Integrated collaborative technologies can enhance project managers' access to project knowledge required in order do/control/manage their job*

H1p: *Integrated collaborative technologies can enhance project managers' capability to identify, analyse and manage/control both errors and violation of a project/task*

2. **Mapping team collaboration characteristics to proactive behaviour antecedents (H2)**

H2a: *Individuals can lead to the development of proactive behaviour*

H2b: *Teams can lead to the development of proactive behaviour*

H2c: *Interaction processes can lead to the development of proactive behaviour*

H2d: *Tasks can lead to the development of proactive behaviour*

H2e: *Support can lead to the development of proactive behaviour*

H2f: *Context can lead to the development of proactive behaviour*

3. **Proactive behaviour** impacts on **project performance**. (H3).

H3a: *Flexible role orientation impact on 'accurate' prediction of the time for planning, design and construction*

H3b: *Flexible role orientation impact on 'accurate' prediction of the cost for planning, design and construction*

H3c: *Flexible role orientation impact on 'raising the quality issues' of the final output*

***H3d:** Flexible role orientation impact on 'comparing the estimated return on investment' for the client*

***H3e:** Trust between the team members impact on 'accurate' prediction of the time for planning, design and construction*

***H3f:** Trust between the team members impact on 'accurate' prediction of the cost for planning, design and construction*

***H3g:** Trust between the team members impact on 'raising the quality issues' of the final output*

***H3h:** Trust between the team members impact on 'comparing the estimated return on investment' for the client*

***H3i:** Self-efficacy impact on 'accurate' prediction of the time for planning, design and construction*

***H3j:** Self-efficacy impact on 'accurate' prediction of the cost for planning, design and construction*

***H3k:** Self-efficacy impact on 'raising the quality issues' of the final output*

***H3l:** Self-efficacy impact on 'comparing the estimated return on investment' for the client*

***H3m:** A control appraisal process impact on 'accurate' prediction of the time for planning, design and construction*

***H3n:** A control appraisal process impact on 'accurate' prediction of the cost for planning, design and construction*

***H3o:** A control appraisal process impact on 'raising the quality issues' of the final output*

***H3p:** A control appraisal process impact on 'comparing the estimated return on investment' for the client*

H3q: *Identification of any possible type of changes impact on 'accurate' prediction of the time for planning, design and construction*

H3r: *Identification of any possible type of changes impact on 'accurate' prediction of the cost for planning, design and construction*

H3s: *Identification of any possible type of changes impact on 'raising the quality issues' of the final output*

H3t: *Identification of any possible type of changes impact on 'estimating the return on investment' for the client*

H3u: *The power you have to make decisions (job autonomy) impact on 'accurate' prediction of the time for planning, design and construction*

H3v: *The power you have to make decisions (job autonomy) impact on 'accurate' prediction of the cost for planning, design and construction*

H3w: *The power you have to make decisions (job autonomy) impact on 'raising the quality issues' of the final output*

H3x: *The power you have to make decisions (job autonomy) impact on 'comparing the estimated return on investment' for the client*

H3y: *Proactive personality to identify problems impact on 'accurate' prediction of the time for planning, design and construction*

H3z: *Proactive personality to identify problems impact on 'accurate' prediction of the cost for planning, design and construction*

H3aa: *Proactive personality to identify problems impact on 'raising the quality issues' of the final output*

H3ab: *Proactive personality to identify problems impact on 'comparing the estimating return on investment' for the client*

H3ac: *Development of the team members' skills impact on 'accurate' prediction of the time for planning, design and construction*

H3ad: *Development of the team members' skills impact on 'accurate' prediction of the cost for planning, design and construction*

H3ae: *Development of the team members' skills impact on 'raising the quality issues' of the final output*

H3af: *Development of the team members' skills impact on 'comparing the estimated return on investment' for the client*

A note in the section is that H1 and H3 are hypotheses compared to H2, which aims to investigate whether the two elements of the conceptual framework are mapping respectively.

3.3. Research Process

The research design process is described in the following image. The initial stage is to clarify to research problem followed by the research question, aim and objectives Following completion of the first three steps, the researcher collected secondary data in order to cover the literature review section of the research (4th step). This is the second chapter of this thesis. The fifth stage of the research process was the draw the research design including research philosophy, methodology, methods, data collection techniques, research limitations and ethical consideration. So, the stages between 5 and 8 conclude the third chapter of this thesis. Between stages 9 and 12 the process followed in order to collect the data is described. The 13th step is to transcribe the data and the 4th step was to analyse them respectively. The findings discussion within this thesis concludes chapters 4, 5 and 6 accordingly. The last two steps, 14th (draw research conclusion) and 15th (write research recommendations for future research), conclude the seventh chapter of this thesis.

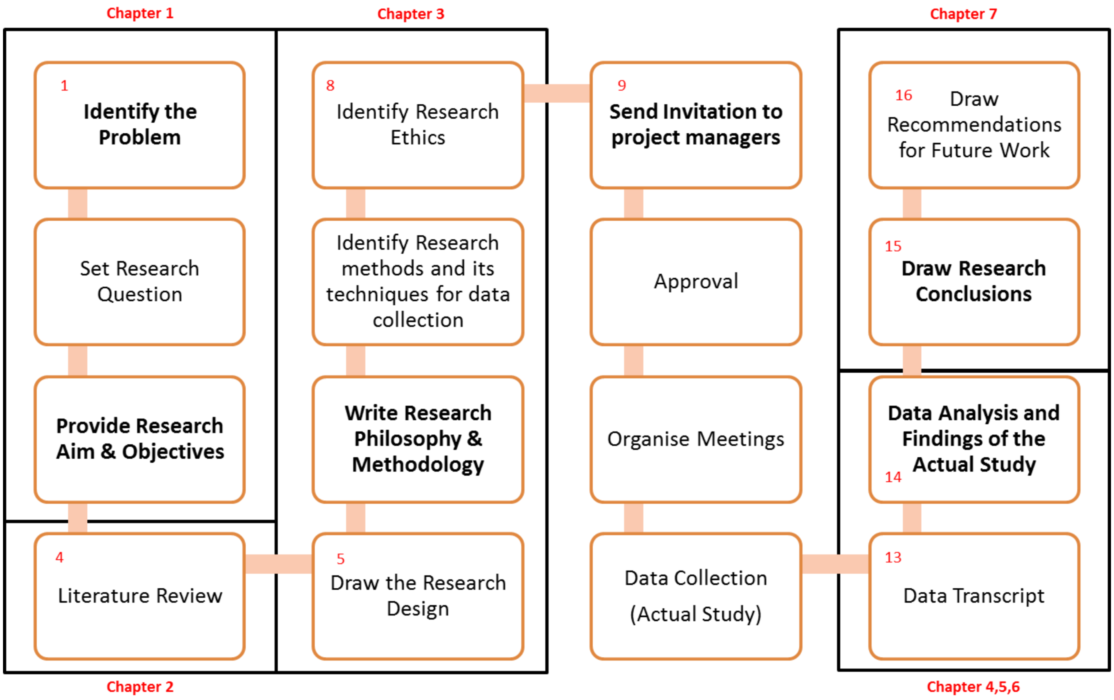


Figure 3.2. Research Design Process

3.4. Research Design

What has been derived so far is a clear way of thinking on how to conduct the research, although the methods and techniques to be used have not yet been presented. Therefore, this section aims to explain in detail which methods and techniques will be used, why these methods and techniques have been chosen and how they will be applied through a process. The research design must be developed in such a manner as to answer the research objectives and to achieve the research aim. Based upon researcher awareness, the dimensions of philosophical thinking are represented below (figure 3.3.).

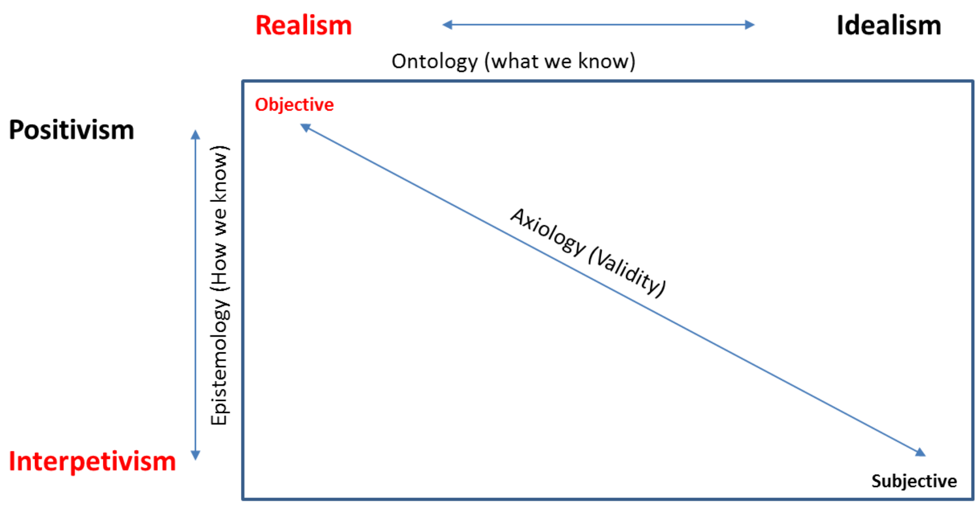


Figure 3.3. Dimensions of researcher philosophy adapted by Saunders et al., (2009) & Sexton (2002)

In order to explore the problem the approach/methodology to be used must take into account the research questions (see section 1.1). The questions are focused on *whether* and *how*. Considering the fact of two worldviews, two different methods must be following accordingly. Creswell (2009, p.16) stated that the researcher tests a theory by specifying a narrow hypothesis and the collection of data *supports* or *refutes* the hypothesis. Therefore, the approach should remain **mixed** and the data are collected via an instrument that measures attitudes; the information is analysed using statistical procedures and the hypothesis is tested respectively.

Within the same book Creswell (2009, p.17) stated that the researcher bases his/her enquiry on the assumption that collecting diverse types of data provides an understanding of a research problem. As mentioned in section 3.2, the philosophical assumptions for this particular research require the pragmatism worldview. For the purpose of this research structured interviews have been used, with questionnaires based on a ‘standardised’ set of questions (Saunders, 2009; p.320). The interviewees’ responses have been recorded. The questions were asked by the researcher using the same tone of voice in order to avoid bias and s**tructured interviews** were used to collect the qualitative data.

However, since the research requires the testing of the strength/credibility of each relationship - Integrated Collaborative Technologies to Team Collaboration; Team

Collaboration to Proactive Behaviour and Proactive Behaviour to Projects' Performance - a **Survey Approach** has been followed. The gathered quantitative data will be used to validate the strength of H1, H2 and H3 respectively, while a similar approach will be conducted to test whether the conceptual framework is applicable within a project environment

The interview process is illustrated in the following figure 3.4. Initially the researcher introduced the research area, aim and points from the literature review to the interviewee. The next stage was to explain the following relationships: that **integrated collaborative technologies** impact on **team collaboration** (H1), **team collaboration** is related to **proactive behaviour** (H2) and **proactive behaviour** impacts on **project performance** (H3). Stages 3, 4 and 5 aimed to take data responses from the main hypotheses (H1, H2 and H3). In the final stage 6 general comments and feedback from the interviewees about the research were provided.

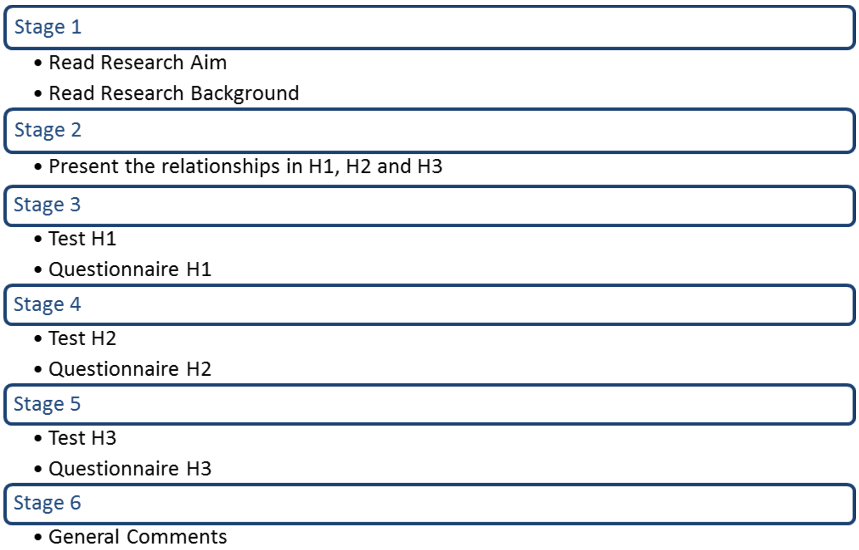


Figure 3.4. Research Interview Process

The data analysis process was divided into five parts. The first part aimed to test the conceptual framework using descriptive statistics (mean value) and the calculation of R- Square (comparing the theoretical data model and the actual data model). In the second, third and fourth part the analysis consisted of hypothesis validation (using descriptive statistics - mean value) and interviewees' opinions (content analysis) respectively. The final part was in the research design plan, where the researcher captured some interesting and challenging points which he would like to bring forward in this research.

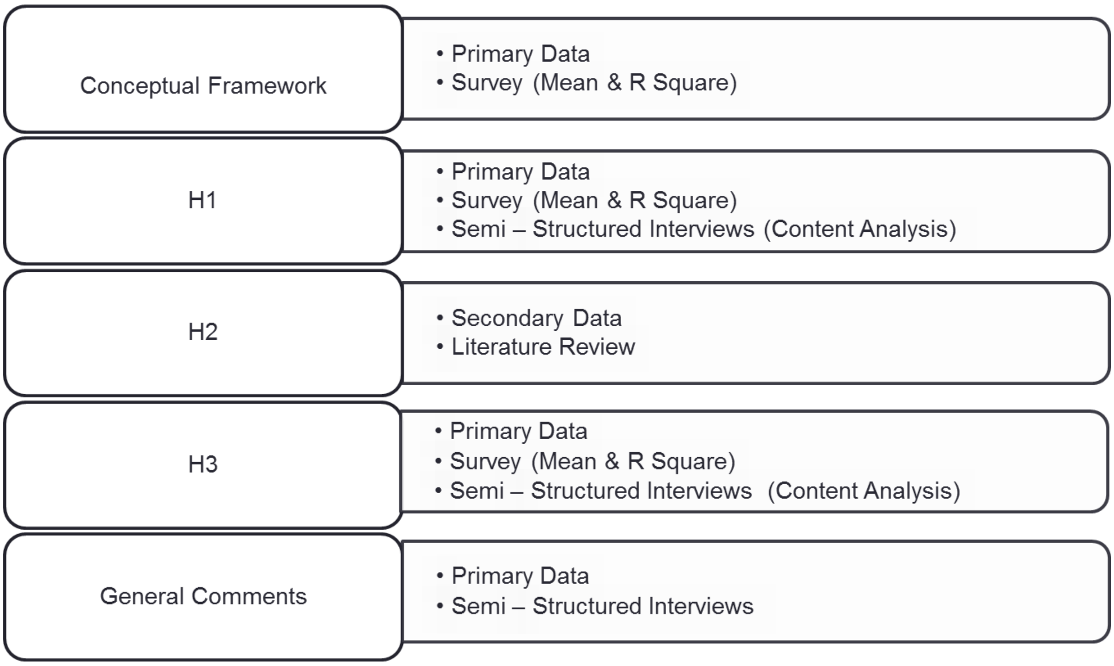


Figure 3.5. Research Data Analysis Process

3.5. Research Sample

In order to find answers to the research questions, it was essential that the interviewees' profile (profession) are in the field of project management. The researcher interviewed professionals working in the broad area of the Architecture, Engineering and Construction (AEC) sector and included Assistant Project Managers, Project Managers, Senior Project Managers, Project Directors and Project Management Consultants.

The selection criteria considered in the experiments was the size of the organisation (large organisations) which are located in the United Kingdom. According to EU recommendation 2003/361 [ref], it is stated that enterprises with <250 employees and either turnover ≤ € 50 m or balance sheet total ≤ € 43 m are defined as small and medium enterprises. As a result any company that employs >250 with either a turnover of ≥ € 50 m or balance sheet total of ≥ € 43 m was considered as a large scale enterprise. The average turnover of the sample is more than £150M for the financial year 2012 and employing on average 240,000 construction professionals for the year 2012 (UK National Statistics, 2013).

In order to ascertain the proportional sample to be collected and for the research to be validated, the researcher looked at the number of registered qualified construction project managers in the UK, then requested information from the following body: Association of Project Managers (APM). According to the APM association has 21,000 registered members and approximately 2000 qualified construction project managers. Considering population size is 2000 qualified project managers, the confidence level is 95% and the error is 10% then the researcher has to collect 92 responses. Hence the researcher sent 120 emails and received 24 responses in total (18 large scale organisations). Moreover, with 95% confidence level the responses (data – answers) are accurate with the error level to be 19.9%.

The following table 3.2. presents the variety of the sample. Furthermore, 29% of the sample was contractors, 33% consultants, 21% clients, 8.5% suppliers and 8.5% architects. The average work experience of the interviewees was 16.5 years in the Architect, Engineering and Construction (AEC) industry. Considering interviewees' profile 96% of the sample was male professionals compared to 4% female professionals.

Sector	Companies	Interviewees
Contractors	5	7
Consultancy	6	8
Clients	3	5
Suppliers	2	2
Architects	2	2
Total	18	24

Table 3.2. The Research Sample

3.6. Research Ethical Considerations

The researcher considered all the ethical considerations in order to conduct this research. In the invitation letter, it was made clear that the data are confidential and will not be distributed to third parties, and that anonymity is assured.

3.7. Conceptual Framework

In this chapter it has been shown that the researcher's stance ontologically is realism and epistemologically is intepretevism. Moreover, the researcher has identified three Hypotheses (figure 3.6) that will be validated as follows: for H1 via the primary data collected; for H2 via the secondary data collected and for H3 via the primary data collected.

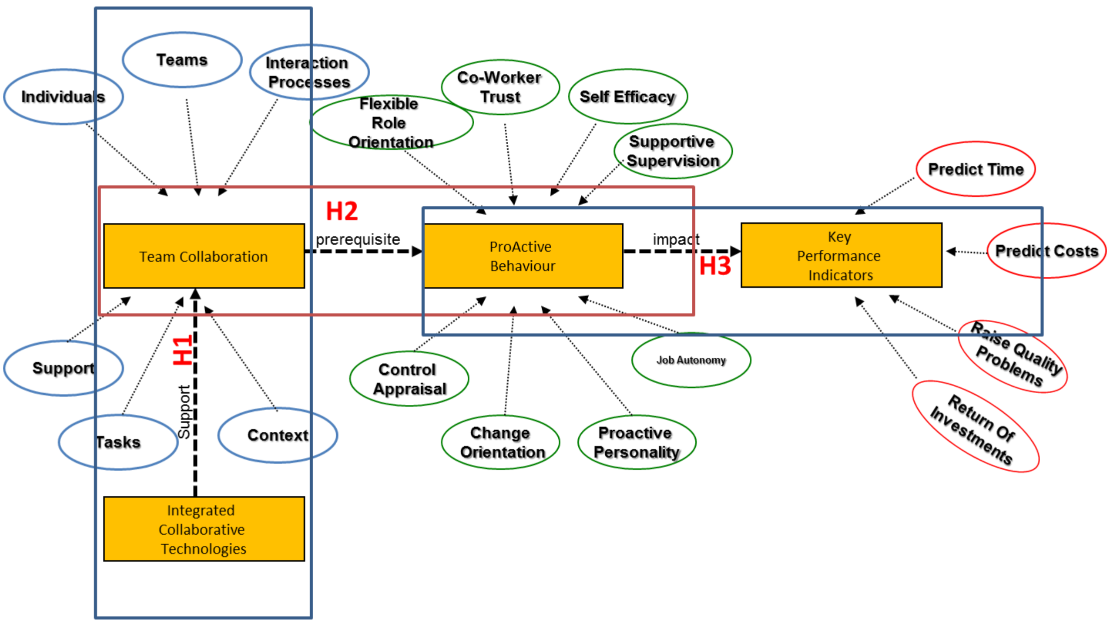


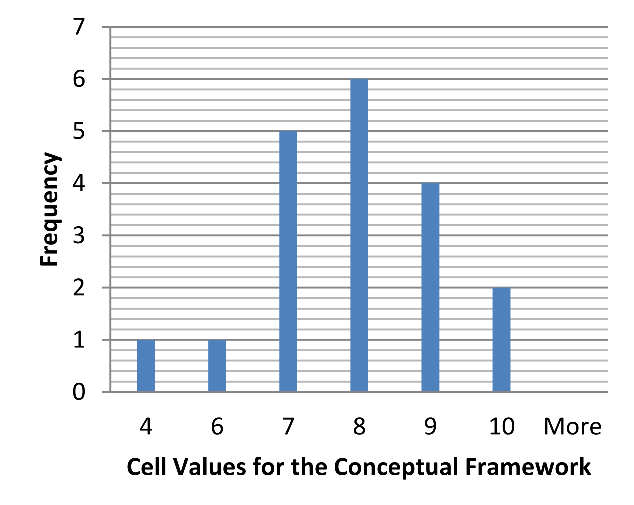
Figure 3.6. Conceptual Framework

In detail, for H1 both structured interviews and survey techniques (mixed methods) were used; for H2 a literature review technique was used and for H3 both structured interviews and survey techniques (mixed methods) were used. The researcher used content analysis and descriptive analysis techniques to interpret the collected data scientifically.

As illustrated in figure 3.6, the hypotheses derived above attempt to test the following assumptions: Integrated collaborative technologies can impact on team collaboration

(H1), Team collaboration is related to proactive behaviour (H2) and Proactive behaviour impacts on project performance (H3). Figure 3.6 presents a conceptual framework which captures the key factors associated with integrated collaborative technologies, team collaboration, proactive behaviour and key performance indicators (KPIs) and their assumed relationships. A questionnaire was designed to rate the degree of applicability of the conceptual framework within the construction framework. The key question passed to the project managers was to "rate the degree to which you would apply the above conceptual framework to your research projects". Subjects asked to the acceptance between 0[no acceptable] and $1 \leq x \leq 10$ [acceptable]. The same group of project managers were interviewed in order to answer the above question. According to the participants' answers (primary research data) it was found that the mean value is equal to $\mu=7.84$. Moreover, for this sample $n=24$, the minimum value was 4, the maximum 10, and value 8 was quite frequent (figure 3.7). There is a range of low values at 4, 6 and 10. Values 7 and 9 were the second and third most popular responses. Finally, due to the atypically large value, the histogram (figure 3.7) is slightly skewed to the left, or negatively skewed (-1.08). Without this value, the histogram would be reasonably symmetrical (figure 3.7).

Normal Distribution



Descriptive Statistical Analysis

Mean	7.842105263
Standard Error	0.326805895
Median	8
Mode	8
Standard Deviation	1.42451387
Skewness	-0.8511036
Range	6
Minimum	4
Maximum	10
Count	24
Confidence Level (95.0%)	0.686593708

Figure 3.7. Normal Distribution and Descriptive Statistical Analysis for the Potential Conceptual Framework

Moreover, the Standard Deviation (SD) between the data and the mean is SD=3.48. The confidence interval for the underlying population mean for the flexible role lead to 'accurate time' equals ± 1.47, or μ=4.73 to μ=6.47. So, at a significance level of 0.05 and probability 95% the accepted range is 4.73<6.20<6.47 (figure 3.6). Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.50 and R^2 (Normal Distribution) = 0.54 the regression line from both models and their data tend to match and both their values are close to 1 (figure 3.7). As a result the hypothesis as to whether the above conceptual framework could be used by project managers to improve project performance is accepted.

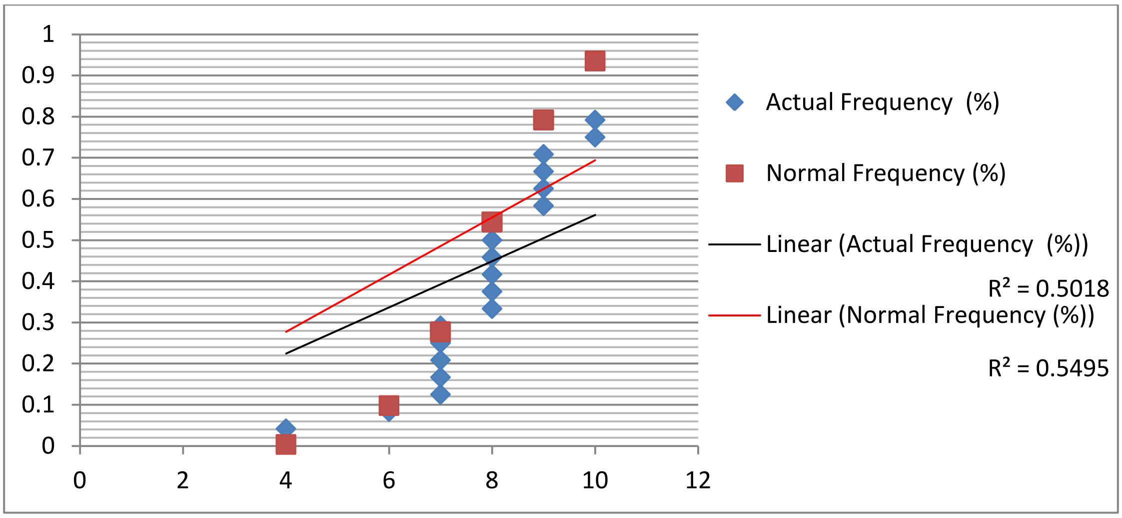


Figure 3.8. Coefficient of Determination for Conceptual Framework

3.8. Chapter Summary

In this chapter it has been shown that the researcher's stance ontologically is realism and epistemologically intepretivism. Moreover, the researcher has identified three hypotheses where integrated collaborative technologies can impact on team collaboration (H1), mapping team collaboration characteristics on proactive behaviour antecedents (H2) and proactive behaviour on project performance (H3). For H1 and H3 have been collected primary and for H2 have been collected secondary data. Furthermore, for research purposes the researcher collected primary data from 24 construction project managers working for 18 different stakeholders (architects, contractors, consultants, suppliers and clients). The selection criteria were that businesses should be large scale and operating within the United Kingdom. For secondary data, professional reports, journal and conference proceedings, and books have been used. In addition, the proposed conceptual framework can be used in construction projects based on construction project managers' opinion due to the capability they have to enhance the collaborative culture within the project, as well as to develop proactive behaviour in each individual team member in order to enhance their project performance.

Chapter 4 – Impact of Integrated Collaborative Technologies on Team Collaboration

4.1. Research Purpose

The purpose of the research is to test if integrated collaborative technologies can have an impact on team collaboration. In order to answer this, the researcher identified the sub-factors of team collaboration: individuals (skills), teams (roles, relationships, share knowledge/awareness, common ground, group processes and composition), the interaction process (learning, coordination, collaboration and decision making), support (tools, networks, resources, knowledge management, error management) and context (organisational structure). In addition to these factors, integrated collaborative technologies and their features have been introduced which can impact on team collaboration. In particular, integrated collaborative technologies in the construction sector are those tools that can help stakeholders work collectively towards problem solving without being impeded by geographical distance. Their features, amongst others, are: BIM, collaborative design software, workflow systems, documentation management systems and knowledge management systems. These features provide the basis for the following sub-hypotheses.

4.1.1. Research Hypothesis

Considering the main hypothesis that integrated collaborative technologies can impact on team collaboration (H1) the research sub-hypotheses are:

- ***H1a:*** *Integrated collaborative technologies can enhance the understanding of roles within a team.*
- ***H1b:*** *Integrated collaborative technologies can enhance the relationships between the project partners (stakeholders)*
- ***H1c:*** *Integrated collaborative technologies can enhance the knowledge sharing and awareness between the project partners (stakeholders)*
- ***H1d:*** *Integrated collaborative technologies can enhance the common ground / understanding of the project brief (scope, aim, objectives, budget, timeline, stakeholders)*

- ***H1e:*** *Integrated collaborative technologies can enhance the group processes (group effectiveness and performance)*
- ***H1f:*** *Integrated collaborative technologies can enhance the collaboration in terms of the heterogeneity and the size of a team*
- ***H1g:*** *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of learning*
- ***H1h:*** *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of coordination*
- ***H1i:*** *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of communication*
- ***H1j:*** *Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of decision making*
- ***H1k:*** *Integrated collaborative technologies can enhance the structure of a project: Organisational Breakdown Structure*
- ***H1l:*** *Integrated collaborative technologies can enhance the structure of a project: Work Breakdown Structure*
- ***H1m:*** *Integrated collaborative technologies can enhance the accessibility of projects' stakeholders to information*
- ***H1n:*** *Integrated collaborative technologies can enhance the networking accessibility and capability between the projects' stakeholders*
- ***H1o:*** *Integrated collaborative technologies can enhance project managers' access to projects' knowledge required in order do/control/manage their job*
- ***H1p:*** *Integrated collaborative technologies can enhance project managers' capability to identify, analyse and manage/control both errors and violation of a project/task*

4.1.2. Questionnaires

In order to answer the Hypothesis H1 and its sub-hypotheses, the researcher designed the survey and the questionnaire considering information and communication technologies and team collaboration. Figure 4.1 represents the potential impact of integrated collaborative technologies on team collaboration.

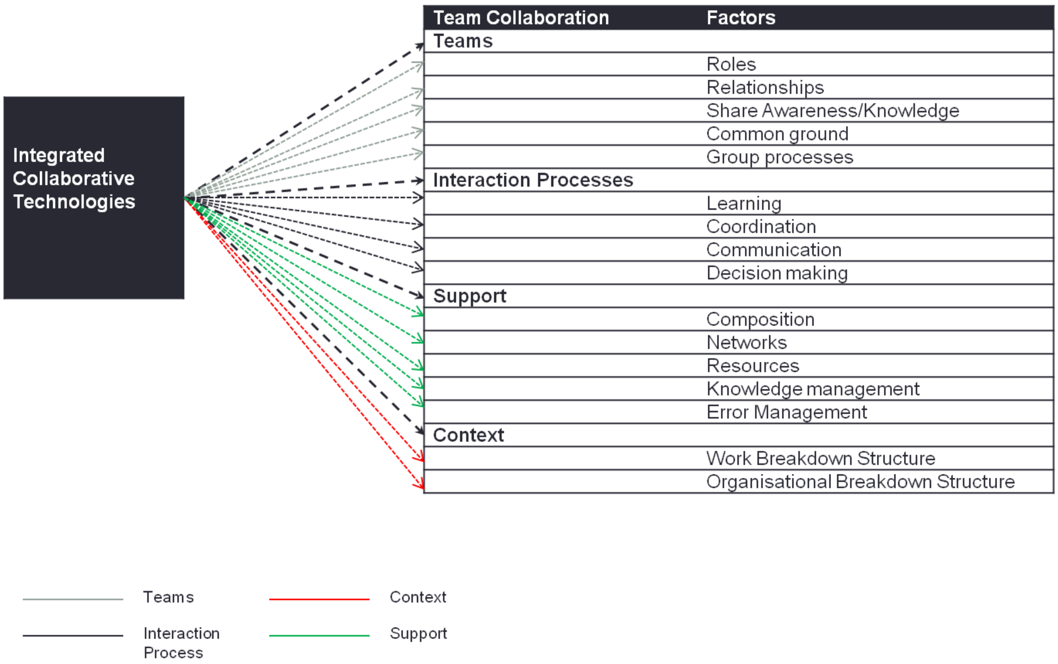


Figure 4.1 The sub hypotheses between integrated collaborative technologies and team collaboration

4.1.3. Research Methodology

Methodologically, the survey aims to test if integrated collaborative technologies can enhance team collaboration, and structured interviews were designed to answer how integrated collaborative technologies can enhance the understanding of roles within a team. The same group of project managers (n=24) responded to both the survey and the structured interviews in order to express subjectively the strength (link) of influence. For the survey the researcher used the Likert scale between 0 and 10 where 0 indicates no influence and 10 indicates high influence. For the discussion of the quantitative data, statistical descriptive analysis techniques have been used, and for the discussion of the qualitative data a content analysis technique has been used. In particular, any value $0<x<1$ where x represents the value that integrated collaborative technologies do not influence team collaboration and $1<y<10$ where y represents the value that integrated collaborative technologies do influence team collaboration the researcher accepts any value $y \geq 5$. This will secure the highest degree of influence of integrated collaborative technologies on team collaboration. As a result any value $1<y<5$ and $0<x<1$ were rejected. The terms used for the analysis are presented in italic form below:

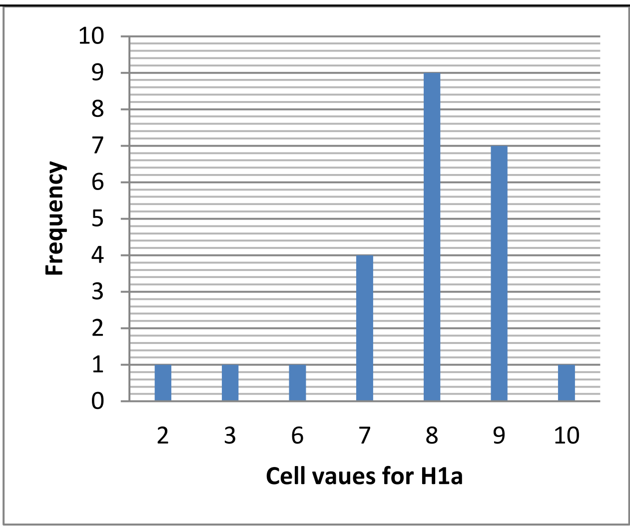
*The mean is the average rate of the scale in a set of data. The mode is the value that appears most often in a set of data. The median is described as the numerical value separating the higher half of a sample, a population, or a probability distribution, from the lower half. The minimum is the lowest value that appears in a set of data. The maximum is the highest value that appears in a set of data. The standard deviation (σ) shows how much variation or "dispersion" exists from the average (mean). The **sum** shows the total sum of the data set. The **skewness** shows a measure of the asymmetry of the probability distribution of a real-valued random variable. The **confidence level** (95.0%) indicates the reliability of an estimate in a set of data. The same group of project managers responded simultaneously to an in-depth discussion on how integrated collaborative technologies influence team collaboration.*

4.2. Primary Research Data Analysis and Discussion

H1a: Integrated collaborative technologies can enhance the understanding of roles within a team.

According to the descriptive statistical analysis, it was found that the degree of influence of integrated collaborative technologies in enhancing the understanding of roles within a construction project environment is equal to the mean value, that is, $\mu=7.66$. By analysing the graphical representation of the distribution of the interviewees' responses it can be shown that the minimum value was 2 and the maximum was 10, and the values between 8 were quite frequent compared to the others. In contrast, the frequency of the range 9 and 7 was the second and third most popular (figure 4.1a). Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.99). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	7.6667
Standard Error	0.3743
Median	8
Mode	8
Standard Deviation	1.8337
Skewness	-1.999
Range	8
Minimum	2
Maximum	10
Count	24
Confidence Level (95.0%)	0.7743

Figure 4.1a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis - H1a

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.83. The confidence interval for the underlying population mean for integrated collaborative technologies in enhancing the understanding of roles within a project team equals ± 0.77, or the values could be between μ=6.89 and μ=8.43. Thus, at a significance level 0.05 and probability 95% the accepted range is 6.89 <7.66 <8.43.

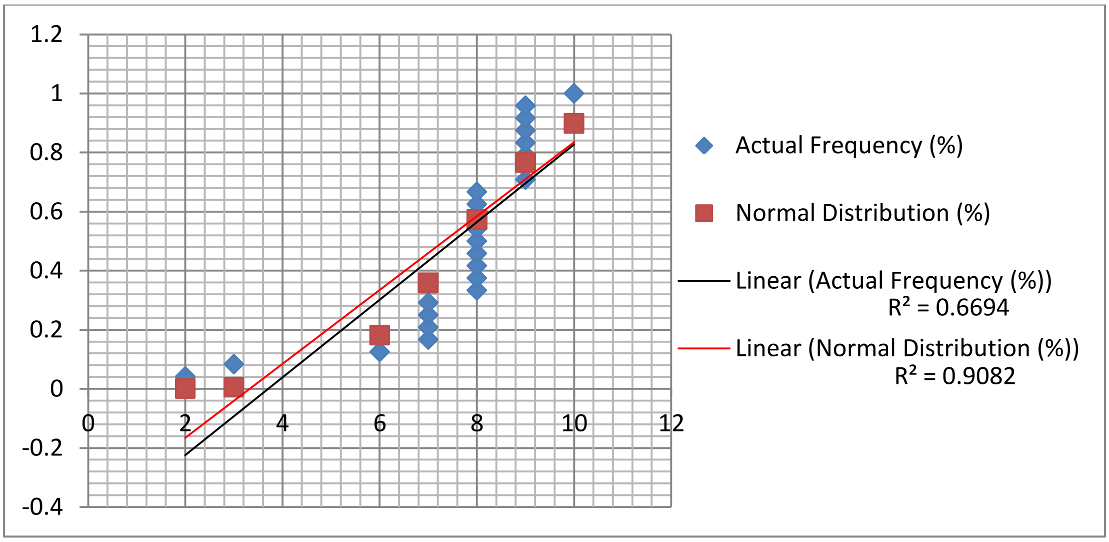


Figure 4.1b. Coefficient of Determination for sub-hypothesis H1a

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.66 and R^2 (Normal Distribution) = 0.90 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1a is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the enhancement of the understanding of roles within a team. In particular:

- **Problem's owner:** the more clarity there is in a team in terms of who is doing what the more chances the project manager has in identifying the owner of an actual problem. In particular, this is likely to be the person who failed to complete a task successfully. For the purpose of tracking this information from the system, the project manager will request access to the system to identify the project status, who is involved and the tasks' constraints, i.e., time, cost, quality, client satisfaction, etc. This type of information will help him/her to identify the problem's owner as well as to provide a solution to the problem. In order to eliminate the risk of another possible future problem, the project manager tests ideas in a virtual environment so he/she can visualise possible consequences for the task progress and thus for project progress.
- **Conflict avoidance:** the more clarity there is in a team in terms of who is doing what the more efficiently project planning can be designed. In a project it is essential that the project manager includes certain items, such as the project brief, in the feasibility study of the project management life cycle. In order to produce the actual feasibility study, team members may join virtually and physically in a meeting with access to project information from anywhere at any time and share it in order make corrections and validate the project information in order to eliminate project risks. Additionally, the team keeps records and retrieves them in future meetings in order to complete or justify a case when necessary. Therefore, harmonious technological integration, including collaboration, accessibility and information exchange, can enhance team members' understanding of their roles within the team.

Pre–identification of team members' responsibilities, background, culture and skills: in particular, interviewees stated that these technologies can help project managers and their team members enhance their understanding of who is involved, what type of responsibilities they have and what project/task requirements exist. Furthermore, project managers stated that "information access and information sharing" between project stakeholders helps them to "look at specific information", e.g. the team members' curriculum vitae (CV) so as to understand each member's specialisation and to help them to delegate the relevant appropriate task(s). From the team members' CVs the project manager can read and identify candidates' background (academic knowledge), culture and skills (collaborative, interaction, etc.) In addition, in a case where project managers could not approach specialised team members for one particular task/activity, they believed they could use these technologies to make contact with other potential candidates and recruit them due to their unique expertise (usually the Human Resources department uses databases – Human Resources' Management Systems (HRMs) - as part of the Enterprise Resources Planning Systems (ERPs) holding information on past applicants which a project manager could access and thus invite a new candidate for interview). Therefore, this technological integration allows team members to enhance their understanding of their colleagues' roles.

- **Clarify team members' responsibilities:** interviewees found these technologies useful at the project design phase, where the project manager needs to contact and meet with other team members so as to set and decide the organisational and work breakdown structure (OBS and WBS) respectively. In particular, the interviewees believed that the unque competitive advantage of integrated collaborative technologies in "connecting from anywhere at any time" allowed them to meet virtually. According to their responses the biggest assets are "saving time", "making quick and efficient decisions", "saving money" and "sharing and filtering information synchronously between two or more team members". As a result, when difficulties occurred during the setup of the OBS or WBS of a project, and team members were not at the office or the project was based in a remote area, project managers found these technologies powerful and useful in their project process – this in spite of the fact that they were expensive to buy and difficult to use in the beginning. Therefore, this technological integration allows team members to enhance their understanding of their colleagues' roles.

According to the above, integrated collaborative technologies that can significantly enhance the understanding and contributing factors of the hypothesis are listed in the following table 4.1:

H1a	**INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES**	**CONTRIBUTING FACTORS SUPPORTING THE HYPOTHESIS**
Enhancement of the understanding of roles within a team.	• Project Information accessibility • Project Information sharing • Synchronous and asynchronous connectivity • Distributed and Co-located Workspace • Collaborative Working Environments (CWE) • Virtual Meetings	• Problem Ownership • Conflict avoidance • Pre–identification of team members' responsibilities, background, culture and skills • Clarification of team members' responsibilities and roles

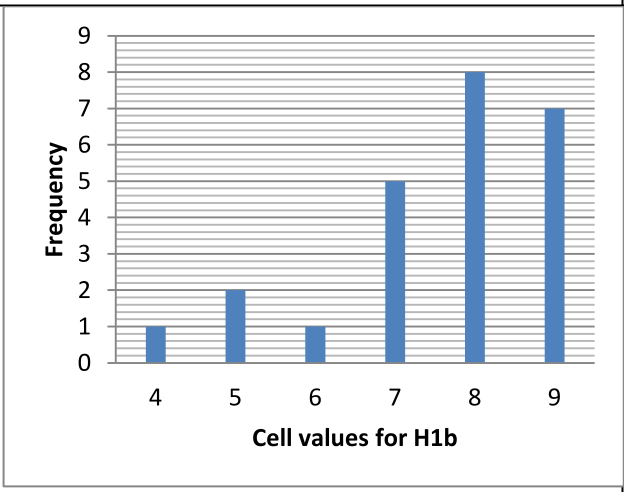
Table 4.1. Features and factors supporting the sub - hypothesis H1a

In his book which includes criticism of project management, Pinto (2007), stated that problem ownership and conflict avoidance are two major aspects that have to be eliminated in any period and at a time when technologies are developing fast. Morris (1994) stated that the pre-identification of problems in a construction environment will give an added value by eliminating some project costs for the client and this will be an asset for business continuation. There is a need for the project manager and the client in particular to clarify who is involved, what it is they are doing and what their duties are, something that Kerzner (2005) considers as vital for a project's progress. The only limitation that has been found in this research is that team members do not know how to make best use of these technologies or even to make best use of collaboration generally (even without technologies). Therefore, a main added value of using these technologies is to enhance team members' understanding of roles within a team.

H1b: Integrated collaborative technologies could enhance the relationships between the project partners (stakeholders)

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the relationships between the project partners within a construction project environment is equal to the mean value, that is μ=7.58. Moreover, for this sample n=24, the minimum value was 4 and the maximum was 9, and the values between 8 and 5 were quite frequent compared to the others. In contrast, the range between 9 and 7 was the second and third most popular in terms of frequency (figure 4.2a). Moreover, a smaller group of project managers provided answers with frequency between 4 and 6. Finally, due to the atypically large value, the histogram (figure 4.2a) is slightly skewed to the left, or negatively skewed (-1.09). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.583333
Standard Error	0.288152
Median	8
Mode	8
Standard Deviation	1.411649
Skewness	-1.09549
Range	5
Minimum	4
Maximum	9
Count	24
Confidence Level (95.0%)	0.596087

Figure 4.2a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis - H1b

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.41. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.59, or the values could be between $\mu=6.99$ to $\mu=8.17$. So at a significance level 0.05 and probability 95% the accepted range is: 6.99 <7.58 <8.17 (figure 4.2b).

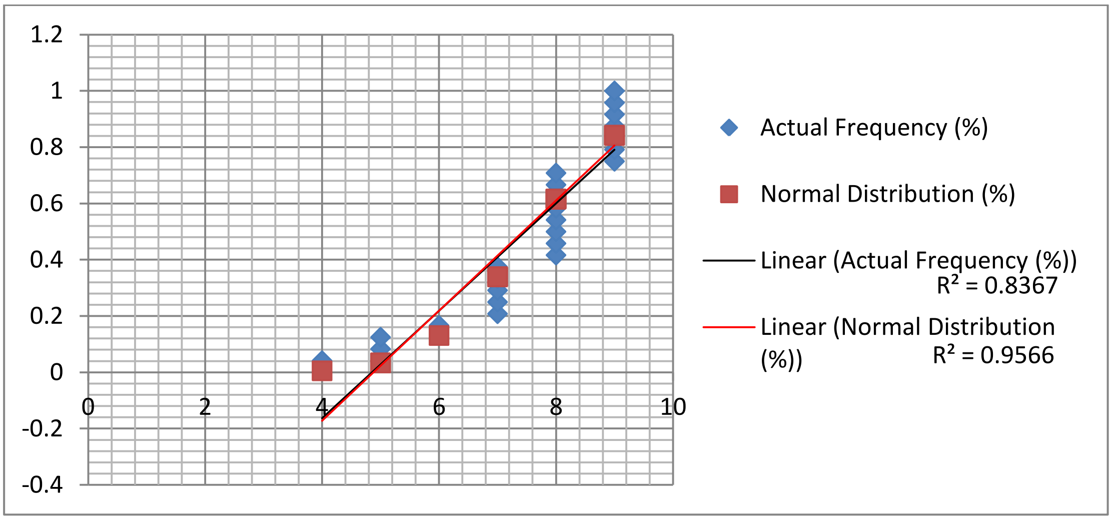


Figure 4.2b. Coefficient of Determination for- H1b

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.83 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1b is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the enhancement of the relationships between the project partners (stakeholders). In particular:

- **Developing Trust:** Trust is attributed to the relationships between people. In the construction sector it is vital that team members work together at every level (operational, tacit and strategic). Interviewees mentioned the barriers that people have between them while they work on a task, i.e., different culture, language, skills and attitude, e.g., self-confidence, collaboration, etc., that reflect the tasks' progress. Therefore, they are seeking to make best use of these integrated collaborative technologies by "training team members on certain topics within team groups where, during these sessions, they can bridge the gap between them" (visual training). Therefore, throughout this process it is possible to interact, socialise (meet new team members) and to start to develop confidence between the trustor and the trustee that will help both to work efficiently. Hence, these technologies support the enhancement of the relationships between the project partners by offering them virtual learning features, e.g., interactive communication, sharing of documentation/information/data, and making available online discussion, including forums.

- **Improving/Enhancing Communication:** Team members working on a construction project can be distributed or co-located. There is a need for an effective communication channel that will bring team members closer. These technologies allow team members to connect from anywhere at any time synchronously or asynchronously, and this connectivity allows them to access information, to exchange this with other team members and to discuss this information in-depth. This process will help team members to clarify misleading points. Hence, these technologies support the enhancement of the relationships between the project partners by offering them advanced communication features e.g., interactive virtual (distributed or co-located) communication, sharing of documentation/information/data, and making available online discussion including forums.
- **Problem Pre-Identification:** It is believed, according to the interviewees' responses, that an important factor of these technologies is in pre–identifying problems in a construction environment due to the nature of sharing and accessing project information from anywhere at any time. In particular, interviewees believed that "access to data and information including past decisions" will help them to reconsider the aspects of an existing problem or even think of a potential problem and to "identify new alternative ways to overcome a problem".

According to the above, integrated collaborative technologies that can significantly enhance the relationships between stakeholders and the contributing factors of the hypothesis are listed in the following table 4.2:

H1b	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS SUPPORTING THE HYPOTHESIS
Enhancement of the relationships between stakeholders	• Project Information accessibility • Project Information sharing • Synchronous and asynchronous connectivity • Co – located or Distributed Work • Virtual Meetings • Virtual Training	• Developing Trust • Enhancing Communication • Problem pre – identifications

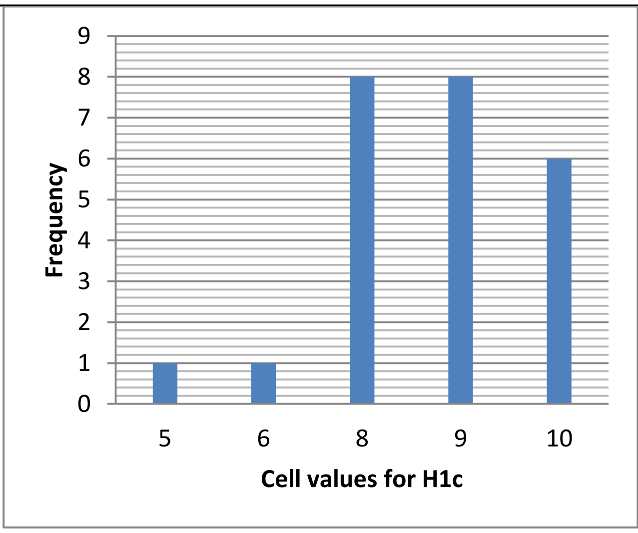
Table 4.2. Features and factors supporting the sub-hypothesis H1b

Ebgu (1999) stated that, amongst other factors, a project manager has to be accountable. Accountability is about trust and the development of trust is a major contributing factor in supporting the hypothesis. Additionally, Kernzer (2006), in his book, explained that communication should be established within a team in a manner that causes it to work more efficiently and effectively. This was also validated in the latest KPI report by the UK Government (2012) which includes the need to predict performance indicators for construction, design and scheduling. Therefore, the added value of the extensive use of integrated collaborative technologies is to allow team members to exchange opinions, even if they have arguments. They can use these technologies for interaction from distributed or co-located sites or even via mobile. Arguments (interaction) help people to enhance their understanding and criticism skills (Goleman, 2012) and this can lead to enhancing both trust and communication. For example, using Building Information Modelling helps stakeholders to exchange drawings, documentation, etc. and to make any amendments at the early stages (Koskela, 2013). Hence, all these contributing factors support the strength of the hypothesis concerning the added value of using these technologies in order to enhance stakeholders' relationships.

H1c: Integrated collaborative technologies can enhance knowledge sharing and awareness between the project partners (stakeholders)

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing knowledge sharing and awareness between the project partners (stakeholders) within a construction project environment is equal to the mean value that is μ=8.62. Moreover, for this sample n=24, the minimum value was 5 and the maximum was 10, and the values 8 and 9 were quite frequent compared to the others. Moreover, a smaller group of project managers provided answers with frequency 5 and 6. Finally, due to the atypically large value, the histogram (figure 4.3a) is slightly skewed to the left, or negatively skewed (-1.27). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	8.625
Standard Error	0.254043
Median	9
Mode	8
Standard Deviation	1.244553
Skewness	-1.27099
Range	5
Minimum	5
Maximum	10
Count	24
Confidence Level (95.0%)	0.525529

Figure 4.3a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis - H1c

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.24. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.52, or the values could be between μ=8.01 to μ=9.14. Thus at a significance level 0.05 and probability 95% the accepted range is: 8.01 <8.62 <9.14 (figure 4.3b).

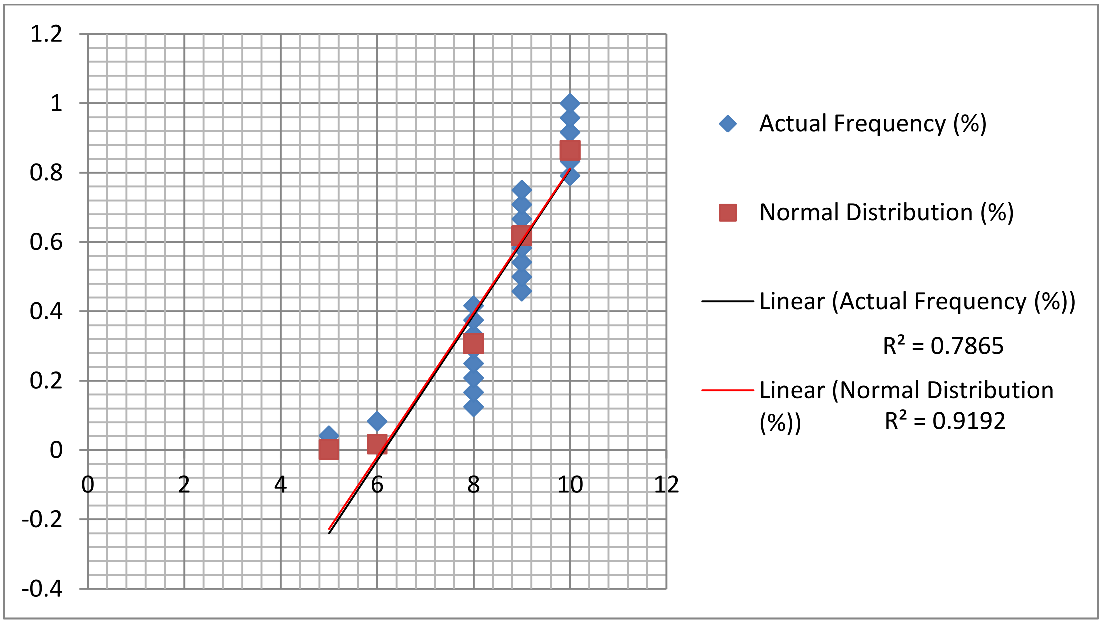


Figure 4.3b. Coefficient of Determination for sub-hypothesis H1c

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.78 and R^2 (Normal Distribution) = 0.91 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1c is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the enhancement of knowledge sharing and awareness between project partners (stakeholders). In particular:

- **Enhancing team collaboration**: These technologies allow "team members to access, and share/exchange data/information from anywhere at any time". Throughout this process team members can enter into a position to "gather complementary data/information" about a problem that could help them enhance their understanding and knowledge. Hence, this knowledge is powerful in solving problems faster and in an efficient way.

- **Pre–identify clients' requirements:** The pre-identification and collection of data/information from the client at an early stage allows team members to "understand coherently the client's requirements". Therefore, they conduct "virtual or physical meetings to identify and confirm the client data/information and to predict the project constraints that could affect project progress consequently". This level of understanding is considered as knowledge that helps them to make each other aware of information that has to be shared, discussed, analysed, and which produces knowledge. The only limitation which has been identified from the interviewees (architects and suppliers mainly) was whether the collected data are valid and have been provided by the right person.
- **Risk Identification**: Another way that knowledge is enhanced is "by sharing information between team members so as to identify project risks". In such a case team members meet virtually or physically to share, discuss and mitigate project risks. Throughout this process they become more familiar with the risks. Additionally, they have the technical capability of simulating and testing the methods of mitigating risks. Furthermore, it is possible to have an overview of the project risks by having access to additional project information e.g., labour, human hours, quantities, suppliers, costs, etc. For this type of information Enterprise Resource Systems (ERPs) are used.
- **Records for Best Practices**: At the end of each virtual or physical meeting the project manager and his/her team members have the technical capability to create new records/data after the completion of their meetings. These records can be retrieved in the future by authorised team members in order to support any future project. They can be used as "best practices" and to enhance new team members' understanding and knowledge of how to "win a new project or to improve a project process".

According to the above, integrated collaborative technologies that can significantly enhance the knowledge sharing and awareness between stakeholders and its contributing factors of supporting the hypothesis are listed in the following table 4.3:

H1c	**INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES**	**CONTRIBUTING FACTORS SUPPORTING THE HYPOTHESIS**
Enhancement knowledge sharing and awareness between stakeholders	• Project Information sharing • Project Information access • Virtual Meetings • Simulation	• Enhancing team collaboration • Pre–identify clients' requirements • Risks Identification: • Records for Best Practices /Key Success factors

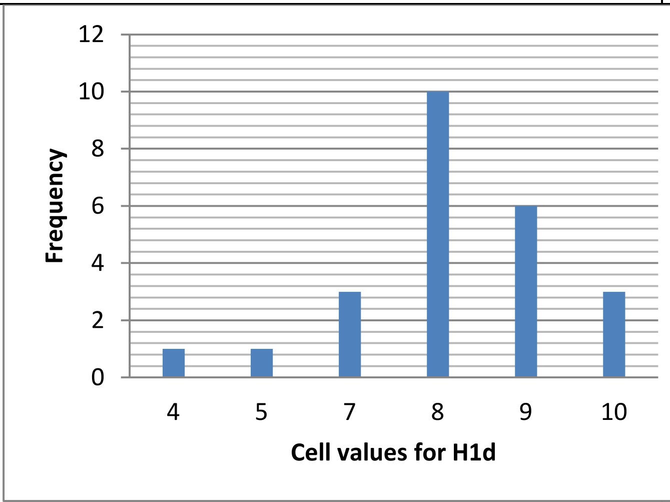
Table 4.3. Features and factors supporting sub-hypothesis H1c

In 'KPIs 2012', the UK Government report, it is clearly stated that the construction industry is lacking in terms of collaboration with project stakeholders, including the supply chain. Additionally, during the parliamentary meeting which took place in The House of Commons in June 2013, the Shadow Minister for Competitiveness and Enterprise stated that "the government is looking to design and develop a new strategy in order to enhance team collaboration by making extensive use of integrated collaborative technologies". The main reason that such statements are made at the present time is due to manufacturers' costs for the design and development of new products supporting the architecture, engineering and construction (AEC) industry. This cost is transferable directly to the contractor and indirectly to the client. As a result, this process leads to raising project risks such as "hidden project costs that are derived from the construction supply chain" for example. In addition to the above, another contributing factor is to keep records of past successful cases (Best Practices – Key Success factors) that could enable the design process of new projects to be more efficient. Hence, the added value of the effect of integrated collaborative technologies on the enhancement of knowledge sharing and awareness between the project partners (stakeholders) is to enhance team collaboration, to pre-identify client's requirements, to pre-identify project risks and to keep records of past successful cases.

H1d: Integrated collaborative technologies can enhance the common ground/understanding of the project brief.

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the understanding of the project brief within a construction environment is equal to the mean value that is μ=8.08. Moreover, for this sample n=24, the minimum value was 4 and the maximum was 10, and the values 8 and 9 were quite frequent compared to the others. Moreover, a smaller group of project managers provided answers with frequency 4 and 5. Finally, due to the atypically large value, the histogram (figure 4.4a.) is slightly skewed to the left, or negatively skewed (-1.27). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	8.083333
Standard Error	0.288152
Median	8
Mode	8
Standard Deviation	1.411649
Skewness	-1.27253
Range	6
Minimum	4
Maximum	10
Count	24
Confidence Level (95.0%)	0.596087

Figure 4.4a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis - H1d

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.41. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.59, or the values could be between μ=7.49 to μ=8.67. Thus at a significance level 0.05 and probability 95% the accepted range is: 7.49 <8.08 <8.67 (figure 4.4b).

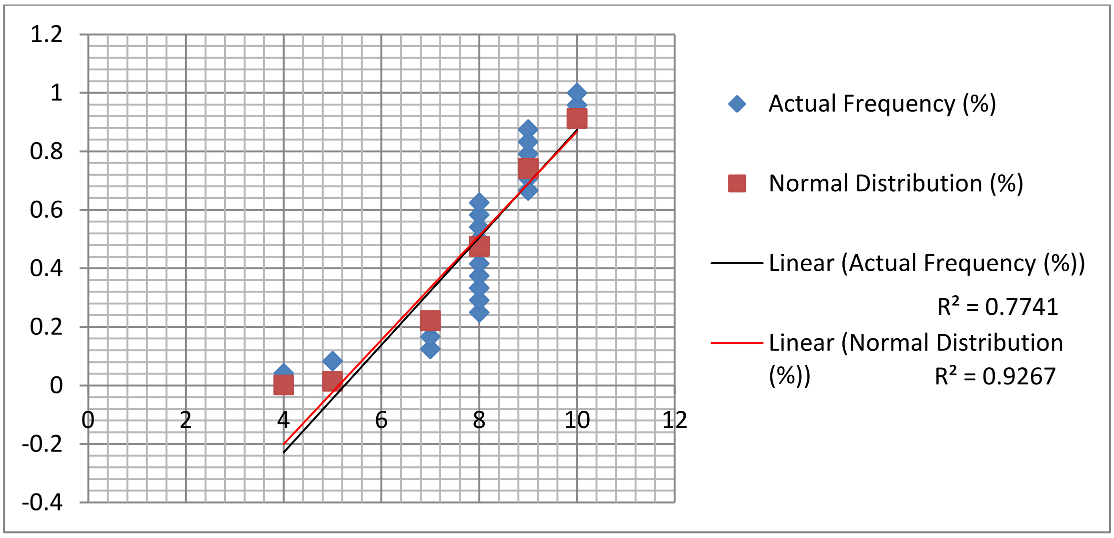


Figure 4.4b. Coefficient of Determination for sub-hypothesis H1d

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.77 and R^2 (Normal Distribution) = 0.92 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1d is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the enhancement of the understanding of the project brief. In particular:

- **Decision Making:** These technologies allow stakeholders to work collaboratively by sharing and exchanging information, experiences and understanding of the project's principles and thus to make "efficient decisions", as stated by the interviewees. Additionally, Decision Support Systems are also being used for support in making decisions. However, team members do not use them in an integrated format and, as a result, the combination of using virtual environments to meet and gain access to decision support systems, including access to project information, enhances the probability of understanding the project brief's details.
- **Problem Pre-Identification**: It is believed, according to the interviewees' responses, that an important factor of these technologies is in helping them to "pre–identify a problem in a construction environment" due to the nature of

sharing and accessing project information from anywhere at any time. In particular, interviewees believed that "access to data, information and past decisions" and "virtual collaboration" will help them to reconsider/rethink the aspects of an existing problem or even think of potential problems and to "identify new alternative ways of dealing with a problem" because they can "simulate and visualise" the consequences during the design phase of a project (online risk assessment exercise).

- **Design Procurement Strategy:** Considering procurement as a key element in a project's progress, interviewees stated that "the right use of these technologies impact on identifying project risks and thus on the selection of the right procurement method". In addition, it has been stated that "technologies could help clients to visualise, and thus to understand, both project process and project fit out within the tender documentation". Furthermore, as mentioned by the interviewees, there is a need to "use these technologies to identify, assess and visualise procurement risks within the supply chain (e.g., finances, delivery, quality, quantity, etc.)". One interviewee (a contractor) mentioned the importance of "Radio Frequency IDentification (RFID) technologies for logistics, product information, etc." This could eliminate the lack of communication between the supply chain and other stakeholders due to the capability of collaboration. The only concern mentioned was the "legal interpretation of these technologies on a contract basis" and "how fast the supply chain can adapt to these new techniques and to change their culture".

According to the above, integrated collaborative technologies that can significantly enhance the understanding of the project brief and its contributing factors in supporting the hypothesis are listed in the following table 4.4:

H1d	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS SUPPORTING THE HYPOTHESIS
Enhancement of understanding project brief	• Project Information sharing • Project Information access • Virtual Meetings • Enterprise Resources Planning Systems • Decision Support Systems • Sensor technologies	• Establishment of collaboration within the decision making process • Design Procurement Strategy • Pre–identify problems

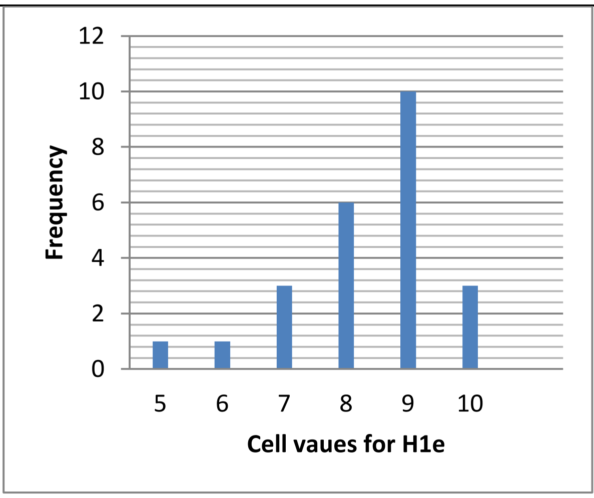
Table 4.4. Features and factors supporting sub-hypothesis H1d

Within the architecture, engineering and construction (AEC) sector the decision gates are presented as a part of the project management life cycle (PMBoK, 2009). In this research it has been shown that stakeholders find difficulties in designing a decision making process due to the nature of the involvement of a huge amount of people and different organisations (with different cultures). This is something that has to be changed: decisions need to be made efficiently and everybody involved should have a say (Briggs et al, 2002). Therefore, there is a need for the establishment of team collaboration during the project life cycle which will help the team to make efficient decisions synchronously. Additionally, the design of a procurement strategy is influenced at the early stage of a project, and technologies can therefore be used to enhance understanding about a project brief and about the procurement strategy in particular. Moreover, considering that project risk assessment is part of the feasibility study (PMBoK, 2008), technology could be involved so as to bring stakeholders together to discuss and decide the procurement strategy after considering and visualising potential risks. Hence, an additional added value of the usage of integrated collaborative technologies is to significantly enhance the understanding of the project brief so as to eliminate risks at an early stage of the project design.

H1e: Integrated collaborative technologies can enhance group processes (group effectiveness and performance)

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the group processes (effectiveness and performance) within a construction project environment is equal to the mean value, that is μ=8.33. Moreover, for this sample n=24, the minimum value was 5 and the maximum was 10, and the value of 9 was quite frequent compared to the others. The second more frequent response was 8. Moreover, a smaller group of project managers provided answers with frequency 5 and 6. Finally, due to the atypically large value, the histogram (figure 4.5a) is slightly skewed to the left, or negatively skewed (-1.00). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	8.333333333
Standard Error	0.253001308
Median	9
Mode	9
Standard Deviation	1.239448218
Skewness	-1.00193979
Range	5
Minimum	5
Maximum	10
Count	24
Confidence Level (95.0%)	0.523373081

Figure 4.5a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1e

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.23. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.52, or the values could be between μ=7.81 to μ=8.85. Thus at a significance level 0.05 and probability 95% the accepted range is: 7.81 <8.33 <8.85.

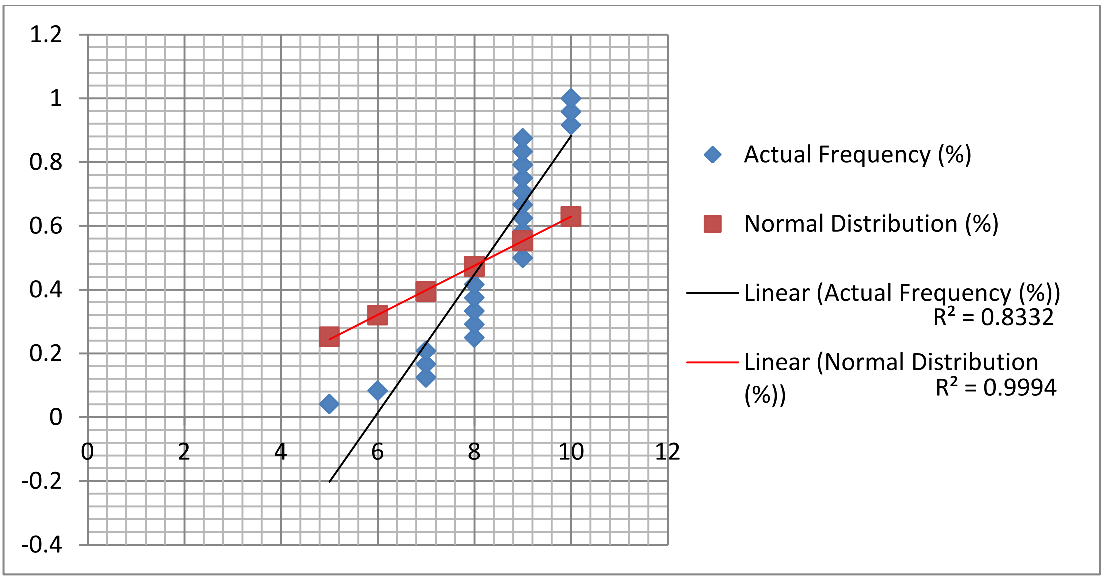


Figure 4.5b. Coefficient of Determination for sub-hypothesis H1e

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.83 and R^2 (Normal Distribution) = 0.99 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1e is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect group processes. In particular:

- **Human Interaction & Communication:** During a virtual meeting team members observe (visualise) how other team members react during the session. In addition, according to the interviewees, team members "feel more confident to match a name with a face" and to understand "project politics". Communication and Politics are the two main factors that could affect the group process based upon interviewees' opinions: "both can have a negative or positive effect on project delivery, cost distribution and quality mainly".
- **Group Performance Risk Identification**: Another way that knowledge is enhanced is "by sharing information between team members so as to identify project groups' risks". In such a case team members can meet virtually or physically to share, discuss and mitigate the groups' risks. Throughout this process they become more familiar with these risks. Additionally, they have the

technical capability of simulating and testing the ways of mitigating these risks. Furthermore, it is possible to have an overview of the project risks by having access to group external factors that could affect the enhancement of the group process. In order for this to be achieved, team members must be "willing and motivated" to express possible external factors that could affect group performance, e.g., sickness, personal problems, etc.

- **Enhancing Team Collaboration**: These technologies allow "team members to access and share/exchange data/information from anywhere at any time". Throughout this process, team members enter into a position to "gather complementary data/information" about a problem that could help them to enhance their understanding and knowledge. This knowledge could be powerful in assisting in solving problems in a faster and more efficient way.
- **Supply Chain Management:** The procurement process is controlled by these technologies during the project management life cycle. However, due to the simulation technical capability to test products during the digital design of a project this "increases the usability of these technologies for the benefit of the client (investor) in terms of quality, transparency, sustainability etc." An example that was provided by the supply chain interviewees was that "using these technologies while a project is being designed means that team members can communicate, test and order products for their projects". Throughout this process team groups exchange and share project requirements in order to enhance their performance.
- **Data Process:** This contributing factor allows team members to "distribute/share information/data with the right person from anywhere at any time". According to the interviewees where data do not reach the right person this could affect group process and, consequently, the project process viability. Therefore, it is vital for the project manager and the team members to have the right data/information and to process it to the right person.

According to the above, integrated collaborative technologies that can significantly enhance the understanding of a project brief and its contributing factors of supporting the hypothesis are listed in the following table 4.5:

H1e	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS SUPPORTING THE HYPOTHESIS
Enhancement of understanding group processes	• Project information access • Project information sharing • Connect from anywhere at any time • Virtual Meetings • 3D simulation • Sensor Technologies • CWE	• Human Interaction & Communication • Group Performance Risk identification • Enhancing team collaboration efficiency • Design Supply chain management strategy • Organisation and Workflow of Project Data/Information

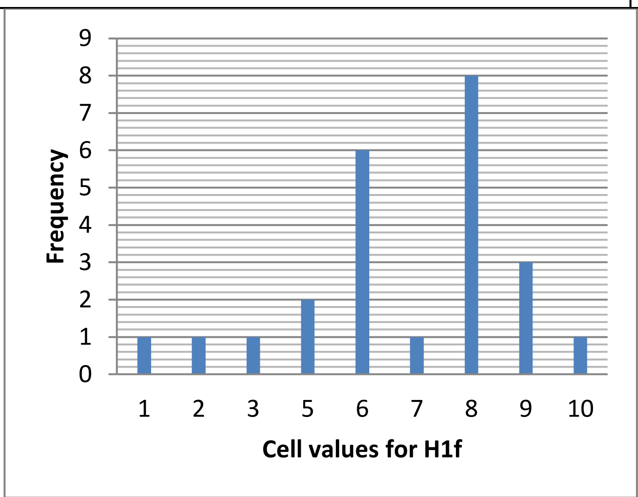
Table 4.5. Features and factors supporting sub-hypothesis H1e

Human interaction and communication is a contributing factor that is imposed by the extensive use of technologies. In particular, human interaction and communication is a factor that aims to enhance communication between team members (Fasel, 2001). Technology can efficiently optimise this process and can affect the group performance risk identification that aims to highlight possible project deficiencies that could affect group progress (Harvey, 2000) by testing them (simulation) and then making appropriate decisions on how to deal with them. Moreover, the contributing factor of enhancing the efficiency of team collaboration is supported by Marttiin (2002) who said that “team collaboration is a strong element in making a team work but what has to be worked out is how to make the team efficient”. Integrated collaborative technologies bring the added value of working “from home” or “from anywhere” by “internet access” and “information access” respectively. McDermott (2005) stated that a construction project without a supply chain management strategy is unlikely to meet its procurement strategy criteria. Therefore, the design of a supply chain management strategy enhances the added value of these technologies by tracking their products and providing access to an amount of information, e.g., product details, quality, quantity, etc. Without its participants having access to appropriate data/information a project cannot move towards the design of the project itself. There is added value of such technologies if team members can organise the data/information so as to have easy access to them when and as required. Hence, an additional added value of the usage of integrated collaborative technologies is to significantly enhance the understanding of group process in a manner so as to eliminate related risks during the project management life cycle.

H1f: Integrated collaborative technologies can enhance collaboration in terms of the heterogeneity and the size of a team

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing collaboration in terms of the heterogeneity and the size of a team within a construction project environment is equal to the mean value that is μ=6.6. Moreover, for this sample n=24, the minimum value was 1 and the maximum was 10, and the value of 8 was quite frequent compared to the others. The second most frequent response was 6. Moreover, a smaller group of project managers provided answers with frequency 1, 2 and 3. Finally, due to the atypically large value, the histogram (figure 4.6a) is slightly skewed to the left, or negatively skewed (-1.02). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.666667
Standard Error	0.461043
Median	7.5
Mode	8
Standard Deviation	2.258639
Skewness	-1.02819
Range	9
Minimum	1
Maximum	10
Count	24
Confidence Level (95.0%)	0.95374

Figure 4.6a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1f

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.25. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.95, or the values could be between μ=5.71 to μ=7.61. So at a significance level 0.05 and probability 95% the accepted range is: 5.71 <6.66 <7.61 (figure 4.6b).

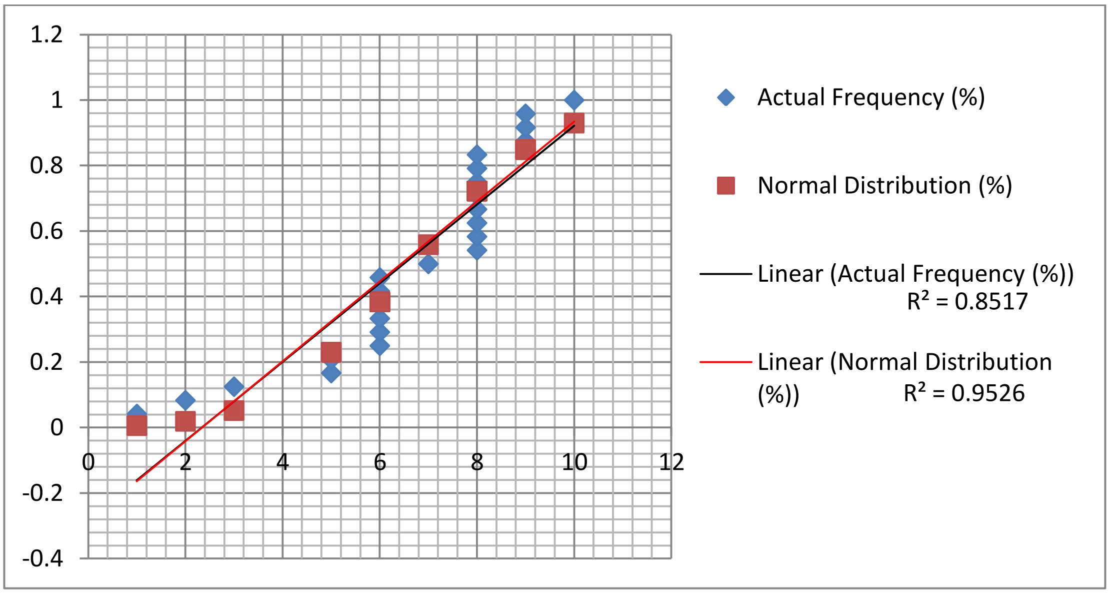


Figure 4.6b. Coefficient of Determination for sub-hypothesis H1f

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1f is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect collaboration in terms of the heterogeneity and the size of a team. In particular:

- **Pre-identification of Team Members' Background, Culture and Skills:** In particular interviewees stated that these technologies could help project managers and their team members enhance their understanding of "peoples' background, culture and skills". Furthermore, project managers stated the importance of "information access and information sharing" before the appointment of a team in order to secure heterogeneity within the team.

- **Personal Development:** This allows project managers to identify gaps within the teams' knowledge and as a result allows "virtual training" to be offered. (The only requirement is access to the Internet and a willingness to be trained). This will impact on teams' productivity and performance respectively.
- **People Management:** This allows project managers to "control their team members from anywhere at any time – virtual control". This control allows project managers to have access to certain project stages and to check whether everything is in place, e.g., time, costs, labours, progress, etc.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance collaboration in terms of the heterogeneity and the size of a team and the ways in which they do this are listed in the following table 4.6.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of collaboration in terms of the heterogeneity and the size of the team	• Project information access • Synchronous & Asynchronous connectivity • Virtual Meeting • Virtual Team Control • Virtual Training	• Team Development • People Management • Pre-identify culture and skills

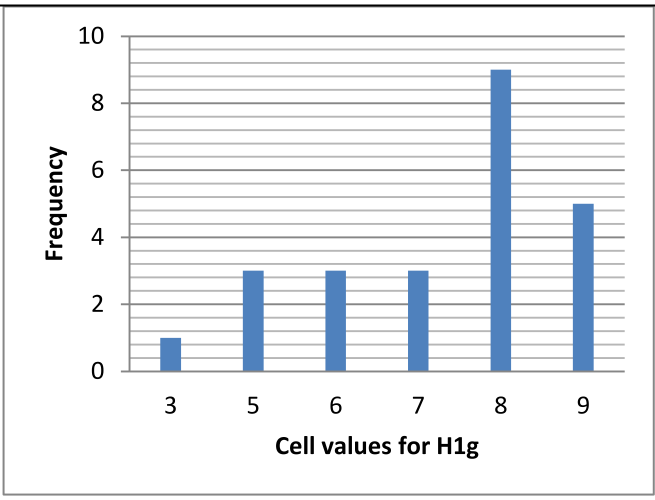
Table 4.6. Features and factors supporting sub-hypothesis - H1f

Team development is an important competence that has to be taken on board by team members if they want to become future project managers. Online education is popular and the demand to follow online sessions has increased significantly. In order to be “attractive” many of these courses are accredited. Accreditation refers to professionally qualified, approved courses that will provide added value to projects and to organisations UK (CIOB, 2012). It has been said that BIM, Sustainability and Team Collaboration are three of the most popular course subjects in the UK (CIOB, 2012). Additionally, project managers will be in a position to control team members synchronously as well as to pre-identify members’ background, culture and skills. Hence, an additional added value of the usage of integrated collaborative technologies is to significantly enhance the homogeneity and size among teams.

H1g: Integrated collaborative technologies can enhance the interaction processes between the project’s stakeholders in terms of learning

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the interaction processes between the project’s stakeholders in terms of learning within a construction project environment is equal to the mean value that is $\mu=7.25$. Moreover, for this sample $n=24$, the minimum value was 3 and the maximum was 9, and the value of 8 was quite frequent compared to the others. The second more frequent response was 9. Moreover, a smaller group of project managers provided answers with frequency 3, 5, 6 and 7. Finally, due to the atypically large value, the histogram (figure 4.7a) is slightly skewed to the left, or negatively skewed (-1.00). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.25
Standard Error	0.325543
Median	8
Mode	8
Standard Deviation	1.594829
Skewness	-1.0085
Range	6
Minimum	3
Maximum	9
Count	24
Confidence Level (95.0%)	0.67344

Figure 4.7a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1g

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.59. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.67, or the values could be between μ=6.58 to μ=7.61. Thus at a significance level 0.05 and probability 95% the accepted range is: 6.58<7.25 <7.92 (figure 4.7b).

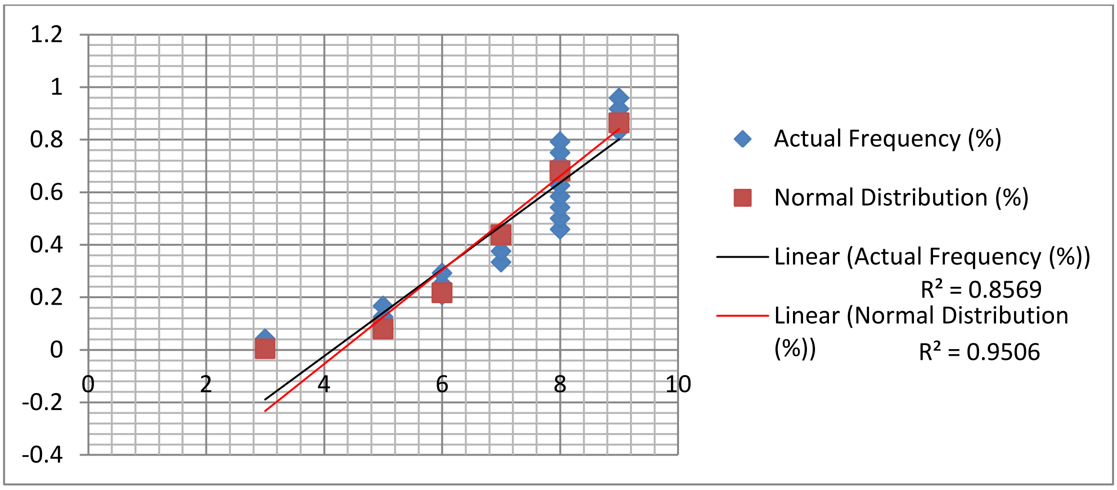


Figure 4.7b. Coefficient of Determination for sub-hypothesis H1g

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1g is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect interaction processes between the project's stakeholders in terms of learning. In particular:

- **Personal Development:** This allows project managers to identify gaps within the teams' knowledge and consequently for "virtual training" to be offered. (The only requirement is access to the Internet and a willingness to be trained). This will impact on teams' productivity and project performance respectively.
- **Key Success Factors (KSF):** Interviewees stated that they can "learn a lot from the past". Therefore, they need to create a database whereby they can access whatever is needed. This will help them to "identify project standards" and will give them the "competitive advantage of win–win projects". Therefore, it is believed that the added value of these technologies will benefit the construction company and also the client in turn as long as he/she is satisfied with the final deliverable (client satisfaction is a performance indicator).

Therefore, there are actual influences whereby integrated collaborative technologies can significantly enhance the interaction processes between the project's stakeholders in terms of learning within a team and the ways in which they do this are listed in the following table 4.7.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the interaction processes between the	• Project information access and sharing • Virtual Training (both synchronous and	• Personal Development • Key Success Factors

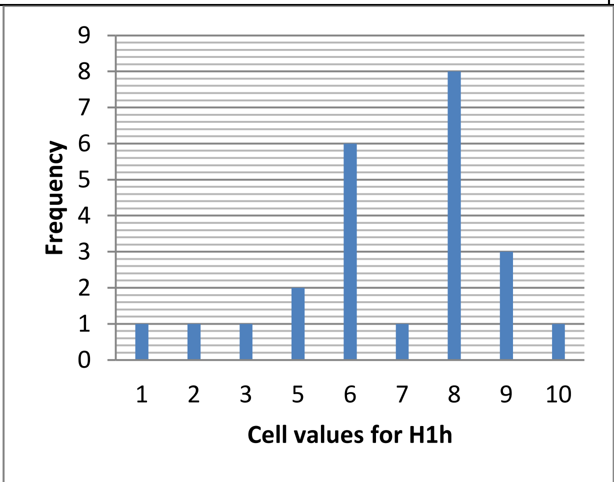
project's stakeholders in terms of learning	asynchronous)	

Table 4.7. Features and factors supporting sub-hypothesis H1g

H1h: Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of coordination

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the interaction processes between the project's stakeholders in terms of coordination within a construction project environment is equal to the mean value that is μ=8.41. Moreover, for this sample n=24, the minimum value was 5 and the maximum was 10, and the value of 8 was quite frequent compared to the others. The second more frequent response was 9. Moreover, a smaller group of project managers provided answers with frequency 5 and 7. Finally, due to the atypically large value, the histogram (figure 4.8a) is slightly skewed to the left, or negatively skewed (-1.11). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	8.416667
Standard Error	0.216332
Median	8
Mode	8
Standard Deviation	1.059806
Skewness	-1.19648
Range	5
Minimum	5
Maximum	10
Count	24
Confidence Level (95.0%)	0.44752

Figure 4.8a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1h

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.05. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.44, or the values could be between μ=7.97 to μ=8.85. Thus at a significance level 0.05 and probability 95% the accepted range is: 7.97<8.41 <8.85 (figure 4.8b).

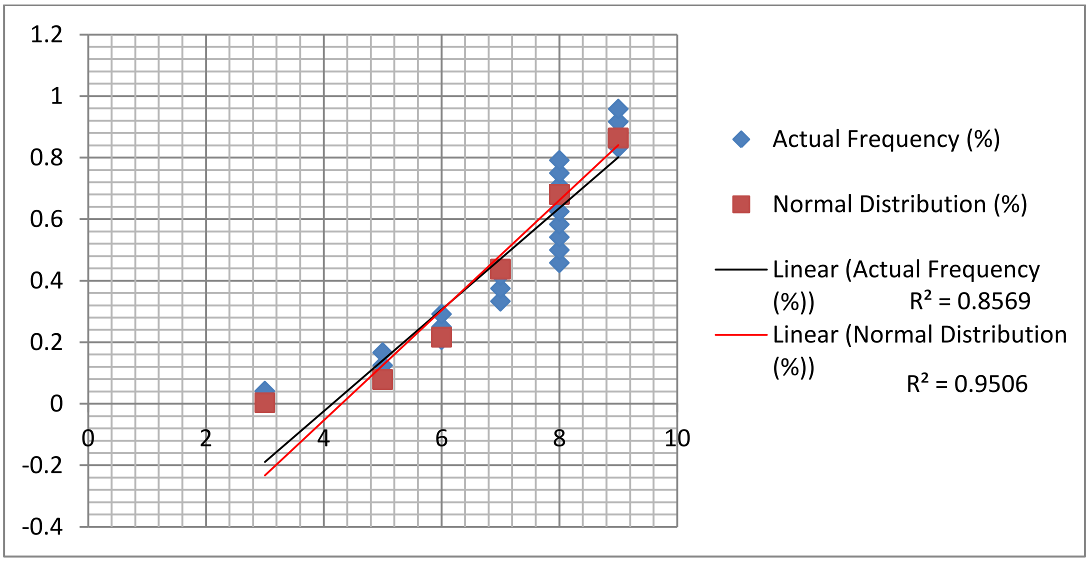


Figure 4.8b. Coefficient of Determination for sub- hypothesis H1h

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1h is accepted.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance the interaction processes between the project's stakeholders in terms of coordination. In particular:

- **Pre-identify the Project Brief:** The need to pre-identify the project brief was found to be a major factor for the interviewees as long as this was the first stage for the design of a project as part of the project management life cycle. In order to produce the actual feasibility study the team members, including the project manager, can virtually and physically join the meeting, where they have access to project information from anywhere at any time and share information in order to coordinate the task/project. Additionally, the team can keep records and retrieve them in future meetings in order to complete or justify a case when necessary. Therefore, such harmonious technological integration (including collaboration, accessibility and information exchange) enhances the interaction processes between the project's stakeholders in terms of coordination.

- **Project Organisational Structure:** The technologies help a project manager to design his/her project organisational structure. It was stated that "the capacity of these technologies to support Virtual Meetings helps them to work from anywhere in order to coordinate the project without considering the geographical location of the team members". Additionally, team members have access to information where they can make amendments in a manner that will satisfy the project's requirements for efficient coordination.

Design Constraints in a project. Without having to consider team members' locations the project manager can be in an appropriate position to "design constraints in a project" due to the capacity of these technologies to support "Virtual Meetings", "Distributed Engineering Design" and "Information Sharing". These three main features allow project managers and stakeholders to bridge client requirements. In certain circumstances they could use "simulation" to test design constraints so as to reduce design risks. Interviewees believed that the interactive use of these technologies can also affect project coordination.

Therefore, there are actual influences whereby integrated collaborative technologies can significantly enhance the interaction processes between the project's stakeholders in terms of coordination.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the interaction processes between the project's stakeholders in terms of coordination.	• Project information access • Project information sharing • Connecting from anywhere at any time • Virtual Meetings • Simulation	• Project Organisational Structure • Design Constrains • Pre-identify project brief

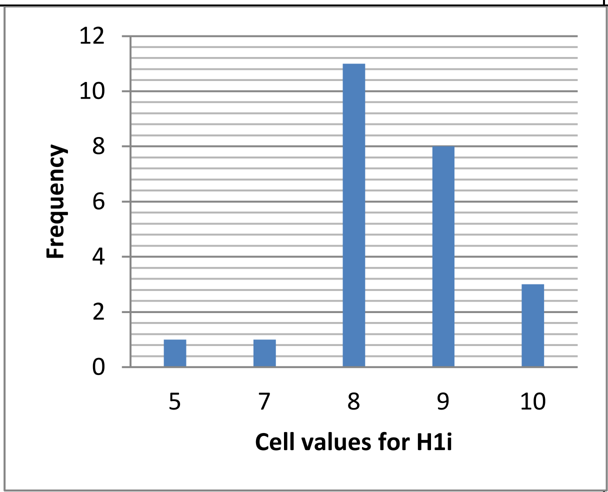
Table 4.8. Features and factors supporting sub-hypothesis - H1h

Project Organisational structure and the pre-identification of critical path in a project are considered as part of the first important stage (preparation) of the design process of the project management life cycle (phases A and B according to the new RIBA Plan of Work, 2013). The identification of design constraints in a project are listed during the second stage (design) of the design process of the project management life cycle (phases C, D and E according to the new RIBA Plan of Work, 2013). All these contributing factors depend on project data/information but the most important factor is whether the attached data/information is correct. Therefore, integrated collaborative technologies add value to projects because end users (team members) can enter project data from either co-located or distributed sites or via a mobile from a live construction site. Therefore, it is vital for the enhancement of the interaction process between team members to consider the above contributing factors when using integrated collaborative technologies.

H1i: Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of communication

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the interaction processes between the project's stakeholders in terms of communication within a construction project environment is equal to the mean value that is μ=8.54. Moreover, for this sample n=24, the minimum value was 5 and the maximum was 10, and the value of 9 was quite frequent compared to the others. The second more frequent response was 8. Moreover, a smaller group of project managers provided answers with frequency 5 and 7. Finally, due to the atypical large value, the histogram (figure 4.9a) is slightly skewed to the left, or negatively skewed (-1.26). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	8.541667
Standard Error	0.232964
Median	9
Mode	9
Standard Deviation	1.141287
Skewness	-1.26019
Range	5
Minimum	5
Maximum	10
Count	24
Confidence Level (95.0%)	0.48192

Figure 4.9a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1i

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.14. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.48, or the values could be between μ=8.06 to μ=8.98. Thus at a significance level 0.05 and probability 95% the accepted range is: 8.06<8.54 <8.98 (figure 4.9b).

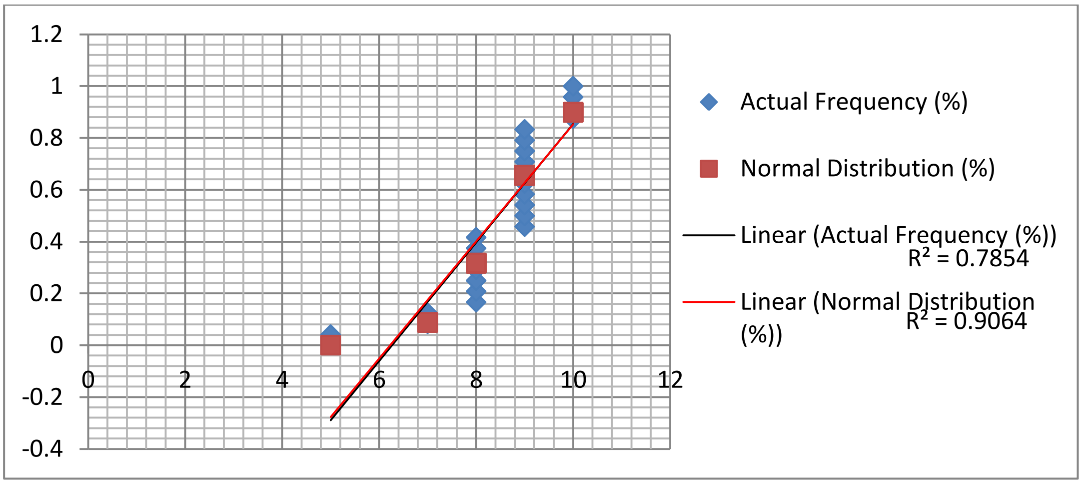


Figure 4.9b. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1i

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.78 and R^2 (Normal Distribution) = 0.90 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1i is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the interaction processes between the project's stakeholders in terms of communication. In particular:

- **Information Process:** This effect process allows team members to "distribute/share information/data with the right person from anywhere at any time". According to the interviewees, in the cases where data do not reach the right person this could affect not only project performance but also project viability. Therefore, it is vital for the project manager and the team members to have the right data/information and to process it to the right person.
- **Conflict Avoidance:** The more clarity there is in a team in terms of who is doing what, the more efficiently project planning can be designed. In a project it is compulsory for the project manager to include, e.g. the project brief, in the feasibility study of the project management life cycle. In order to obtain the actual feasibility study the team members can virtually and physically join the meeting, where they can have access to project information from anywhere at any time and

can share it in order to make corrections and validate the project information in order to eliminate project risks. Additionally, the team can keep records and retrieve them in future meetings in order to complete or justify a case where necessary. Therefore, such harmonious technological integration (including collaboration, accessibility and information exchange) allows the interaction process between stakeholders to be enhanced in terms of communication.

Develop Trust: All the way through the process where a team member requests data, information or a past decision from another team member(s), intercommunication and interactive dialogue is created and thus, it is believed, that this assists in the drive towards developing trust. The main requirement recommended by the interviewees is “sharing accurate information”. Technically, the information sharing protocol includes xtensible markup language ("XML"), simple object access protocol ("SOAP"), and web services description language ("WSDL"). In order to meet all four of these design patterns, technologies are evolving and include blogs, wikis, really simple syndication, tagging and chat. These aim to keep the interaction process between stakeholders enhanced in terms of communication.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance interaction processes between the project’s stakeholders in terms of communication in order to improve the information process, develop co-worker trust and team collaboration, and the ways in which they do this are listed in the following table 4.9.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the interaction processes between the project's stakeholders in terms of communication	• Project information access • Project information sharing • Connect from anywhere at any time • Virtual meeting • Blogs, wikis, really simple syndication, tagging and chat	• Information process • Conflict avoidance • Develop Trust

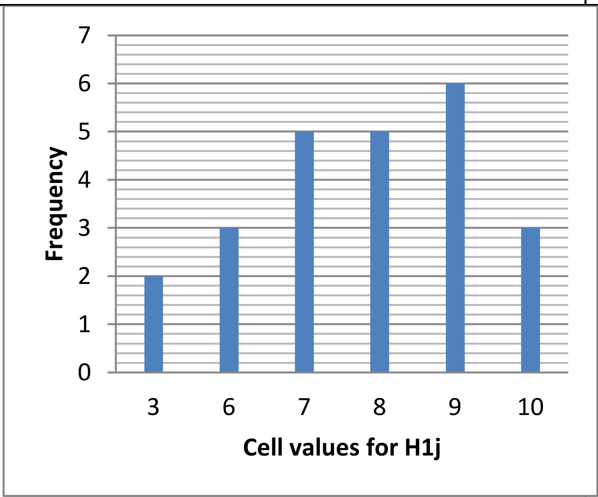
Table 4.9. Features and factors supporting sub-hypothesis - H1i

According to Egbu (1999), a project manager has to be, amongst other factors, accountable. Accountability relates to trust and team members have to learn how to develop trust as well as how to avoid conflicts in a project. Both these contributing factors affect project progress and can affect team members' self-confidence., which in turn could affect the progress of the project. Therefore, integrated collaborative technologies can support team members' conversations and dialogues regardless of where they are located. In addition, the factor of Organisation and Workflow of Project Data/Information plays an important role in ensuring smooth project progress in the operational stages. Therefore, technologies play a significant role in the operational process of a project. According to research, the lack of use of these technologies is a fact of life and senior project managers have to invest in the development of these skills in their team members. According to the Eye of Competences (2006) the organisational and project workflow is critical in order to progress the right information at the right moment to the right person. Therefore, it is vital for the enhancement of the interaction process between team members to consider the above contributing factors by using integrated collaborative technologies for better communication.

H1j: Integrated collaborative technologies can enhance the interaction processes between the project's stakeholders in terms of decision making

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the interaction processes between the project's stakeholders in terms of decision making within a construction project environment is equal to the mean value that is $\mu=7.62$. Moreover, for this sample $n=24$, the minimum value was 3 and the maximum was 10, and the value of 9 was quite frequent compared to the others. The second more frequent responses 7 and 8 were equally frequent. Moreover, a smaller group of project managers provided answers with frequency 5 and 6. Finally, due to the atypically large value, the histogram (figure 4.10a) is slightly skewed to the left, or negatively skewed (-1.10). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	7.625
Standard Error	0.38454
Median	8
Mode	9
Standard Deviation	1.883856
Skewness	-1.10607
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.795483

Figure 4.10a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1j

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.88. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.79, or the values could be between μ=6.83 to μ=8.41. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=6.83 <7.62 <8.41 (figure 4.10b).

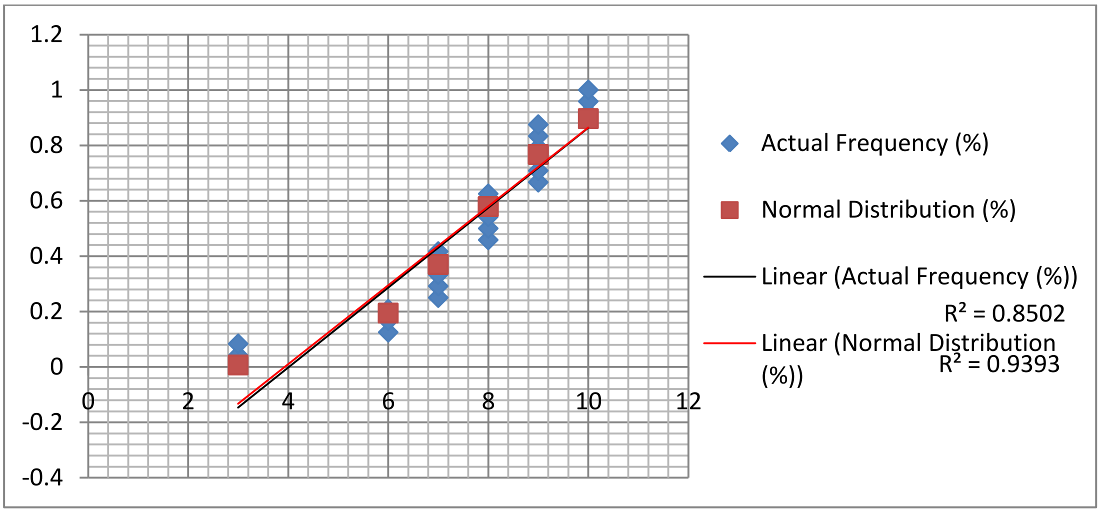


Figure 4.10b. Coefficient of Determination for sub-hypothesis H1j

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.93 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1j is accepted.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance the interaction processes between the project's stakeholders in terms of making decisions within a team, and the ways in which they do this are listed in the following table 4.10. In particular:

- **Team Collaboration:** This allows team members to "distribute/share information/data with the right person from anywhere at any time". According to the interviewees, in such cases, if data do not reach the right person this could affect not only project performance but also project viability. Therefore, it is vital for the project manager and the team members to have the right data/information and to process it to the right person for the right decision to be made. Technologies, because they keep and track records, allow the interaction process between stakeholders to be enhanced in terms of decision making.

- **Conflict Avoidance:** The more clarity there is in a team in terms of who is doing what, the more efficiently project planning can be designed. In a project it is compulsory for the project manager to include, e.g. the project brief, in the feasibility study of the project management life cycle. In order to produce the actual feasibility study the team members can virtually and physically join the meeting, where they can have access to project information from anywhere at any time and share it in order to make corrections and validate project information in order to eliminate project risks. Additionally, the team can keep records and retrieve them in future meetings in order to complete or justify a case where necessary. Therefore, such harmonious technological integration (including collaboration, accessibility and information exchange) allows the interaction process between stakeholders to be enhanced in terms of decision making.
- **Problem Pre-Identification**: It is believed, according to the interviewees' responses, that an important factor of these technologies is in helping participants to "pre–identify a problem in a construction environment" due to the nature of sharing and accessing project information from anywhere at any time. In particular, interviewees believed that "access to data, information and past decisions" and "virtual collaboration" will help them to reconsider/rethink the aspects of an existing problem or even think of potential problems and allow them to "identify new alternative ways to undertake a problem" because they can "simulate and visualise" the consequences during the design phase of a project (online risk assessment exercise). Thus, the technological integration of the above features allows the interaction process between the stakeholders to be enhanced in terms of decision making.

Therefore, there are actual influences whereby integrated collaborative technologies can significantly enhance the interaction processes between the project's stakeholders in terms of making efficient decisions within a team, and the ways in which they do this are listed in the following table 4.10.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the interaction processes between the project's stakeholders in terms of making decisions.	• Project Information access • Project Information sharing • Connect from anywhere at any time • Databases • Data Mining • Virtual Meetings	• Problem pre-identification • Team Collaboration • Problem Avoidance

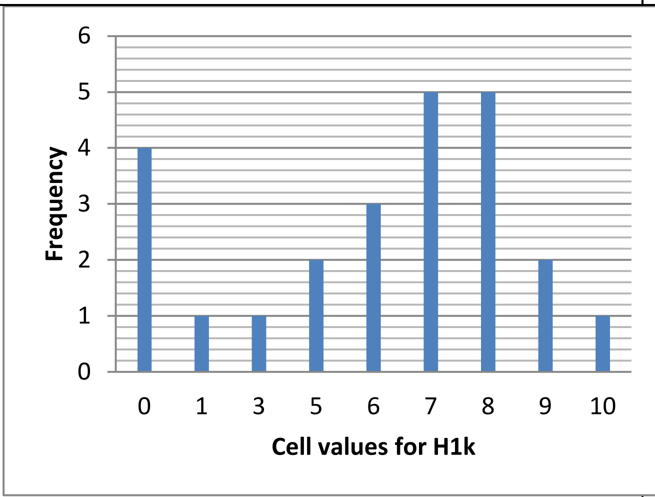
Table 4.10. Features and factors supporting sub-hypothesis - H1j

Decision making and the 'gates' where decisions must be made occur all the time within the project management life cycle. These are made in order to solve project problems and the use of technologies provides competitive advantage by sharing the particular data that are required in order to make efficient decisions (Pinto, 2007) In addition to this factor, conflict avoidance and the pre-identification of problems contribute to the enhancement of the interaction process between team members when using integrated collaborative technologies. This is achieved because of the capability of such technologies to bring together different stakeholders so as to make efficient decisions. Thus easy access to data/information via co-located, distributed and mobile communication significantly helps the interaction process between the team members. Consequently, it can be stated that the hypothesis is accepted.

H1k: Integrated collaborative technologies can enhance the structure of a project: Organisational Breakdown Structure

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the design of the structure (the organisational breakdown structure) of a project within a construction project environment is equal to the mean value that is $\mu=5.79$. Moreover, for this sample n=24, the minimum value was 0 and the maximum was 10, and the values of 7 and 8 were equal frequent responses compared to the others. The second more frequent response was 0. Moreover, a smaller group of project managers provided answers with frequency 1 and 2. Finally, due to the atypically large value, the histogram (figure 4.11a) is slightly skewed to the left, or negatively skewed (-0.91). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	5.791667
Standard Error	0.61083
Median	7
Mode	7
Standard Deviation	2.992442
Skewness	-0.91699
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	1.263598

Figure 4.11a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1k

Moreover, the Standard Deviation (SD) between the data and the mean is SD=2.99. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 1.26, or the values could be between μ=4.53 to μ=7.05.Thus at a significance level 0.05 and probability 95% the accepted range is: μ=4.53 <5.79 <7.05 (figure 4.11b).

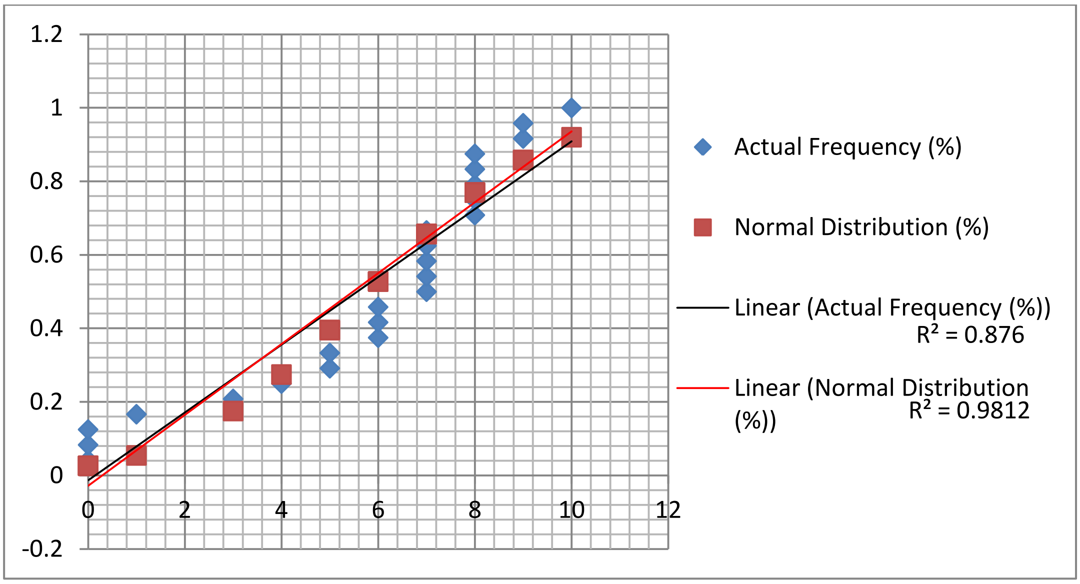


Figure 4.11b. Coefficient of Determination for sub-hypothesis H1k

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.87 and R^2 (Normal Distribution) = 0.98 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1k is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the design of the organisational breakdown structure. In particular:

- **Selection of the Right Team Members:** Interviewees found these technologies useful at the project design phase, where the project manager needs to contact and meet with other team members so as to set and design the organisational breakdown structure (OBS). In particular, the interviewees believed that the unique competitive advantage of integrated collaborative technologies in "connecting from anywhere at any time" allowed them to meet virtually. According to their responses, the biggest assets are "saving time", "making quick and efficient decisions", "saving money" and "sharing and filtering information synchronously between two or more team members"; all these during the selection process. As a result, when difficulties occurred during the setup of the OBS of a project, and team members were not at the office or the project was based in a remote area, project managers "found these technologies powerful and useful to their project process" – this in spite of the fact that they were expensive to buy and difficult to use in the beginning. Moreover, they could use these technologies to find the right person with the right qualifications to be placed in the organisational breakdown structure respectively. Therefore, by this technological integration team members can enhance the design of the organisational breakdown structure.

- **Team Collaboration:** This affect allows team members to "distribute/share information/data with the right person from anywhere at any time". According to the interviewees, in such cases if data do not reach the right person that could affect not only project performance but also project viability. Therefore, it is vital for the project manager and the team members to have the right data/information and to process it to the right person so the right decision can be made. Technologies, because they keep and track records, allow the interaction process between stakeholders to be enhanced in terms of designing the organisational breakdown structure.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance the structure of a project (Organisational Breakdown Structure – OBS) and the ways in which they do this are listed in the following table, table 4.11.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the structure of a project (Organisational Breakdown Structure – OBS)	• Project Information access • Project Information sharing • Connect from anywhere at any time • Synchronous connection • Virtual Meetings	• Roles and Responsibilities • Select right people • Team Collaboration

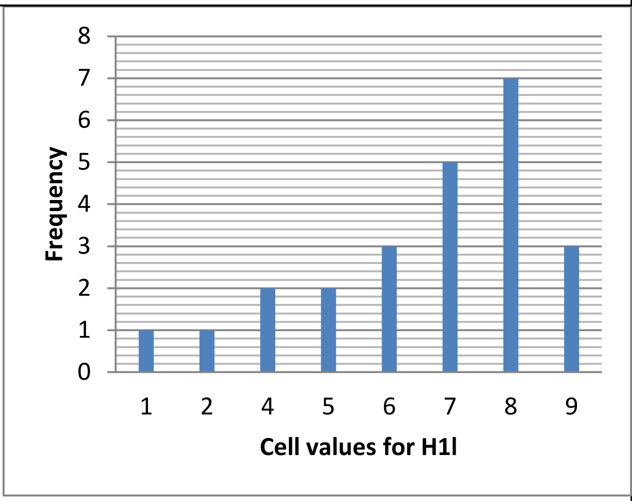
Table 4.11. Features and factors supporting sub-hypothesis - H1k

Team roles, including responsibilities, allocated to each role and the selection of the right people, are the main contributing factors that support this sub-hypothesis. According to Kerzner (2006) a smooth design for an organisational breakdown structure requires the skill, initially, of understanding the need/task that has to be completed and then based upon this understanding the project manager has to select the right person. For this purpose, the project manager and the team members need access to the data/information of the candidates. Therefore, online services are part of the integrated collaborative technologies which help to design a strong organisational breakdown structure. Moreover, collaboration and coordination with other partners is required in order to interview candidates virtually. During the virtual interview the panel will be in a position to distinguish the strong skills of the candidate - but it is the case that interviewers do not always feel very secure in using online face-to-face communication (this is the only limitation that has been identified and is something that Panteli (2004) mentioned in his research paper). Nevertheless, the enhancement of the design of the OBS can be achieved by using integrated collaborative technologies.

H1l: Integrated collaborative technologies can enhance the structure of a project: Work Breakdown Structure

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the design of the structure (the work breakdown structure) of a project within a construction project environment is equal to the mean value, that is $\mu=6.5$. Moreover, for this sample $n=24$, the minimum value was 0 and the maximum was 10, and the value of 8 was a frequent response compared to the others. The second most frequent response was 7. Moreover, a smaller group of project managers provided answers with frequency 1 and 2. Finally, due to the atypically large value, the histogram (4.12a) is slightly skewed to the left, or negatively skewed (-1.39). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.5
Standard Error	0.458416
Median	7
Mode	8
Standard Deviation	2.245769
Skewness	-1.39447
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	0.948305

Figure 4.12a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1l

Moreover, the Standard Deviation (SD) between the data and the mean is SD=2.249. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.94, or the values could be between μ=4.53 to μ=7.05. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=5.56 <6.5 <7.44 (figure 4.12b).

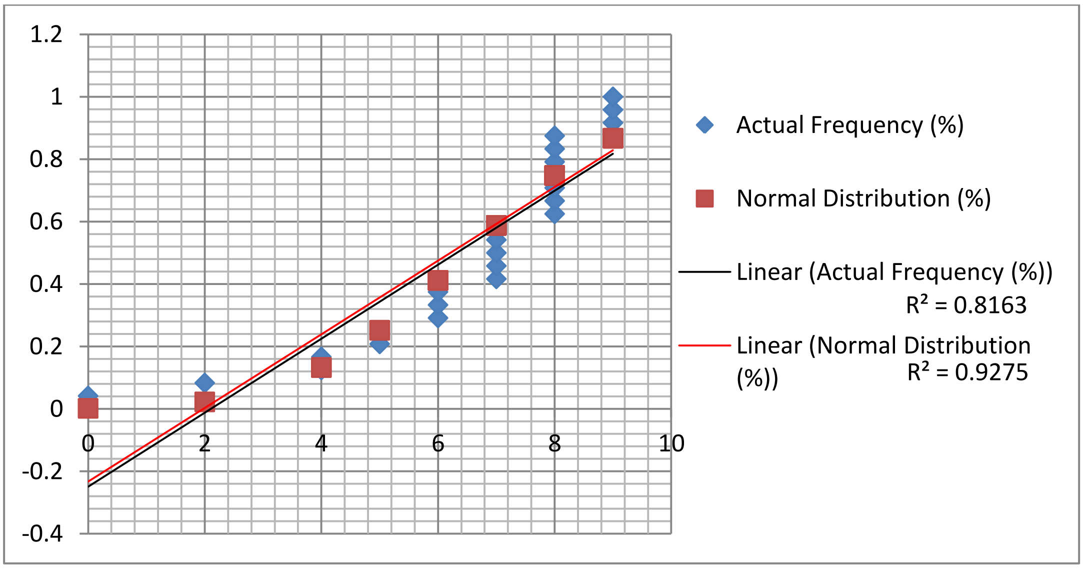


Figure 4.12b. Coefficient of Determination for sub-hypothesis H1l

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1l is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the design of the Work Breakdown Structure of a project. In particular:

- **Team Communication/Collaboration:** This affect allows team members to "distribute/share information/data with the right person from anywhere at any time". According to interviewees, the work breakdown structure is "a difficult process that requires experience and collaborative partners". In addition, they stated that they benefit from the use of these technologies due to the direct access to project information so as to match the right person per project task/activity. Their only concern was whether they had employed the right professionals. If the appropriate people are not in place there is a negative impact on project performance and also on project viability. Therefore, it is vital for the project manager and team members to have access to, and share, the right data/information.
- **Select the Right Team Members:** Interviewees found these technologies useful in the project design phase, where the project manager needs to contact and meet with other team members so as to set and design the work breakdown structure (WBS). In particular, the interviewees believed that the unique competitive advantage of integrated collaborative technologies was in "connecting from anywhere at any time" allowing them to meet virtually. According to their responses, the biggest assets were "saving time", "making quick and efficient decisions", "saving money" and "sharing and filtering information synchronously between two or more team members"; all these during the selection process of what activities have to be completed by each team member. As a result, when difficulties occurred during the setup of the WBS of a project, and team members were not at the office or the project was based in a remote area, project managers

"found these technologies powerful and useful to their project process" – this in spite of the fact that they were expensive to buy and difficult to use in the beginning. Moreover, they could use these technologies to identify the right person for each task so they could be included in the work breakdown structure. Therefore, due to this technological integration, team members can enhance the design of the work breakdown structure.

- **Design Project Schedule (Programme):** In such a case a project manager is in a position to use these technologies, e.g. 3D Modelling so as to visualise a problem, interactive and collaborative information, access project information (ERPs) and simulation in order to evaluate. If all the above are working interactively/integratedly this impacts on the design of the Work Breakdown Structure of a project.

Therefore, there are actual influences whereby integrated collaborative technologies can significantly enhance the design of the work breakdown structure within a team and the ways in which they do this are listed in the following table 4.12.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancement of the design of the work breakdown structure of a project	• Project Information access • Project Information sharing • Connect from anywhere at any time • Synchronous and Asynchronous connection • ERPs • Visualisation • 3D Modelling	• Team Communication/Collaboration • Select right team members • Design Project Schedule (Programme)

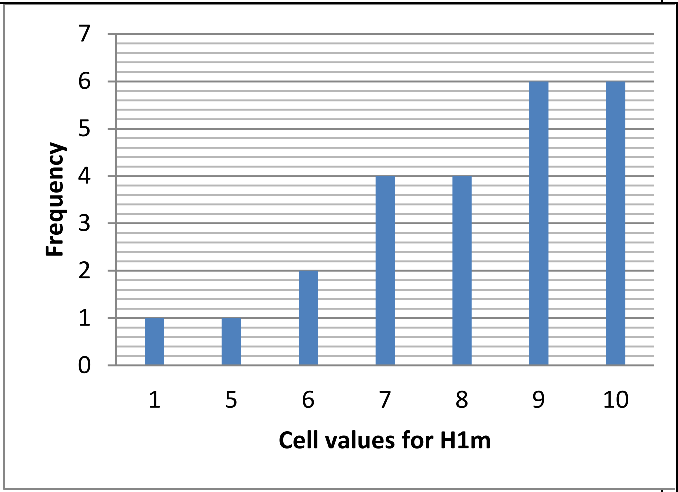
Table 4.12. Features and factors supporting sub-hypothesis - H1l

Team roles including the responsibilities allocated to each role and the selection of the right people are main contributing factors that support this sub- hypothesis. According to Kerzner 2007) a smooth design for a work breakdown structure requires the skill, initially, of understanding the project's requirements and then, based upon this understanding, the project manager has to recruit the right person for this task. For this purpose the project manager and the team members need access to the data/information of the candidates. Therefore, online services are a part of the integrated collaborative technologies which help to design a work organisational breakdown structure. Moreover, collaboration and coordination with other partners is required in order to interview candidates virtually. During the virtual interview the panel will be in a position to distinguish the strengths of the candidate - but it is the case that interviewees do not always feel very secure in using online face-to-face communication (this is the only limitation that has been identified and is something that Pantel (2004) mentioned in his research paper. Furthermore, the design of project drawings and the design of the procurement strategy are two factors that are enhanced by the use of integrated collaborative technologies because of the technical capability of the project manager and his/her team to use features made available by such technologies, e.g. 3D modelling, simulation, ERPs, etc. A limitation in this case, according to Zanni (2013), is a lack of using these technologies within the project management life cycle. Therefore, enhancement of the design of WBS can be achieved by using integrated collaborative technologies.

H1m: To what degree and how can integrated collaborative technologies enhance the accessibility of projects' stakeholders to information

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the accessibility of projects' stakeholders to information within a construction environment is equal to the mean value that is $\mu=7.95$. Moreover, for this sample $n=24$, the minimum value was 0 and the maximum was 10, and the values of 9 and 10 were equally the most frequent responses. The second most frequent responses were 7 and 8. Moreover, a smaller group of project managers provided answers with frequency 3 and 5. Finally, due to the atypically large value, the histogram (figure 4.13a) is slightly skewed to the left, or negatively skewed (-2.08). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.95833
Standard Error	0.45635
Median	8.5
Mode	9
Standard Deviation	2.23566
Skewness	-2.0825
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	0.94404

Figure 4.13a. Normal Distribution and Descriptive Statistical Analysis for sub - hypothesis - H1m

Moreover, the Standard Deviation (SD) between the data and the mean is SD=2.23. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.94, or the values could be between μ=4.53 to μ=7.01. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=4.53 <7.95 <7.01 (figure 4.13b-).

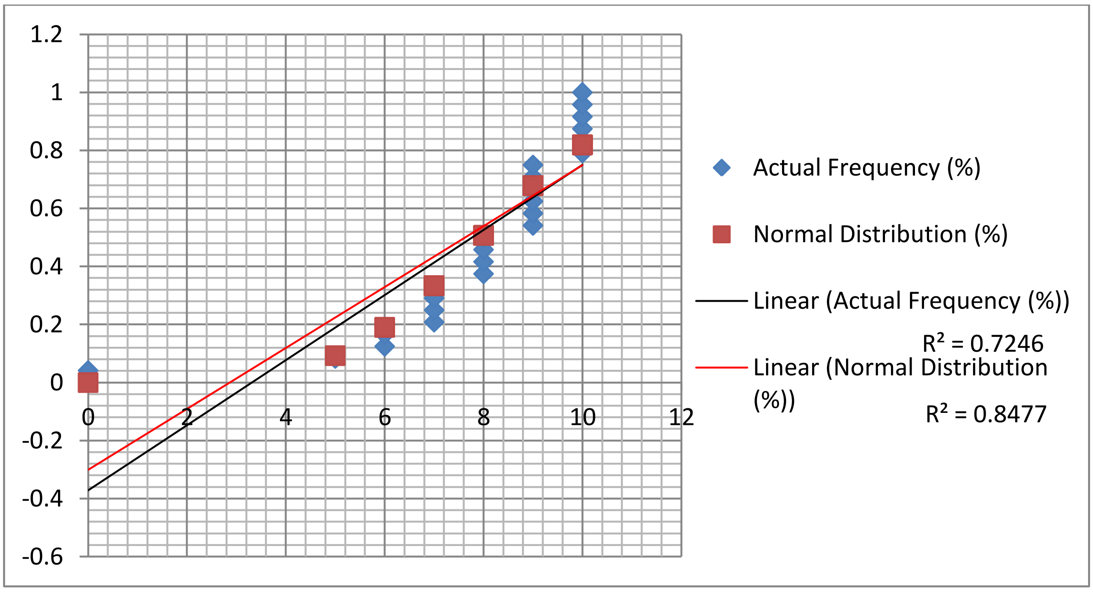


Figure 4.13b. Coefficient of Determination for sub-hypothesis H1m

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.72 and R^2 (Normal Distribution) = 0.84 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1l is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the accessibility of projects' stakeholders to information. In particular:

- **Design Interoperable Strategies**: Interviewees stated that in order for "stakeholders to work together they have to invest in diverse systems that they can work interoperably". This will help them to "communicate, synchronously or asynchronously, and gain access to information from anywhere at any time". In such cases, a project manager (due to his/her accessibility to project information) acquires the benefit of considering aspects that could affect the project's progress. Therefore, he/she is at a competitive advantage to identify "incidents and problems that could occur at any time". This way of thinking secures him/her the design of more interoperable strategies that will impact on project performance and progress.
- **Problem Resolution:** Interviewees stated that, in order for a project manager to maintain contact with his/her team so as to resolve a problem efficiently and quickly, then " he can run virtual meetings in order to communicate with the team, to identify the problem's owner, to gain access to a problem's details and, finally, to give a solution". Therefore, these technologies affect the accessibility of projects' stakeholders to information.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance the accessibility of projects' stakeholders to information within a team and the ways in which they do this are listed in the following table, table 4.13.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhance the accessibility of project stakeholders to information	• Project Information access & sharing • Connect from anywhere at any time • Synchronous and Asynchronous connection • Virtual Meetings • Interoperable Systems	• Design of Interoperable Strategies • Access to Project Information • Problem Resolution

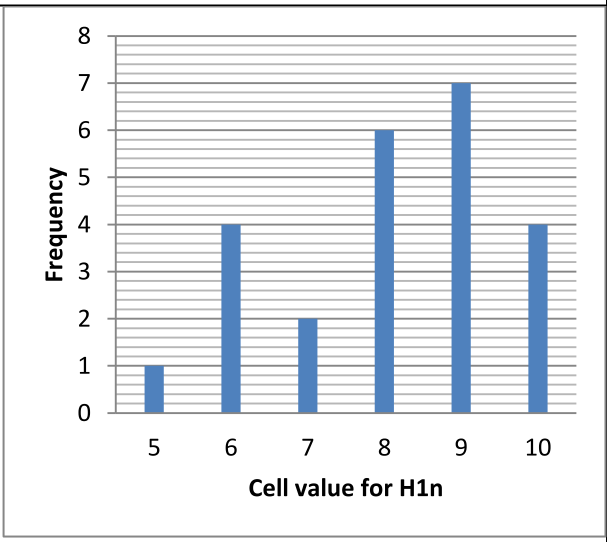
Table 4.13. Features and factors supporting sub-hypothesis - H1m

The enhancement of the accessibility of project stakeholders to information by the use of integrated collaborative technologies is by supporting the design of interoperable strategies as well as by allowing access to project information and providing problems' solutions. These three contributing factors affect the project design from the preparation stage to the RIBA work programme (2013). The point is that it is certainly believed that these technologies offer added value to projects but the limitation, according to research, is that because end users do not currently see the added value they provide, they tend not to use them. Therefore, they need further training. In the international market there are organisations (private, public and professional bodies) that offer these courses but it is believed, according to the BIM Task Forum of the UK Government, that generally the curriculum is not strong enough. Hence this Forum is aiming to design a curriculum that the above organisations can use in order to train competent end-users. Therefore, an added value of integrated collaborative technologies is in enhancing project stakeholders' accessibility to project information and also to provide training by ICT training providers on how to seek information, access appropriate information and then to use it.

H1n: Integrated collaborative technologies can enhance the networking accessibility and capability between the projects' stakeholders

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing the networking accessibility and capability between the stakeholders within a construction environment is equal to the mean value that is μ=8.06. Moreover, for this sample n=24, the minimum value was 5 and the maximum was 10, and the value of 9 was the most frequent response compared to the others. The second most frequent response was 8. Moreover, a smaller group of project managers provided answers with frequency 5 and 6. Finally, due to the atypically large value, the histogram (figure 4.14a) is slightly skewed to the left, or negatively skewed (-0.51). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	8.083333
Standard Error	0.300463
Median	8
Mode	9
Standard Deviation	1.47196
Skewness	-0.51267
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	0.621554

Figure 4.14a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis - H1n

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.47. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.62, or the values could be between μ=7.44 to μ=8.68. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=7.44 <8.06<8.68 (figure 4.14b).

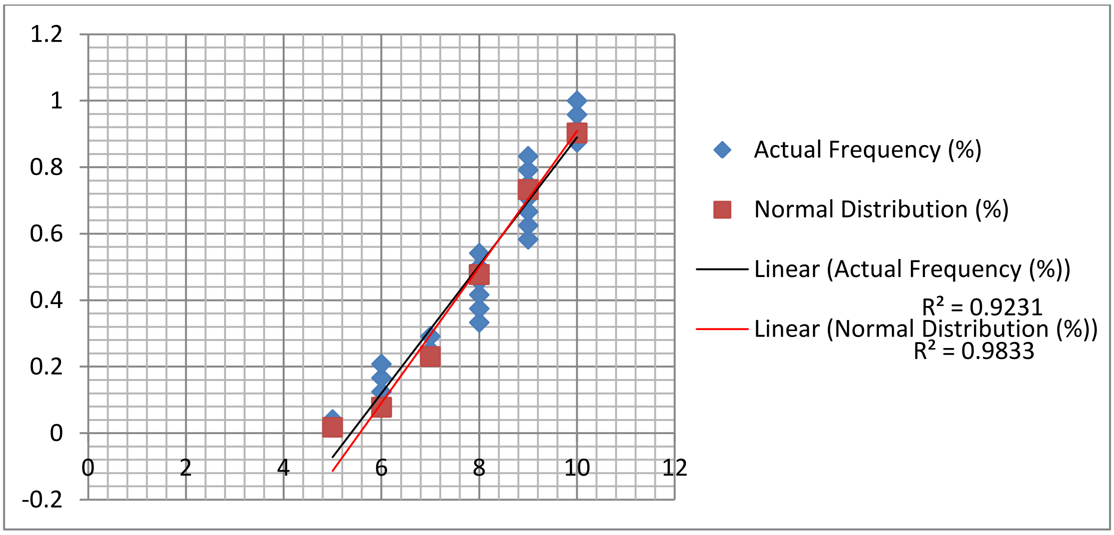


Figure 4.14b. Coefficient of Determination for sub-hypothesis H1n

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.85 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1n is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect the enhancement of networking accessibility and capability between the stakeholders within a construction environment. In particular:

- **Project Information Sharing:** Interviewees believed that, with the use of the above technologies project stakeholders benefit from "looking at specific information" that helps them to understand project details in depth. They believed that, up to the present time, a lack of understanding drives them to repeat the same mistakes or causes time and cost overruns. Sometimes, in order to keep the costs down they had to reduce project quality. In addition, during a meeting (physical or virtual) the project team can control team members' activities and information, e.g. cost, time, product, location, etc. because they have access to Enterprise Resources Planning Systems (ERPs) whilst they are in the meeting.

- **Efficient Management:** Efficiency is an indicator that helps a project manager and his/her members to "maintain project efficiency at a high level". Most of the interviewees did not mention any awareness of the "Key Performance Indicators published by the UK government" but they designed "their performance indicators" based on their past experience. Now, however, these technologies can eliminate this gap due to the opportunity of integrating "KPI mechanism tool, communication tool and design tools" so as to calculate project indicators (qualitatively and quantitatively) more "accurately". In addition to this, forums have been designed where team members can share and discuss project issues, internally or externally.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance the networking accessibility and capability between the stakeholders in a team within a construction environment and the ways in which they do this are listed in the following table, table 4.14.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancing the networking accessibility and capability between the stakeholders	• Project Information access and sharing • Virtual Meetings • ERPs • Communication Tools • KPI Tools	• Efficient Management • Project Information Sharing

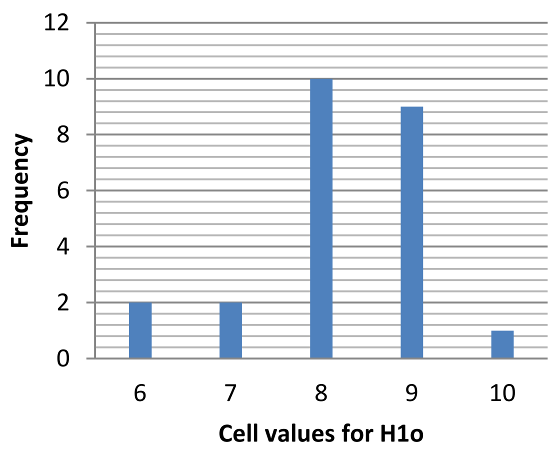
Table 4.14. Features and factors supporting sub-hypothesis - H1n

The contributing factors support the sub-hypothesis that efficient management and project information sharing play a significant role in enhancing the networking accessibility and capability between stakeholders. In particular Pinto (2007) states in his report on the "management of projects" that humans play a more important role than tasks. But if they do not perform efficiently then this will reflect in the deliverable process. Therefore, these technologies impact on the enhancement of the networking accessibility and capability between stakeholders.

H1o: Integrated collaborative technologies can enhance project managers' access to project knowledge that is required in order to do/control/manage their job

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing projects managers' access to project knowledge in order to manage a task within a construction environment is equal to the mean value that is µ=8.20. Moreover, for this sample n=24, the minimum value was 6 and the maximum was 10, and the value of 8 was the most frequent response compared to the others. The second most frequent response was 9. Moreover, a smaller group of project managers provided answers with frequency 6 and 7. Finally, due to the atypically large value, the histogram (figure 4.15a) is slightly skewed to the left, or negatively skewed (-0.76). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	8.20833
Standard Error	0.19945
Median	8
Mode	8
Standard Deviation	0.97709
Skewness	-0.7597
Range	4
Minimum	6
Maximum	10
Count	24
Confidence Level (95.0%)	0.41259

Figure 4.15a. Normal Distribution and Descriptive Statistical Analysis for the sub-hypothesis - H1o

Moreover the Standard Deviation (SD) between the data and the mean is SD=0.97. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.41, or the values could be between μ=7.99 to μ=8.41. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=7.99 <8.20 <8.41 (figure 4.15b).

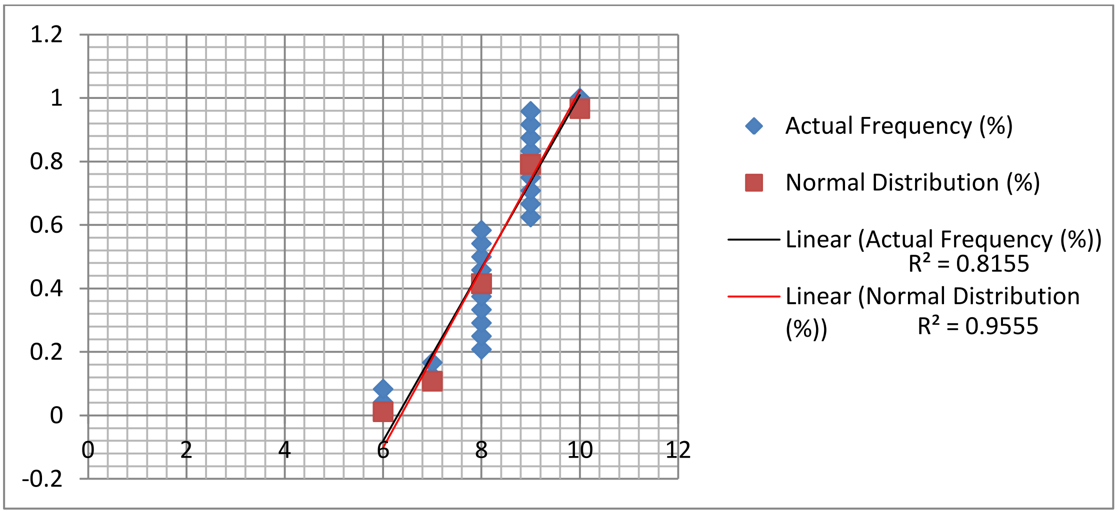


Figure 4.15b. Coefficient of Determination for sub-hypothesis H1o

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.81 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis Hlo is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that enhance project managers' access to project knowledge in order to manage a task within a construction environment. In particular:

- **Well-being of Stakeholders:** Interviewees stated that having access to information (remotely) did "impact on their quality of life (QQL)". In particular, it was mentioned that stress was reduced: "in the past I had to call a colleague to send me the document via email in a compatible format". Another example mentioned was that different systems of Architect Drawing Tools are not compatible with each other, e.g. Revit with Bentley BIM. In addition, some of the participants had compared these technologies within an integrated collaborative environment and their BIM engineers had found this to be possible.

- **Productivity:** In addition, these technologies play a significant role in assisting project managers in visualising problems (2D/3D/4D Modelling), designing the schedule (Gantt Chart), accessing project information (ERPs), sharing it amongst the team, and evaluating the solution (simulation). If all the above are working interactively/integrated then this impacts on the team's performance and consequently on project performance. In one word, this was defined by the interviewees as "efficiency". In particular, they used the word 'efficiency' because technology adds value by representing data/information in models? As a result, they can process the project in a more professional manner due to their capacity to meet the requested performance targets, e.g. time, cost, quality, etc.

Therefore, there is an actual influence whereby integrated collaborative technologies can significantly enhance projects managers' access to project knowledge in order to manage a task and the ways in which they do this are listed in the following table, table 4.15.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGY FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancing projects managers' access to project knowledge in order to manage a task	• Project Information access and sharing • Synchronous connection • Virtual Meetings • ERPs • 2D/3D/4D Modelling • Simulation	• Wellbeing • Productivity

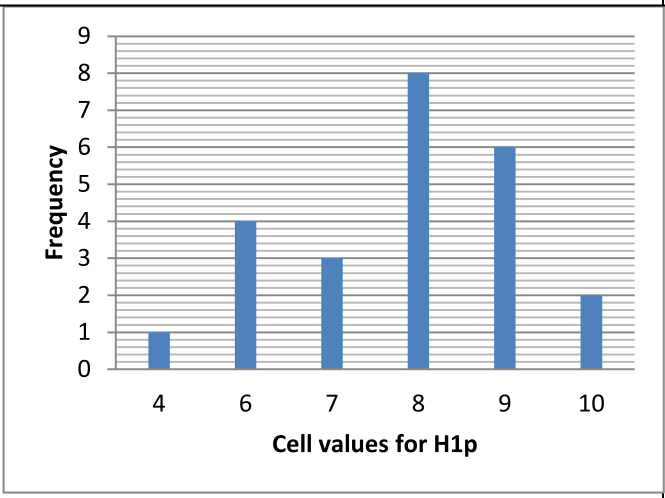
Table 4.15. Features and factors supporting sub-hypothesis - H1o

In this section it was found that two contributing factors support the sub-hypothesis: wellbeing and productivity. Both factors are considered as major factors by Parker et al. (2006) and Patel et al. (2012) in order to keep team members' psychology at a high level. Both have stated that, in terms of organisational psychology, both factors affect team members' wellbeing and productivity. In particular, these factors affect happiness and performance at work. When team members work - either co-located, distributed or remotely - they need a way to work together and to maintain a good quality of life. By using the latest technologies, such as laptops/tablets/netbooks which can support (hardware) integrated collaborative technologies, they can access knowledge so as to manage a job. Therefore, the sub-hypothesis that these technologies can enhance projects managers' access to project knowledge in order to manage tasks is accepted.

H1p: Integrated collaborative technologies enhance project managers' capability to identify, analyse and manage/control both errors and violation of a project/task

According to the descriptive statistical analysis it was found that the degree of influence of integrated collaborative technologies in enhancing projects managers' capability to identify, analyse and manage both errors and violation of a task within a construction environment is equal to the mean value that is $\mu=7.79$. Moreover, for this sample $n=24$, the minimum value was 4 and the maximum was 10, and the value of 8 was the most frequent response compared to the others. The second more frequent response was 9. Moreover, a smaller group of project managers provided answers with frequency 4, 6 and 7. Finally, due to the atypically large value, the histogram (figure 4.16a) is slightly skewed to the left, or negatively skewed (-0.73). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	7.791667
Standard Error	0.294756
Median	8
Mode	8
Standard Deviation	1.444003
Skewness	-0.73737
Range	6
Minimum	4
Maximum	10
Count	24
Confidence Level (95.0%)	0.60975

Figure 4.16a. Normal Distribution and Descriptive Statistical Analysis for sub-hypothesis H1p

Moreover, the Standard Deviation (SD) between the data and the mean is SD=1.44. The confidence interval for the underlying population mean for integrated collaborative technologies to enhance the relationships between the project stakeholders equals ± 0.60, or the values could be between μ=7.19 to μ=8.39. Thus at a significance level 0.05 and probability 95% the accepted range is: μ=7.19 <7.79 <8.39 (figure 4.16b).

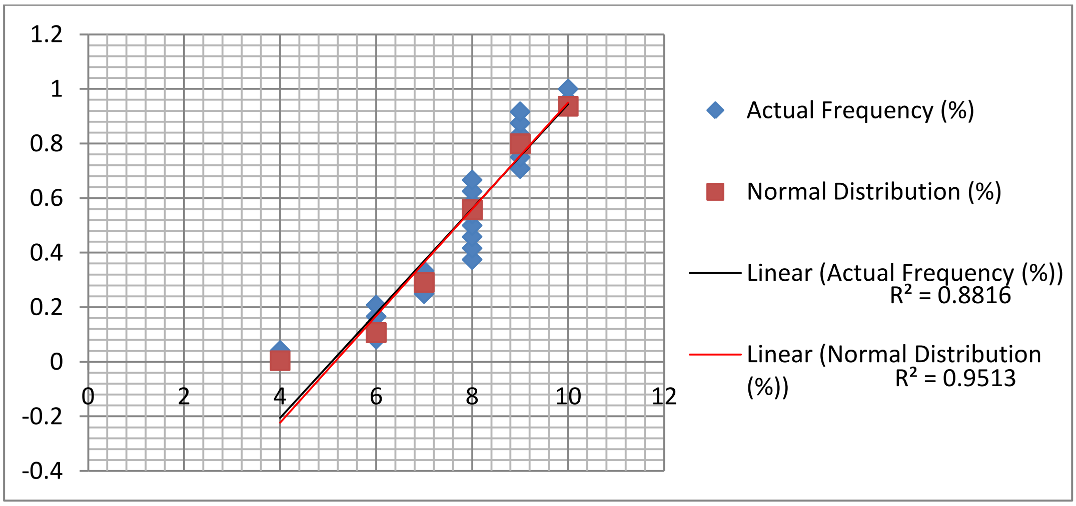


Figure 4.16b. Coefficient of Determination for sub-hypothesis H1p

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.88 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub-hypothesis H1p is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the features of integrated collaborative technologies and the contributing factors that affect projects managers' capability to identify, analyse and manage both errors and the violation of a task within a construction environment. In particular:

- **Access to Project Information:** Interviewees believed that, with the use of the above technologies, project stakeholders benefit by "looking at specific information" that helps them to understand project details in-depth. They believed that, up to the present time, a lack of understanding drives them to repeat the same mistakes or causes time and cost overruns. Sometimes, in order to keep the costs down, they had to reduce project quality. In addition, during a meeting (physical or virtual), the project team can control team members' activities and information e.g. cost, time, product, location etc. because they can access Enterprise Resources Planning Systems (ERPs) whilst they are in the meeting.
- **Efficiency:** These technologies also play a significant role in assisting project managers in visualising the problem (2D/3D/4D Modelling), designing the schedule (Gantt Chart), accessing project information (ERPs), sharing it amongst the team, and evaluating the solution (simulation). If all the above are working interactively/integratedly then this impacts on the team's performance and, consequently, on project performance. In one word this is defined by the interviewees as "efficiency". In particular they used the word 'efficiency' because technology adds value by representing data/information in models. As a result, they can process the project in a more professional manner due to their capacity to meet requested performance targets such as time, cost, quality, etc.
- **Review Project Information:** The use of 2D/3D/4D Modelling, designing the schedule (Gantt Chart), accessing project information (ERPs), sharing it amongst the team, and evaluating the solution (simulation) allows team members to review

this information at a certain level where thereafter project managers can identify, analyse and manage/control both errors and the violation of a project/task. Therefore, the project manager and stakeholder team members can feel more confident about the level of project information, which in turn could affect project progress could cause: delays, cost overruns, low quality, unsatisfied customers, etc.

Thus, there is an actual influence whereby integrated collaborative technologies can significantly enhance projects managers' capability to identify, analyse and manage both errors and violation by giving them access to information within a team, and the ways in which they do this are listed in the following table 4.16.

SUB - HYPOTHESIS	INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES	CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT
Enhancing project managers' capability to identify, analyse and manage both errors and violation by giving them access to information	• Project Information access and sharing • Synchronous connection • Virtual Meetings • ERPs • 2D/3D/4D Modelling • Gantt Chart • Simulation	• Access to Project Information • Review of Project Information • Efficiency

Table 4.16. Features and factors supporting sub-hypothesis - H1p

In this section the added value of the enhancement of projects managers' capability to identify, analyse and manage both errors and violations of tasks are interconnected with the following two contributory factors: access and review of project information. In particular, it has been seen that mistakes can happen in a task but project managers did not have the technology to predict these errors or to report them (Schrage, 1990). In addition, past examples have shown ignoring errors can lead to repeat mistakes in a project and thus can cause the same problems in the future (Pinto, 2007). As a result, the solution is to give access to project information to project managers from anywhere at any time and also to provide them with the capability to review information; then it is more likely that they can identify, analyse and manage both the errors and the violations of a task. This occurs because of proactive awareness and because the capability is available to create records (2D/3D/4D), to access these records (ERPs), to share and meet with team members and also to have the capability to test (simulation). The interactive usage of the above technologies in a manner that will enhance project managers' capability to identify, analyse and manage both errors and task violation shows that this sub-hypothesis can be accepted.

4.3. Values of Integrated Collaborative Technologies and Team Collaboration

In this section it has been proved that integrated collaborative technologies influence team collaboration. In particular, in figure 1 it is illustrated that the maximum mean is $\mu=8.64$, namely that this is the strength of influence of the link between enhancing knowledge sharing and awareness between project stakeholders and the use of integrated collaborative technologies within a construction environment. The second highest mean value is $\mu=8.54$, showing the influence of the link between enhancing the interaction process between project stakeholders in terms of communication and the use of integrated collaborative technologies within a construction environment. Moreover, the mean with least impact concerning the degree of influence of integrated collaborative technologies on team collaboration is the design of the organisational breakdown structure, where $\mu=5.79$. As a result, it is initially clear that there is a need to continue investing in integrated collaborative technologies, e.g. Building Information Modelling, to be able to support team collaboration within a construction project. The benefits from such an investment will impact on the project's process and deliverables due to the direct impact of such integrated collaborative technologies on team performance. In addition, there is clearly an impact on sustainable design and construction. This is one of the aims of the Good Practice Guidance-Sustainable Design and Construction (Building Research Establishment, 2012) where stakeholders are encouraged to optimise the design process, visualise the details and check whether the project is aligned with the buildings' regulations; also to analyse the energy used in the project and advise the client respectively. The team can compute the material quantities in detail (this will secure the alignment of the project with LEED [Lead in Energy and Environmental Design] and BREEAM [Building Research Establishment Environmental Assessment Method certification]) and can reduce waste and inefficiency (lean management). Stakeholder team members, therefore, are strongly advised to use integrated collaborative technologies where project information will be distributed amongst them appropriately.

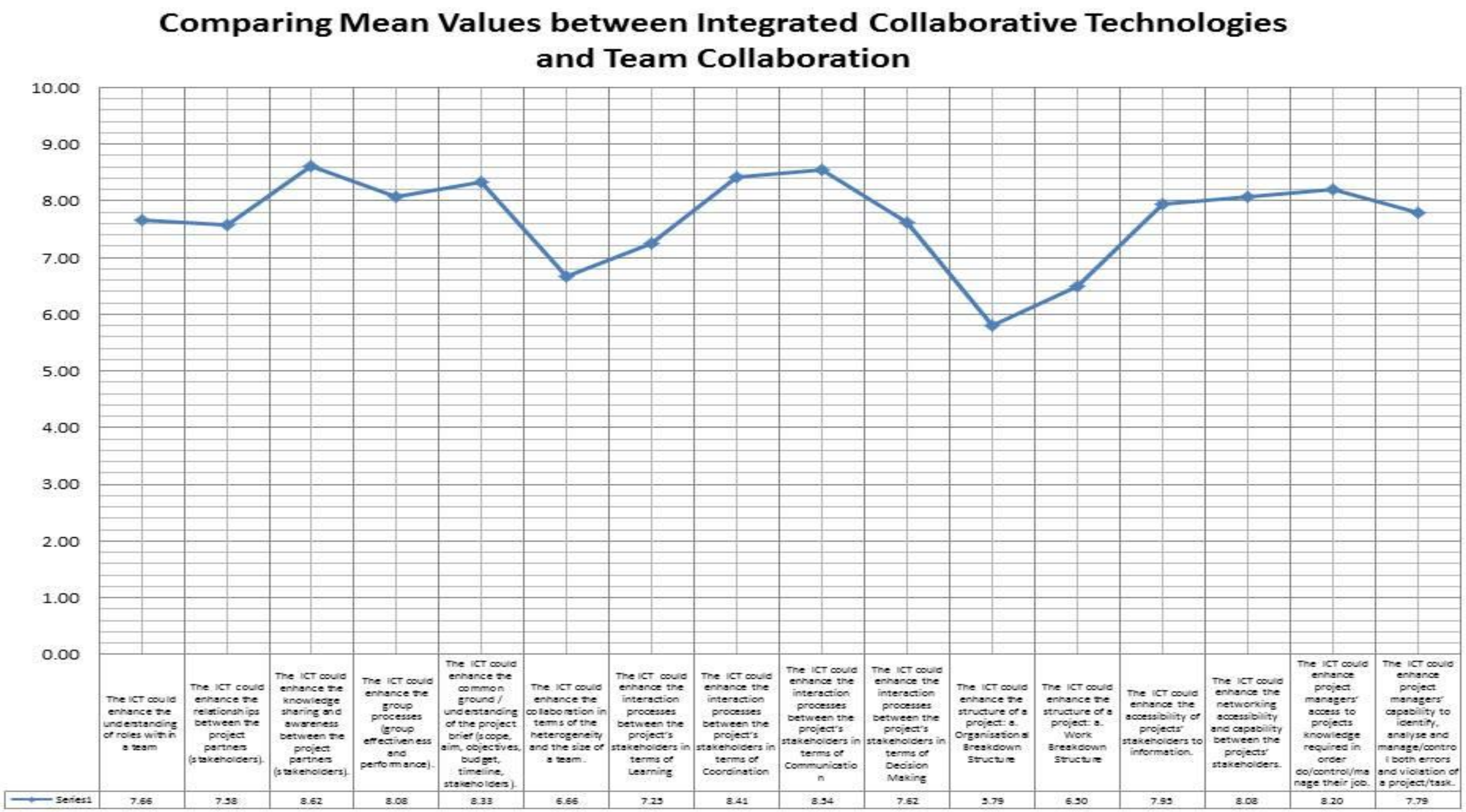


Figure 4.2: Strength of the degree of influence Integrated Information Technologies impact on Team Construction Collaboration

The answers from the participants have shown that integrated collaborative technologies can enhance:

- The understanding of roles within a team.
- The relationships between the project partners (stakeholders).
- Knowledge sharing and awareness between the project partners (stakeholders).
- The common ground/understanding of the project brief (scope, aim, objectives, budget, timeline, stakeholders).
- Group processes (group effectiveness and performance).
- Collaboration in terms of heterogeneity and team size.
- The interaction processes between the project stakeholders in terms of:
    - Learning
    - Coordination
    - Communication
    - Decision making
- The design of:
    - Organisational breakdown structure
    - Work breakdown structure
- The accessibility of project stakeholders to information.
- The networking accessibility and capability between the projects' stakeholders.
- Project managers' access to the project knowledge required in order do/control/manage their job.
- Project managers' capability to identify, analyse and manage/control errors in a project/task.

In addition to the above, the strength values of integrated collaborative technologies and team collaboration are illustrated in figure 4.17.

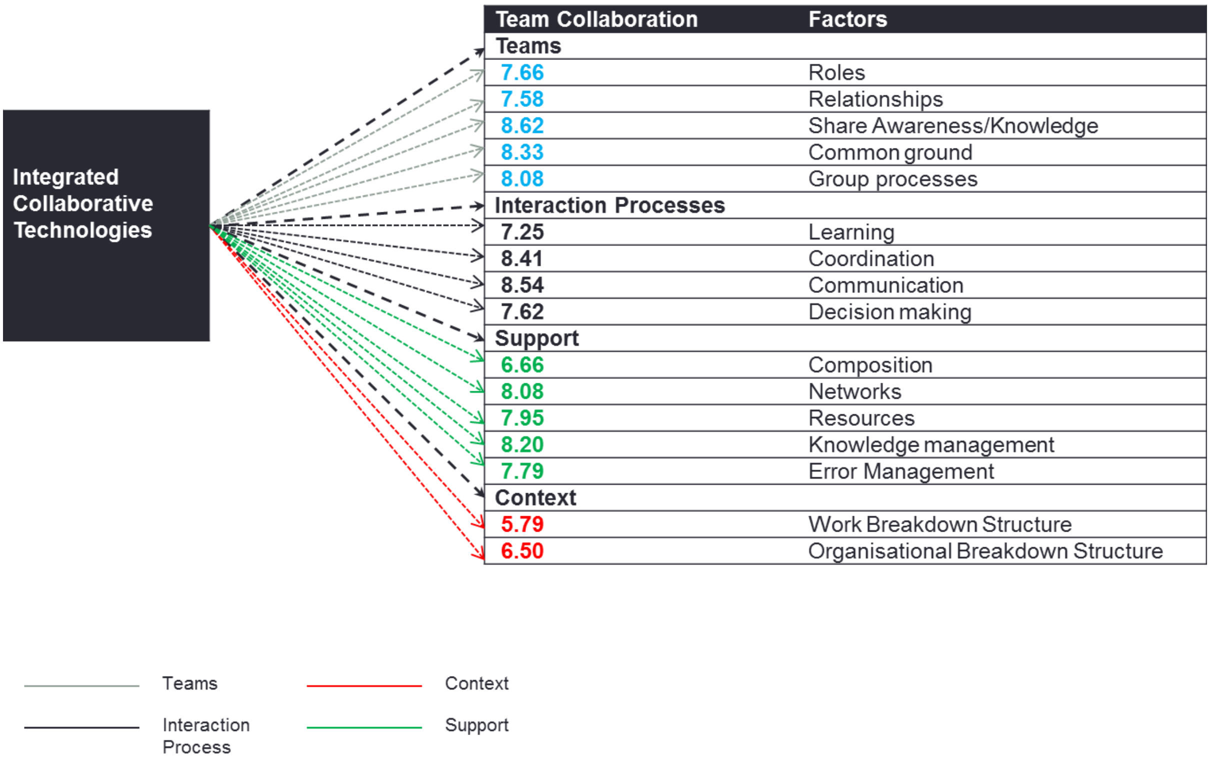


Figure 4.17: Strength Values of Integrated Information Technologies and Team Construction Collaboration

As discussed in the section on research methodology, looking at the values 0<x<1 where x represents the value that integrated collaborative technologies do not influence team collaboration and 1<y<10 where y represents the value that integrated collaborative technologies do influence team collaboration, the researcher accepts any value y ≥5. This will secure the highest degree of integrated collaborative technology influence on team collaboration. As a result, all the above sub-hypotheses are acceptable and valid too. A summary of the findings are presented in table 4.17.

INTEGRATED COLLABORATIVE TECHNOLOGIES INFLUENCE ON TEAM COLLABORATION IN CONSTRUCTION PROJECTS				
	SUB - HYPOTHESES	**STRENGTH OF INFLUENCE**	**INTEGRATED COLLABORATIVE TECHNOLOGIES FEATURES**	**CONTRIBUTING FACTORS WITHIN THE CONSTRUCTION ENVIRONMENT**
H1a	Enhancement of the understanding of roles within a team.	**µ=7.66**	• Project Information accessibility • Project Information sharing • Access to Enterprise Resources Planning Systems including Human Resources Systems and Accounting Information Systems • Synchronous and asynchronous connectivity from anywhere at any time • Virtual Meetings	• Problem Ownership • Conflict avoidance • Pre–identification of team members' responsibilities, background, culture and skills • Clarification of team members' responsibilities and roles
H1b	Enhancement of the relationships between stakeholders	**µ=7.58**	• Project Information accessibility • Project Information sharing • Synchronous and asynchronous connectivity from anywhere at any time • Virtual Meetings • Virtual Training	• Developing Trust • Enhancing Communication • Problem pre - identification
H1c	Enhancement of knowledge sharing and awareness between stakeholders	**µ= 8.62**	• Project Information sharing • Project Information access • Virtual Meetings • ERPs • Databases	• Enhancing team collaboration • Pre–identify clients' requirements • Risk Identification • Records for Best Practices

H1d	Enhancement of understanding project brief	**μ=8.08**	• Project Information sharing • Project Information access • Virtual Meetings • ERPs • RFID • Databases	• Decision Making process • Design Procurement Strategy • Pre – identify problems
H1e	Enhancement of understanding of project brief	**μ=8.33**	• Project information access • Project information sharing • Connect from anywhere at any time • Virtual Meetings • 3D simulation	• Human Interaction & Communication • Group Performance Risk identification • Enhancing team collaboration • Supply chain management • Data Process
H1f	Enhancement of the collaboration in terms of the heterogeneity and the size of a team	**μ=6.66**	• Project information access • Synchronous & Asynchronous connectivity • Virtual Meetings • Virtual Team Control • Virtual Training	• Team Development • People Management • Problem's pre-identify members' background, culture and skills
H1g	Enhancement of the interaction processes between the project's stakeholders in terms of learning	**μ=7.25**	• Project information access and sharing • Virtual Training (both synchronous and asynchronous) • Databases	• Personal Development • Key Success Factors
	Enhancement of the interaction processes between the project's stakeholders in	**μ=8.41**	• Project information access • Project information sharing • Connect from anywhere at any time • Virtual Meeting	• Project Organisational Structure • Design Constrains

H1h	terms of coordination		• Simulation	• Pre – identify project brief
H1i	Enhancement of the interaction processes between the project's stakeholders in terms of communication	**μ=8.54**	• Project information access • Project information sharing • Connect from anywhere at any time • Virtual meetings • Blogs, wikis, really simple syndication, tagging and chat	• Information process, • Development of trust • Team collaboration • Problem's pre-identification skills
H1j	Enhancement of the interaction processes between the project's stakeholders in terms of making decisions.	**μ=7.62**	• Project Information access • Project Information sharing • Connect from anywhere at any time • Databases • Data Mining • Virtual Meeting	• Problem's pre-identification • Team Collaboration • Problem Avoidance skills
H1k	Enhancement of the structure of a project (Organisational Breakdown Structure – OBS)	**μ=5.79**	• Project Information access • Project Information sharing • Connect from anywhere at any time • Synchronous connection • Virtual Meetings	• Roles and Responsibilities • Select right people • Team Collaboration
H1l	Enhancement of the structure of a project (Work Breakdown Structure – WBS)	**μ=6.25**	• Project Information access • Project Information sharing • Connect from anywhere at any time • Synchronous and asynchronous connection • ERPs • Visualisation • 3D Modelling	• Team Communication/ Collaboration • Select right team members • Design Project Schedule (Programme)
H1m	Enhance the accessibility of projects' stakeholders to information.	**μ=7.95**	• Project Information access & sharing • Connect from anywhere at any time • Synchronous and asynchronous connection	• Design of Interoperable Strategies • Access to Project Information • Problem

			• Virtual Meetings • Interoperable Systems	Resolution skills
H1n	• Enhance the networking capability and accessibility between project managers	• μ=8.06	• Project Information access and sharing • Virtual Meetings • ERPs • Communication Tools • KPI Tools	• Efficient Management • Project Information Sharing
H1o	• Enhance project managers' access to project knowledge to control their job	• μ=8.2	• Project Information access and sharing • Synchronous connection • Virtual Meetings • ERPs • 2D/3D/4D Modelling • Gantt Chart • simulation	• Wellbeing • Productivity
H1p	Enhancing project managers' capability to identify, analyse and manage both errors and violation by giving them access to information	**μ=7.79**	• Project Information access and sharing • Synchronous connection • Virtual Meetings • ERPs • 2D/3D/4D Modelling • Gantt Chart • Simulation	• Access to Project Information • Review of Project Information • Efficiency

Table 4.17: Integrated Collaborative Technologies and Team Collaboration.

Furthermore, the enhancement of the understanding of roles within a construction project team by making extensive use of integrated collaborative technologies features impacts on the clarification of problem ownership, the avoidance of conflicts, and the pre-identification and clarification of team members' responsibilities, roles, background, culture and skills. Moreover, it has been shown that technological features can enhance the relationships between stakeholders by providing opportunity to access information (a)synchronously from anywhere at any time. Hence stakeholders learnt to trust co–workers, to enhance communication and to pre-identify project problems. In addition the enhancement of sharing knowledge and awareness between stakeholders contributes towards the development of a collaborative culture where project risks and client requirements can be identified and records for best practices created. Also, it has been found that the use of these technologies during the understanding process of the project brief strongly impact on the decision making process, to design project procurement strategy and to pre–identify project risks similarly. This is achieved due to the capability these technologies give to cross check information from different systems and to make it available to project stakeholders during a (virtual) meeting. Likewise the technological features impact on the deployment of the group process in such a manner as to allow enhanced human interaction and communication, enhanced project team performance, to identify project risks as well as to manage the supply chain and the data process respectively. The collaboration in terms of heterogeneity and the size of a construction project team has been impacted similarly by allowing members to be self-developed as well as efficiently managed.

An additional competitive advantage of the use of integrated collaborative technology features are the enhancement of the interaction process between project stakeholders in terms of learning by setting up key success factors, coordinating by pre–identifying project and design constraints, strongly communicating (μ=8.54) by improving collaboration and trust efficiently and decision making by solving and pre–identifying project problems. The design of both WBS and OBS are also enhanced, where (a)synchronous technology features allow team members to communicate and access information from anywhere at any time. As a result clarification of roles and responsibilities as well as the opportunity to develop a collaborative culture are achieved. Moreover, it has been shown that enhanced stakeholder access to project information during a (virtual) meeting impacts on the design of appropriate interoperable strategies as well as teaching stakeholders how to provide problem solutions.

4.4. Summary

The development of a collaborative culture in a project is achievable by using integrated collaborative technologies such as Building Information Modelling. This is due to the access to information either synchronous or asynchronous from anywhere where stakeholders can share and access knowledge and awareness between themselves and thus be able to understand common ground in the project brief, to control the project process, and to enhance the interaction and networking processes. In addition, they are in a position to pre – identify and promptly respond to project errors and uncertainties, who is involved (Organisational Breakdown Structure) and what type of activities/tasks (Work Breakdown Structure). The above elements allow them to significantly enhance the collaborative culture within a construction project. Moreover, project stakeholders within this collaborative culture can also learn and make efficient decisions that will impact project process. Henceforth, the impact of integrated collaborative technologies on team collaboration is the deployment of a collaborative culture in a construction project.

Chapter 5 -Impact of Team Collaboration on Proactive Behaviour

5.1. Research Purpose

The purpose of this research chapter is to explain theoretically whether team collaboration can lead to proactive behaviour. In order to answer this, the researcher identified the sub-factors of team collaboration within a construction project: individuals (skills), teams (roles, relationships, sharing of knowledge/awareness, common ground, group processes and composition), interaction processes (learning, coordination, collaboration and decision making), support (tools, networks, resources, knowledge management, error management) and context (organisational structure). Team collaboration in the construction sector is a skill and "obligation" for the smooth progress of a project due to the nature of many people working together towards one common goal. In addition to these factors, proactive behaviour and its antecedents are also important. Although proactivity is a major competence for the role of a project manager it is not usually developed in a manner to support project progress. Proactive behaviour antecedents are: flexible role orientation, co-worker trust, self-efficacy, change orientation, control appraisal, job autonomy, proactive personality, and supportive supervision. Therefore, this study investigates whether team collaboration can impact on proactive behaviour and, henceforth, this provides the basis for the following sub-hypotheses.

5.1.1. Inter–relationships to be tested

Considering the research objective that team collaboration can impact on proactive behaviour (H2), the sub-interrelationships are:

H2a: *Mapping individuals to the development of proactive behaviour*

H2b: *Mapping teams to the development of proactive behaviour*

H2c: *Mapping interaction to the development of proactive behaviour*

H2d: *Mapping tasks to the development of proactive behaviour*

H2e: *Mapping support to the development of proactive behaviour*

H2f: *Mapping context to the development of proactive behaviour*

5.2. Secondary Research Data Analysis and Discussion

H2a Individuals and the Development of Proactive Behaviour

Patel et al. (2011) stated that collaboration is fundamentally a social activity, requiring interaction between two or more individuals and that it is crucial to team performance. Bornemann et al. (2003) highlighted the importance of team members bringing their own set of skills, knowledge and experiences to collaborations. Moreover, the psychological characteristics of individuals can all impact on collaboration (Deddoes-Jones and Miller, 2007) and thus lead collaboration to success or failure. As highlighted by Kerzner (1996), in order for a project manager, as an individual/single entity, to secure collaborative success, he/she must accept what is incorrect, and therefore be in charge and take ownership of the problem. Parker (2006), in her paper on modelling proactive behaviour, defined this 'ownership' as **flexible role orientation**, allowing the project manager to be in the position to better understand strategy, at both project and organisational level, as well as to significantly enhance his/her understanding of other individuals' knowledge and expertise. As a result of collaboration between two or more individuals trust amongst them is developed and thus **co-worker trust** is developed (Parker et al., 2006). By developing co-worker trust between individuals self-efficacy is derived, due to the need for a project manager to complete project tasks (Eye of Competence, 2006). Therefore, psychological factors have to be maintained at a high level in order to secure the degree of **self–efficacy** required for a project manager to efficiently manage a task or project. Moreover, the degree of self-efficacy also impacts on project and organisational performance (KPI, 2000). Therefore, the project manager as an individual has to be capable of controlling the project/task process by taking into account his/her team's unique skills, knowledge and expertise. According to the KPI, control of the project process, control **appraisal**, is vital in order to secure a project's viability and sustainability and, in the case where the project manager feels/understands the need to make a change, he/she must feel confident enough (self-efficacy, as previously stated) to design and implement a change as well as make the decision promptly. According to Parker et al. (2006), when a project manager has this intention for change, he/she is defined as a **change oriented** person, while the latter is defined as **job autonomy**. Thus, when a project manager as an individual wishes to identify problem/problems in advance, he/she must bring his/her own set of skills: both knowledge and expertise. He/she will then be considered as having a proactive personality. Moreover, in order to enhance leadership effectiveness in a self-management context, according to Parker et al (2006), a project manager has to clarify his/her self-goals in order to be able to observe him/herself (self–observation), to be able to set his/her own expectations (self–expectations) and to motivate him/herself (self–enforcement). This is defined as supportive supervision (Parker et al., 2006). As a result, in order to be an accountable team member within a project scheme, a project manager must be able to enhance his/her own skills (knowledge and expertise) and to look after him/herself (psychological factors and wellbeing). Consequently, there is an impact on the 'individual' as part of a collaborative team in developing a construction project managers' proactive behaviour.

H2b Teams and the Development of Proactive Behaviour

Patel et al. (2011) stated that teams have a specified organisational function and contribute to organisational objectives, including projects. Generally, teams are made up of individuals engaging in shared tasks with complementary skills who are committed to a common target, performance goals and approach for which they hold themselves mutually accountable (Katznebach and Smith, 1994, p.45). Teamwork bridges interdependent tasks which are subsequently integrated, being part of an intra-inter group collaboration/team collaboration. Within a construction organisation or project team roles have to be identified. Each team member will be responsible and must set their own tasks under the supervision of a line manager. In the construction project management world this is defined as Organisational Breakdown Structure (OBS). As a result, the project manager is in a position to better understand strategy, at both project and organisational level, as well as to significantly enhance his/her understanding of other individuals' knowledge and expertise. This is identified by Parker (2006, p.638) as **flexible role orientation** and, in order for this to be achieved, collaboration is required. Collaboration is enhanced when team relationships are good, including group dynamics; interpersonal cohesion; task cohesion; professional, social and personal relationships within the team; respect and trust between team members and overall team morale. Consequently, throughout this process, trust among members of a project team (**co-worker trust**) is attained (Parker, 2006). By integrating both collaboration and trust, construction team members feel more confident concerning the tasks to be completed within a particular time frame and based on an agreed budget. This shared awareness/knowledge allows team members to work together effectively, adjusting their activities as necessary through an understanding of member roles, responsibilities, expertise, skills, limitations, preferences, biases, social networks, intentions and emotions. Therefore, in turn, this means that they are more confident in completing proactive, interpersonal and integrative project tasks (**self-efficacy**). The more competent and confident a team project manager is, the more likely it is that he/she will influence project outcomes (**control appraisal**). This is something that can be achieved by developing a common ground between the team members and is easier to achieve where team members have a shared culture, vocabulary, values or interests and a shared understanding of working practices and group norms. Where the latter cannot be achieved successfully the project manager should be in a position to be **change oriented** within group and project processes so as to optimise project/task procedures and performance(s). This influences the team project manager in making decisions within the team (job autonomy). Therefore, when a project manager takes into consideration who is doing what (OBS), he/she is in a competent position to identify problems in advance (proactive personality) due to the elimination of risks related to team members, including the project manager him/herself due to heterogeneity and group size. A project manager, therefore, must be a self-efficative leader (supportive supervision) and, in order to be an accountable team member of a project scheme, must look after team member relationships, ensure shared awareness/knowledge between team members, build common ground, optimise group and project processes and maintain the consistency of the team composition. Consequently, the 'team' has an impact, as a part of team collaboration, in developing the proactive behaviour of construction project managers.

H2c Interaction Processes and the Development of Proactive Behaviour

Patel et al. (2011) stated that one view of collaborative working is that individuals and teams are part of a collaborative working environment within which they engage in interaction processes. The factors relating to collaborative interaction processes are learning, coordination, communication and decision making. In order to ensure that he/she understands how to delegate roles in a team (**flexible role orientation**) a construction project manager must ensure that there will be both formal and informal learning opportunities for each individual member, so that they will be in a position to develop and improve skills and, consequently, increase knowledge. The more they learn the more they can communicate and make effective decisions within a project task or an activity. However, coordination helps to sustain team collaboration and thus to develop or enhance trust among members of a project team (**co-worker trust).** Moreover, the interaction process between team members helps a project manager to be confident in completing proactive, interpersonal and integrative project tasks (**self-efficacy**) and in influencing project outcomes (**control appraisal**) respectively. Hence, the more confident a project manager is, the more risks he/she can take in order to optimise project/task procedures and/or performance(s) (**change oriented**). As a result, he/she is in a position to make decisions within the team (**job autonomy**). Concurrently, while he/she is in a position to learn, to improve communication between team members and to coordinate a project task or an activity, he/she is also in a position to foresee project risks (Kerzner, 2009). Consequently, he/she has a proactive personality and is, therefore, able to identify problems in advance. Arguably, he/she must be a self-efficative leader (supportive supervision) in order to secure stability in a project's progress and, in order to be an accountable team member of a project scheme, a project manager must motivate team members to learn more, must coordinate the team, must enhance communication between team members and make efficient decisions. Consequently, 'integrated processes' have an impact, as part of team collaboration, in developing the proactive behaviour of construction project managers.

H2d Tasks and the Development of Proactive Behaviour

Patel et al. (2011) stated that individuals and teams engage in collaborative processes at work in order to complete tasks/projects to meet defined goals. Team task performance is as critical as collaborative performance. The factors relating to collaborative tasks that are carried out within a construction project are type of project (Girald and Robin, 2006), task structure (Arthur et al., 2005) or Work Breakdown Structure (WBS) and the demand on individuals, teams and processes (Edwards and Wilson, 2004). The type of project (traditional, construction management, design and build, design – bid – built, etc), its structure and the demand (workload) impact on the selection process of who will be involved. In addition, Kerzner (2009) and Pinto (2004) stated the importance of knowing the type of project, the WBS and the demand in order to eliminate operational risks. As a result, a project manager has to be **flexible** in order to organise, manage and control project progress. Therefore, in order to support collaboration, it is vital to enhance trust among members of a project team (**co-worker trust**). This will cause the construction project manager to organise the WBS effectively and efficiently, by bringing in the right people according to project type. As a result, he/she will be confident in completing proactive, interpersonal and integrative project tasks (**self-efficacy**). Thereafter, he/she will be able to influence project outcomes (**control**

appraisal) and to be **change oriented** in a project/task so as to optimise projects/task procedures and or performance(s). Thus, by knowing the project's type, its WBS and the demands in terms of individuals, tasks and processes, the project manager will be in an autonomous position to make decisions within the team (**job autonomy**). This awareness/knowledge helps him/her to identify problems in advance (**proactive personality**). Moreover, in order to enhance his/her leader effectiveness in a self-management context, according to Parker et al. (2006), a project manager has to clarify his/her self-goals, to be able to observe himself/herself (self–observation), to be able to set his/her own expectations (self–expectations) and to motivate him/herself (self-enforcement). This is defined as supportive supervision (Parker et al., 2006). As a result, in order to be an accountable team member of a project scheme, a project manager must know project type, the WBS and the individuals, tasks and process demands. Consequently, there is an impact by 'tasks', as a part of the team collaboration, in developing the proactive behaviour of construction project managers.

H2e Support and Development of Proactive Behaviour

Patel et al. (2011) stated that collaboration within organisations requires effective and appropriate support which will usually make the difference between a successful collaboration and an unsuccessful one. The factors relating to the support provided for collaborative work in a construction project are tools, networks, resources, training, team building, knowledge management and error management. In the modern construction world technologies have played a significant role in eliminating project performance indicators (known as Key Performance Indicators - KPIs). The most recent technology that allows this is Building Information Modelling (BIM) alongside a Lean Management philosophy. The broader role of technology is to support team members in working collaboratively, effectively, efficiently and productively. Moreover, this network of team members (personal and professional) can provide a forum for the discussion of ideas and can generate awareness of possible collaborations. This network can be physical or virtual (co-located or distributed). In addition to tools and networks it is important that project team members have access to resources (finances, time, physical space, materials, equipment, tools). Without access to such resources there is a risk of non-effective collaboration and thus an impact on project progress. In any case, both resources and knowledge management, as support factors, should be captured, structured, transferred, stored, made available and utilised as necessary (Patel et al., 2011). Another factor which impacts on project team member support is training.

Continuous Professional Development (CPD) should be mandatory in order to improve productivity and employee (client) satisfaction and, in the construction sector, the relevant professional bodies are keen to offer CPD events. Patel et al. (2011) stated that the impact of technical skills' improvement on client satisfaction is comparable to the impact of team building on organisational processes. Moreover, error is a factor that impacts negatively on the collaborative work of construction project team members. All these factors impact on how a project manager should select the right people (**flexible role orientation**) to work with and on how he/she provides them with the right support. During the support delegation process, trust among team members could be developed (**co-worker trust**). The construction project manager could invite the team members into a meeting (physical or virtual) and explain to them how they will be supported. During this meeting the project team members would learn how to be confident in making the best use of construction project manager support so as to be able to complete proactive, interpersonal and integrative project tasks (**self-efficacy**). By working under this mind-set they will be able to influence project outcomes (**control appraisal**) and to be **change oriented** in a project/task so as to optimise project/task procedures and or performance(s). Thus, by knowing how to make the best use of the supportive resources they will become more autonomous and hence will be competent in making efficient decisions within the team (**job autonomy**). This awareness/knowledge helps them to identify problems in advance (**proactive personality**). Moreover, in order to enhance his/her leader effectiveness in a self-management context, according to Parker et al. (2006), a project manager has to clarify his/her self-goals, be able to observe him/herself (self–observation), be able to set his/her own expectations (self–expectations) and to motivate him/herself (self–enforcement). This is defined as supportive supervision (Parker et al., 2006). As a result, in order to be an accountable team member of a project scheme it is important for a project manager to know how to support his/her team. This is undertaken by offering them tools (technologies), networking opportunities (physical or virtual), access to resources, training, team building skills, knowledge management and training in how to manage project errors. Consequently, as a part of team collaboration, 'support' impacts on developing the proactive behaviour of construction project managers.

H2f Context and the Development of Proactive Behaviour

Context usually determines the types of individuals and teams who are involved in collaborative work, including the type of tasks that need to be carried out (Patel et al., 2011:p.3-5). The context and - in particular – the culture, working environment, business climate and the organisational structure of an organisation influence how people work. Therefore, in the construction sector, the project manager's role is to be flexible enough in order to pick the right person to run a project/task **(flexible role)**. The project manager has to maintain the balance between team members by designing and developing a culture where every single member feels comfortable. Additionally, the working environment plays a significant role in the development of a common culture and, moreover, impacts on project performance. Research has shown that a friendly working environment can impact on employees' productivity (Hackman, 1990) while research also showed that the stability of the business climate may affect the business/project opportunities available and the team's and organisation's effectiveness (Unsworth and West, 2000). As a result, it is highly possible that, due to business stability, a project manager feels confident about the business environment and this could positively reflect on him/her being confident in completing proactive, interpersonal and integrative project tasks (**self-efficacy**). In addition, the organisational structure should be designed in a manner that allows the project manager to be able to influence project outcomes (**control appraisal**) and to be **change oriented** in a project/task so as to optimise project/task procedures and or performance(s). Thus, by knowing how to make best use of supportive resources, a project manager will become more autonomous and hence will be competent in making efficient decisions within the team (**job autonomy**). This awareness/knowledge helps him/her to identify problems in advance (**proactive personality**). Moreover, in order to enhance his/her leader effectiveness in a self-management context, according to Parker et al. (2006) a project manager has to clarify his/her self-goals, to be able to observe him/herself (self–observation), to be able to set his/her own expectations (self–expectations) and to motivate him/herself (self–enforcement). This is defined as supportive supervision (Parker et al., 2006). As a result, in order to be an accountable team member of a project scheme, it is important for a project manager to know how to support his/her team, in particular by offering them the right construction project context, designing a common culture between the team members, developing a friendly, interactive and dynamic environment between the team members, creating the right business environment so that team members produce optimum results, and by designing an organisational structure that can influence and support project and organisational goals. Consequently, as a part of team collaboration, 'context' impacts on developing proactive behaviour within construction project managers.

A summary of the findings is presented in the following table, table 5.1.

	IMPACT OF TEAM COLLABORATION ON THE DEVELOPMENT OF PROACTIVE PROJECT MANAGERS
Individuals	
	• Each individual team member within a collaboration context can impact on the development of flexible thinking and on the orientation of construction project managers by sharing ideas and empowering other team members with their experiences. • Each individual team member within a collaboration context can impact on the development of trust among members in a project team by sharing ideas that can impact on project progress. • Each individual team member within a collaboration context impacts on the development of self-efficant construction project managers by enhancing psychological factors, i.e., motivation and wellbeing. • Each individual team member within a collaboration context impacts on the development of control appraisal processes that will help construction project managers in influencing the project outcome. This occurs due to teams' ability to encourage their project manager. • Each individual team member within a collaboration context impacts on the development of intentions to initiate/propose changes in a project/task so as to optimise project/task procedures and or performance(s). This is achieved by tracking the problem, sharing the problem and solving the problem. • Each individual team member within a collaboration context impacts on the development of making efficient decisions. Efficient decisions are achieved by having access to the right data/information. • Each individual team member within a collaboration context impacts on the development of awareness of how construction project managers can identify

	problems in advance. This is useful because team members provide and share information and project managers provide constructive feedback. • Each individual team member within a collaboration context impacts on the development of a project manager/leader's effectiveness due to the trust achieved via sharing data/information.
Teams	
	• Project teams can impact on the development of flexible thinking and on the orientation of construction project managers by sharing ideas and empowering other team members with their experiences. • Project teams impact on the development of trust among members in a project team by sharing ideas that could impact on project progress. • Project teams impact on the development of self-efficant construction project managers by enhancing psychological factors, i.e., motivation and wellbeing. • Project teams impact on the development of control appraisal processes that will help construction project managers in influencing the project outcome. This occurs due to the team's ability to encourage their project manager. • Project teams impact on the development of intentions to initiate/propose changes in a project/task so as to optimise project/task procedures and or performance(s). This is achieved by tracking the problem, sharing the problem and solving the problem. • Project teams impact on the development of making efficient decisions. Efficient decisions are achieved by having access to the right data/information. • Project teams impact on the development of awareness of how construction project managers can identify problems in advance. This is useful because team members provide and share information and project managers provide constructive feedback. • Project teams impact on the development of a project manager/leader's effectiveness due to the trust achieved via sharing data/information.
Tasks	
	• Project tasks impact on the development of the flexible thinking orientation of construction project managers by organising ideas and enhancing them with team members' skills, including knowledge and experience. • Project tasks impact on the development of trust among members in a project team by bringing together different people with different backgrounds to share

	ideas that could impact on project progress. • Project tasks impact on the development of self-efficant construction project managers by testing them on how they could impact on project progress. • Project tasks impact on the development of the control appraisal processes that will help construction project managers in influencing the project outcome. This occurs due to the activities that must take place. • Project tasks impact on the development of the intentions of initiating/proposing changes in a project/task so as to optimise project/task procedures and or performance(s). • Project tasks impact on the development of making efficient decisions. Efficient decisions are achieved due to the capacity of having access to the right data/information and understanding tasks and processes. • Project tasks impact on the development of awareness of how construction project managers can identify problems in advance. This is useful because they then know in detail the breakdown of tasks and how to process them. • Project tasks impact on the development of a project manager/leader’s effectiveness due to the need to clarify which task(s) has/have to be done and why.
Support	
	• Team support can impact on the development of the flexible thinking orientation of construction project managers by offering them tools, networks, resources, training and by building team relationships. • Team support impacts on the development of trust among members in a project team by sharing resources to support project needs and by offering training. • Team support impacts on the development of self-efficant construction project managers by enhancing psychological factors, i.e., motivation and wellbeing, as well as by offering training. • Team support impacts on the development of the control appraisal processes that will help construction project managers in influencing the project outcome. This occurs due to the teams’ ability to meet on a regular basis in order to ensure project progress. • Team support impacts on the development of the intentions of initiating/proposing changes in a project/task so as to optimise project/task procedures and or performance(s). This is achieved by tracking, sharing and

	solving the problems based on existing resources. • Team support impacts on the development of making efficient decisions. Efficient decisions are achieved due to the capacity of having access to the correct data/information. This support is offered by the use of technology and by integrated collaborative technologies in particular. • Team support impacts on the development of awareness of how construction project managers can identify problems in advance. Technologies (tools) used by team members can help them to identify problems in advance. • Team support impacts on the development of a project manager/leader's effectiveness due to the trust achieved via sharing data/information.
Context	
	• Team context can impact on the development of the flexible thinking orientation of construction project managers by sharing ideas and employing valuable people to give an added value to the project. • Team context impacts on the development of trust among members in a project team by communicating what tasks have to be done. • Team context impacts on the development of self-efficant construction project managers by linking project context to business context. • Team context impacts on the development of the control appraisal processes that will help construction project managers in influencing the project outcome. This occurs due to the need to design an efficient organisational and work structure. • Team context impacts on the development of the intentions of initiating/proposing changes in a project/task so as to optimise project/task procedures and or performance(s). This is achieved by tracking the problem, sharing the problem and solving the problem in both organisational and work structure. • Team context impacts on the development of making efficient decisions. Efficient decisions are achieved due to the capacity of having access to the correct project data/information. • Team context impacts on the development of awareness of how construction project managers can identify problems in advance. That is useful because they provide and share this information with team members and the project manager also provides constructive feedback. • Team context impacts on the development of a project manager/leader's

	effectiveness due to the trust achieved on a project contextual level.

Table 5.1. Team collaboration impacts on proactive behaviour

As a result the potential impact of team collaboration characteristics on the development of proactive behaviour's antecedents for a construction project manager is illustrated in figure 5.1.

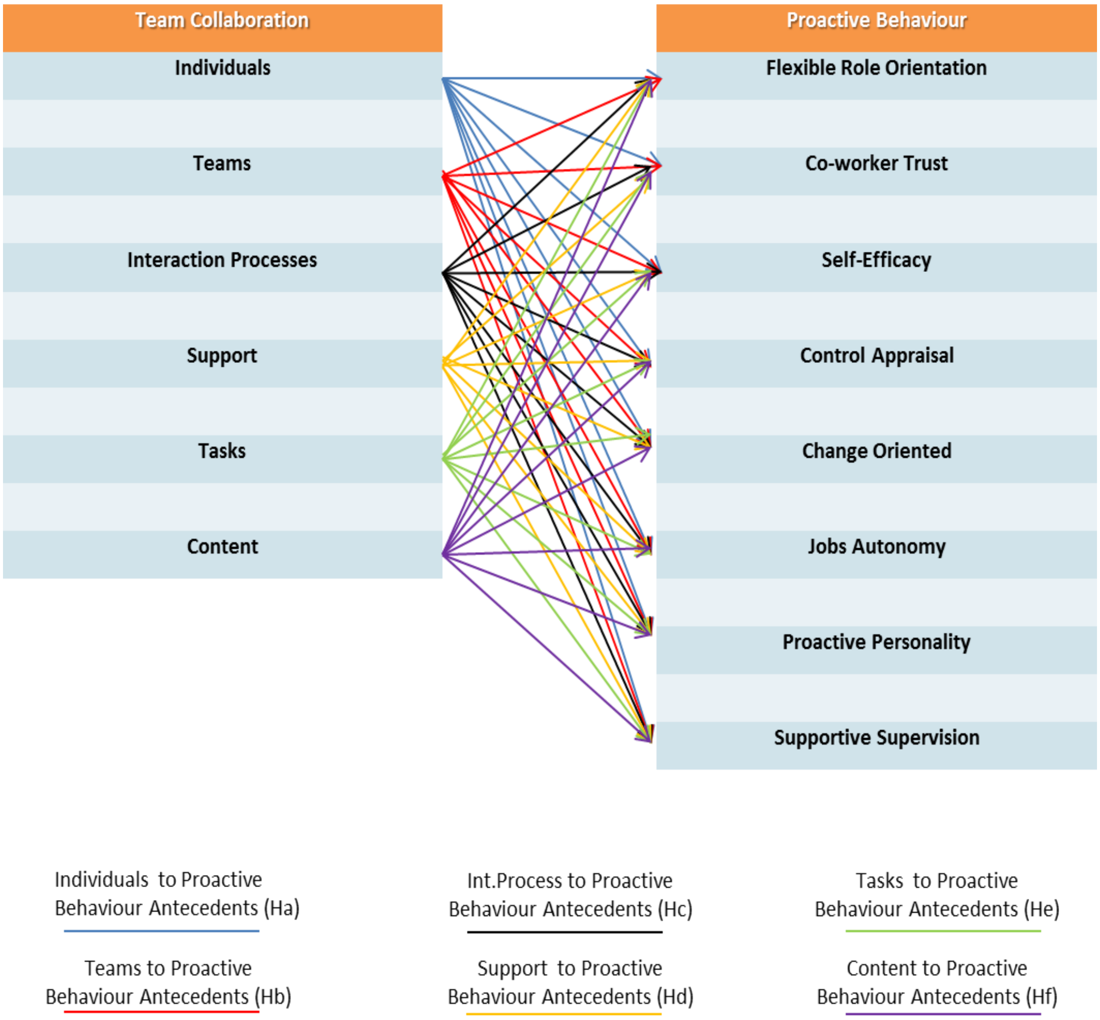


Figure 5.1. Potential impact of team collaboration on the development of proactive behaviour

The purpose of this research chapter is to explain theoretically whether team collaboration can lead to proactive behaviour. In order to answer this, the researcher identified the sub-factors of team collaboration within a construction project: individuals (skills), teams (roles, relationships, sharing of knowledge/awareness, common ground, group processes and composition), interaction processes (learning, coordination, collaboration and decision making), support (tools, networks, resources, knowledge management, error management) and context (organisational structure). Team collaboration in the construction sector is a skill and "obligation" for the smooth progress of a project due to the nature of many people working together towards one common goal. In addition to these factors, proactive behaviour and its antecedents are also important. Although proactivity is a major competence for the role of a project manager it is not usually developed in such a manner as to support project progress. Proactive behaviour antecedents are: flexible role orientation, co-worker trust, self-efficacy, change orientation, control appraisal, job autonomy, proactive personality, and supportive supervision. Therefore, this study investigates whether team collaboration can impact on proactive behaviour and, henceforth, this provides the basis for the following sub-hypotheses.

5.3. Summary

Proactive behaviour of construction project managers seems to develop within a team where project stakeholders share knowledge and awareness. In particular, project managers can enhance their skills in such a manner as to be flexible; to trust; to be self – efficant; to control project process; to make efficient decisions; to be a leader and to pre – identify, track and share project problems. As a result teams perform effectively and efficiently due to the enhancement of individual skills and hence project managers can operate and manage interactive process (learning, coordination, communication and decisions). Furthermore, the accessibility to information that is offered to project managers causes them to operate and manage the project (task) process. To sum up a proactive construction project manager has to collaborate with other teams members in order to operate and manage a project process efficiently and effectively.

Chapter 6: Impact of Proactive Behaviour on Project Performance

6.1. Research Purpose

The purpose of the research in this chapter is to test whether the proactive behaviour of construction project managers can have an impact on project performance. In order to answer this, the researcher identified proactive behaviour antecedents: flexible role orientation, co – worker trust, self – efficacy, change orientation, control appraisal, job autonomy, proactive personality, and supportive supervision. In addition to these factors key performance indicators for construction projects (KPIs) have been introduced. These KPIs are: accurate time prediction – design & construction, accurate cost prediction – design & construction, raising of quality issues and return on investment (client). Henceforth, this provides the basis for the following sub-hypotheses:

6.1.1. Research Hypothesis

The research hypothesis is: team collaboration impact on proactive behaviour (H3) and the research sub – hypotheses are:

- ***H3a:*** *Flexible role orientation can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3b:*** *Flexible role orientation can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3c:*** *Flexible role orientation can have an impact on 'raising the quality issues' of the final output*
- ***H3d:*** *Flexible role orientation can have an impact on 'comparing the estimated return on investment' for the client*
- ***H3e:*** *Trust between the team members can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3f:*** *Trust between the team members can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3g:*** *Trust between the team members can have an impact on 'raising the quality issues' of the final output*
- ***H3h:*** *Trust between the team members can have an impact on 'comparing the estimated return on investment' for the client*

- ***H3i:*** *Self-efficacy can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3j:*** *Self-efficacy can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3k:*** *Self-efficacy can have an impact on 'raising the quality issues' of the final output*
- ***H3l:*** *Self-efficacy can have an impact on 'comparing the estimated return on investment' for the client*
- ***H3m:*** *A control appraisal process can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3n:*** *A control appraisal process can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3o:*** *A control appraisal process can have an impact on 'raising the quality issues' of the final output*
- ***H3p:*** *A control appraisal process can have an impact on 'comparing the estimated return on investment' for the client*
- ***H3q:*** *Identification of any possible type of changes can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3r:*** *Identification of any possible type of changes can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3s:*** *Identification of any possible type of changes can have an impact on 'raising the quality issues' of the final output*
- ***H3t:*** *Identification of any possible type of changes can have an impact on 'estimating the return on investment' for the client*
- ***H3u:*** *The power you have to make decisions (job autonomy) can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3v:*** *The power you have to make decisions (job autonomy) can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3w:*** *The power you have to make decisions (job autonomy) can have an impact on 'raising the quality issues' of the final output*
- ***H3x:*** *The power you have to make decisions (job autonomy) can have an impact on 'comparing the estimated return on investment' for the client*
- ***H3y:*** *Proactive personality to identify problems can have an impact on 'accurate' prediction of the time for planning, design and construction*

- ***H3z:*** *Proactive personality to identify problems can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3aa:*** *Proactive personality to identify problems can have an impact on 'raising the quality issues' of the final output*
- ***H3ab:*** *Proactive personality to identify problems can have an impact on 'comparing the estimating return on investment' for the client*
- ***H3ac:*** *Development of team members' skills can have an impact on 'accurate' prediction of the time for planning, design and construction*
- ***H3ad:*** *Development of team members' skills can have an impact on 'accurate' prediction of the cost for planning, design and construction*
- ***H3ae:*** *Development of team members' skills can have an impact on 'raising the quality issues' of the final output*
- ***H3af:*** *Development of team members' skills can have an impact on 'comparing the estimating return on investment' for the client*

6.1.2. Questionnaires

In order to answer Hypothesis H3 and its sub – hypotheses the researcher designed the survey and the questionnaire considering proactive behaviour and project performance characteristics, as identified analytically in Chapter 2. Figure 6.1 represents the potential impact of proactive behaviour on project progress.

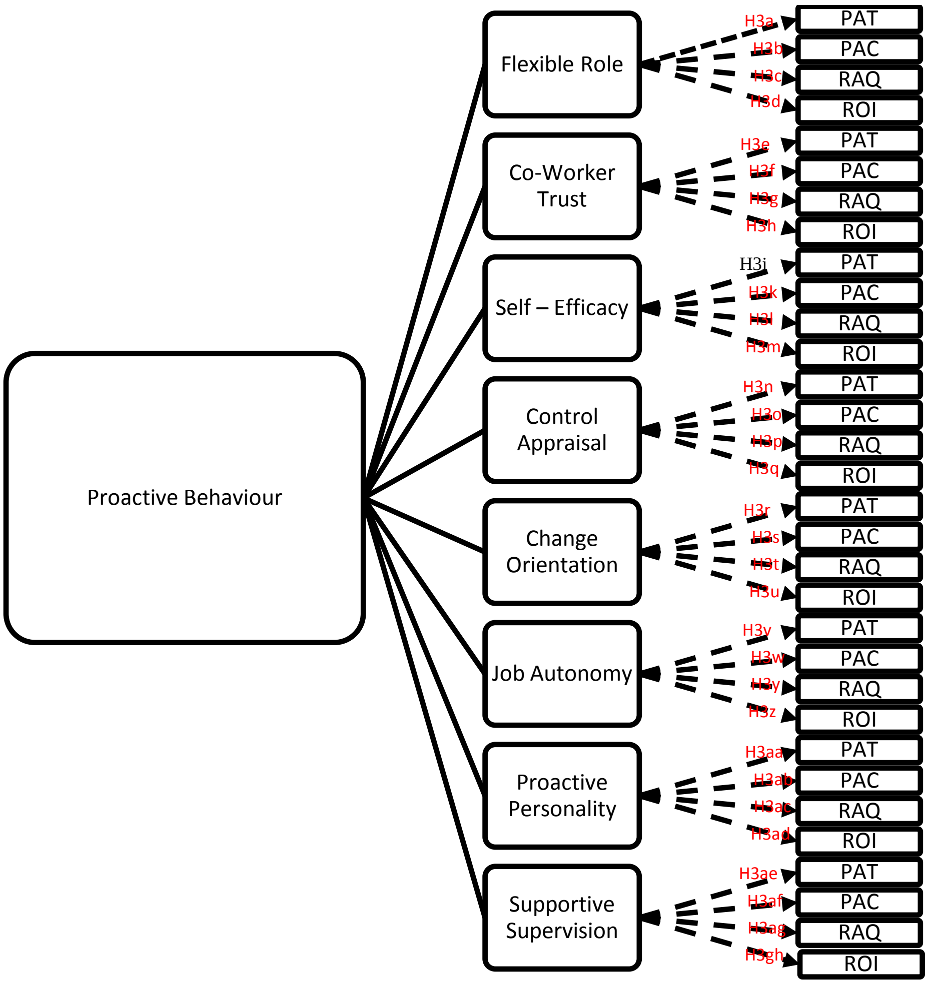


Figure 6.1. The sub hypotheses between proactive behaviour and project progress

Where

PAT=Predict Accurate Time

PAC= Predict Accurate Cost

RAQ=Raise Accurate Quality

ROI=Return on Investment

6.1.3. Research Methodology

Methodologically, the survey aims to test if proactive behaviour has an impact on project performance through using a survey and a structured questionnaire. The same group of project managers (n=24) have been selected to answer H3, as H1 and H2. They have responded to both survey and structured interviews in order to express subjectively the strength (link) of influence. For the survey the researcher used the Likert scale between 0 and 10 where 0 (no influence) and 10 (high influence). For the discussion of the quantitative data, statistical descriptive analysis techniques were used while for the discussion of the qualitative data content analysis technique was used. In particular, for any value $0<x<1$ where x represents the value where team collaboration does not influence proactive behaviour and $1<y<10$ where y represents the value where proactive behaviour antecedents do impact on project performance, the researcher accepts any value $y \geq 5$. This will secure that the highest degree of proactive behaviour antecedents do impact on project performance. As a result any values $1<y<5$ and $0<x<1$ were rejected.

The terms used for the analysis are presented in italic form below:

The mean is the average rate of the scale in a set of data. The mode is the value that appears most often in a set of data. The median is described as the numerical value separating the higher half of a sample, a population, or a probability distribution, from the lower half. The minimum is the lowest value that appears in a set of data. The maximum is the highest value that appears in a set of data. The standard deviation (σ) shows how much variation or "dispersion" exists from the average (mean). The ***sum*** *shows the total sum of the data set. The* ***skewness*** *shows a measure of the asymmetry of the probability distribution of a real-valued random variable. The* ***confidence level*** *(95.0%) indicates the reliability of an estimate in a set of data.*

The same group of project managers have responded simultaneously to an in-depth discussion about how proactive behaviour and its antecedents impact project performance.

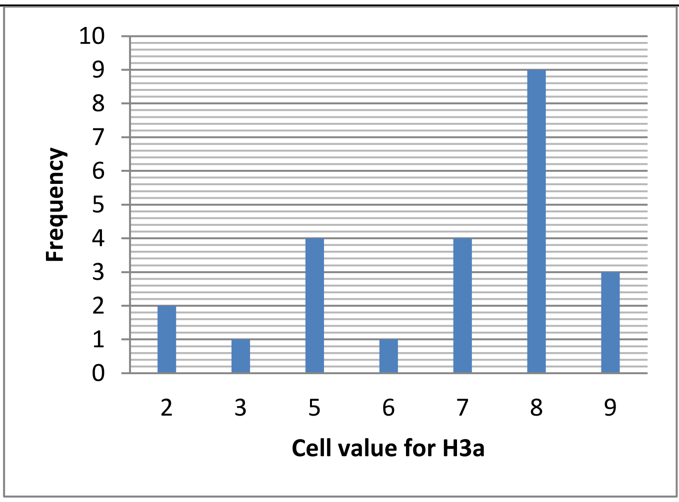
6.2 Primary Research Data Analysis and Discussion

6.2.1. Flexible Role

H3a: Flexible role orientation can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of flexible role orientation on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, $\mu = 6.6$. Moreover for this sample $n=24$, the minimum value was 2 and the maximum was 9, and values between 7 and 8 were quite frequent (figure 6.1a). There is a range of low values between 2 and 4, which makes sense because one group of project managers did not have a very good understanding of the question. Moreover, another group of project managers provided answers with a frequency between 5 and 6. Finally, due to the atypical large value, the histogram is slightly skewed to the left, or negatively skewed (-1.086). Without this value, the histogram would be reasonably symmetrical (figure 6.1a).

Normal Distribution	*Descriptive Statistical Analysis*



Mean	6.667
Standard Error	0.428
Median	7.5
Mode	8
Standard Deviation	2.099
Skewness	-1.09
Range	7
Minimum	2
Maximum	9
Count	24
Confidence Level (95.0%)	

Figure 6.1a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3a

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.098. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals $\mu=6.6 \pm 0.88$ minutes, or $\mu=5.72$ to $\mu=7.48$. So, at a significance level of 0.05 and probability 95% the accepted range is: $5.72<6.6<7.48$ (figure 6.1b).

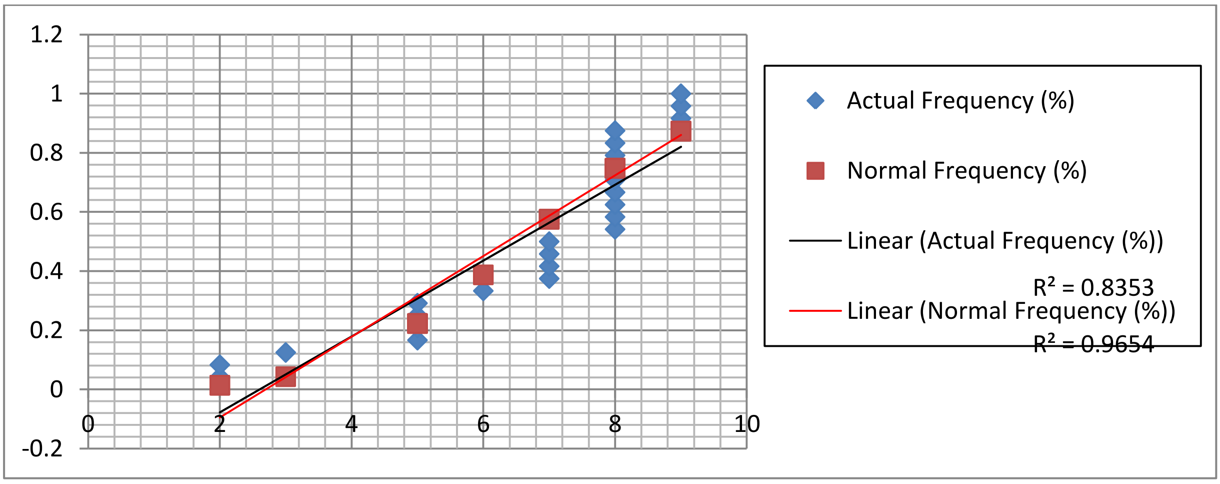


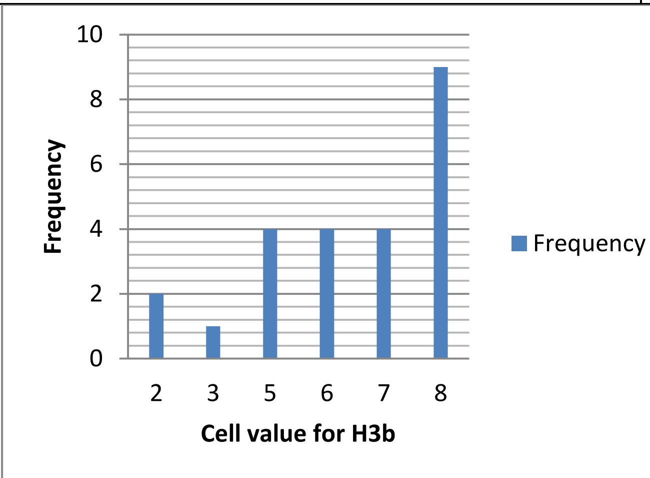
Figure 6.1b. Coefficient of Determination for sub-hypothesis H3a

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.96 and R^2 (Normal Distribution) = 0.83, the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.1b). As a result the sub hypothesis H1a is accepted.

H3b: Flexible role orientation can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of the flexible role lead to accurately predict the cost for planning, design and construction is equal to the mean value, that is, μ=6.29. Moreover for this sample n=24, the minimum value was 2 and the maximum was 8, and the values between 7 and 8 were quite frequent. It is clear the frequency is between the ranges 6-7 (figure 6.2a) in the second most popular area. That makes sense because one group of project managers had a very good understanding of the question. Moreover a smaller group of project managers provided answers with frequency between 4 and 5. Finally, due to the atypical large value, the histogram (figure 6.2a) is slightly skewed to the left, or negatively skewed (-1.081). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.291666667
Standard Error	0.387668461
Median	7
Mode	8
Standard Deviation	1.899179838
Skewness	-1.081431635
Range	6
Minimum	2
Maximum	8
Count	24
Confidence Level (95.0%)	0.801953312

Figure 6.2a Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3b

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.899. The confidence interval for the underlying population mean for flexible role lead to 'accurate time' equals μ=6.29 ± 0.80 minutes, or μ=5.48 to μ=7.09. So at a significance level 0.05 and probability 95% the accepted range is: 5.48<6.29<7.09.

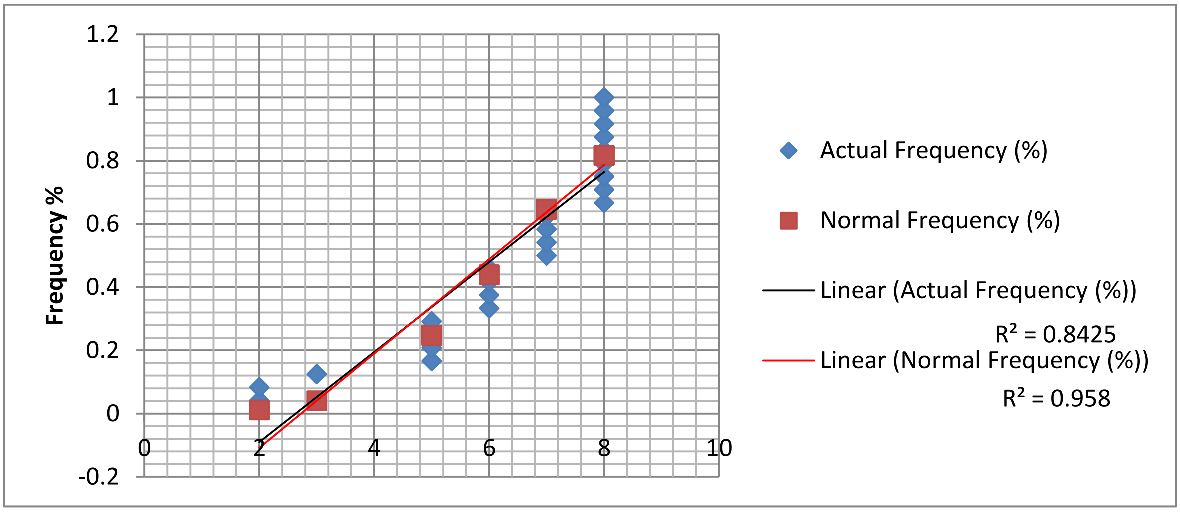


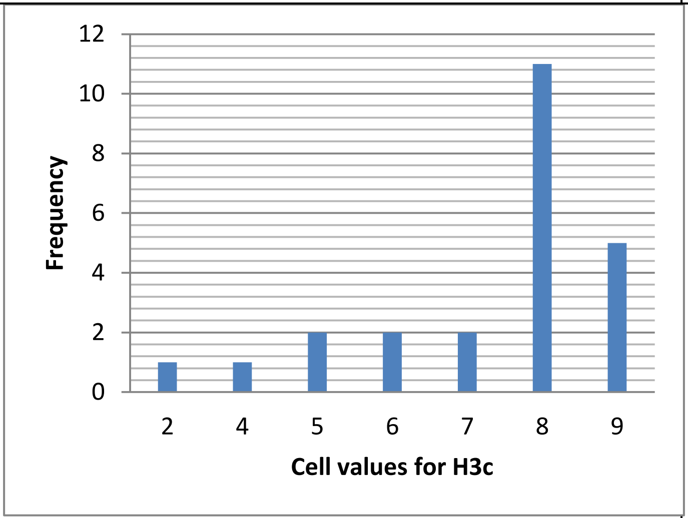
Figure 6.2b. Coefficient of Determination for sub-hypothesis H3b

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.84 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.2b). As a result the sub hypothesis H3b is accepted.

H3c: Flexible role orientation can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of flexible role leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=7.29. Moreover for this sample n=24, the minimum value was 2 and the maximum was 9. Values 7 and 8 were the most frequent, although 9 was also indicated (figure 6.3a). That makes sense because one group of project managers had a very good understanding of the question. Moreover a smaller group of project managers provided answers with frequency between 6 and 7 as well as between 4 and 5. Finally, due to the atypical large value, the histogram (figure 6.3a) is slightly skewed to the left, or negatively skewed (-1.53). Without this value, the histogram would be reasonably symmetric.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	7.291666667
Standard Error	0.363553151
Median	8
Mode	8
Standard Deviation	1.781039429
Skewness	-1.539997531
Range	7
Minimum	2
Maximum	9
Count	24
Confidence Level (95.0%)	0.752066993

Figure 6.3a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3c

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.78. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals μ=7.29 ± 0.75 minutes, or μ=6.53 to μ=8.04. So at a significance level 0.05 and probability 95% the accepted range is: 6.53<7.29<8.04 (figure 6.3b)

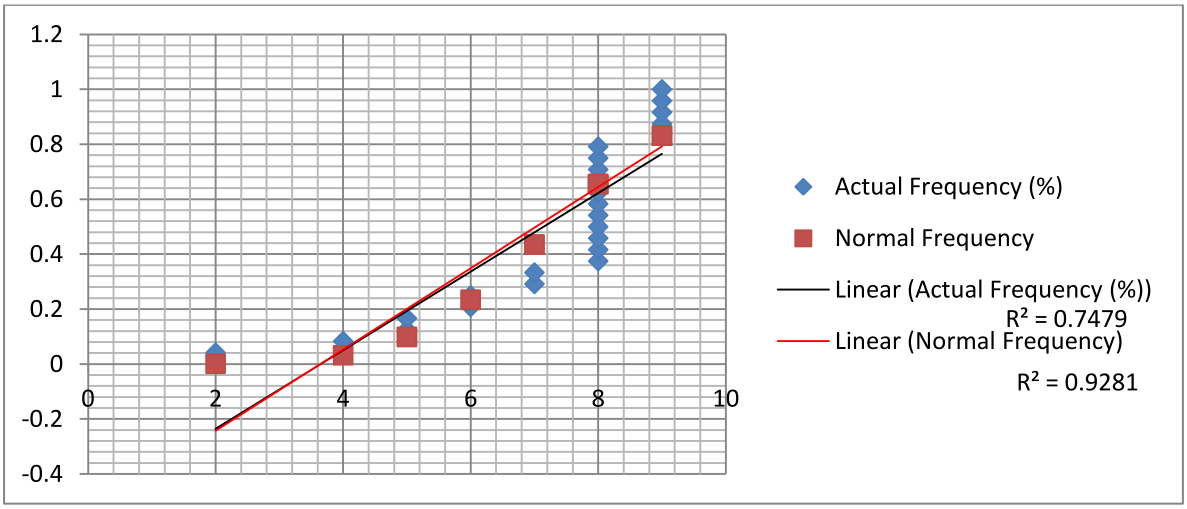


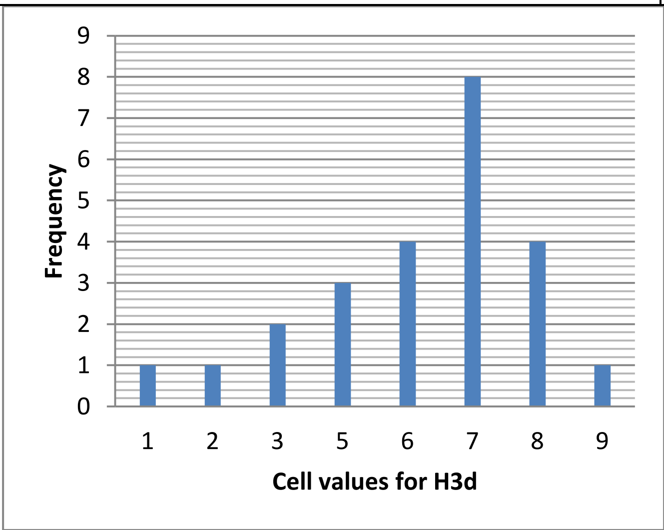
Figure 6.3b. Coefficient of Determination for sub-hypothesis H3c

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.74 and R^2 (Normal Distribution) = 0.92, the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3c is accepted.

H3d: flexible role orientation impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of flexible role leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=6. Moreover for this sample n=24, the minimum value was 0 and the maximum was 9, and the values between 8 and 9 were quite frequent compared to the others. In contrast, the range between 6 and 7 in terms of the frequency was the second most popular (figure 6.4a.). That makes sense since one group of project managers had a very good understanding of the question. Moreover a smaller group of project managers provided answers with frequency between 4 and 5. In addition a smaller group of project managers provided answers with frequency between 0 and 1, and between 2 and 3. Finally, due to the atypically large value, the histogram (figure 6.4a.) is slightly skewed to the left, or negatively skewed (-1.29). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6
Standard Error	0.43821112
Median	7
Mode	7
Standard Deviation	2.146787286
Skewness	-1.294367039
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	0.906508768

Figure 6.4a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3d

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.14. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals μ=6 ± 0.90 minutes, or μ=6.53 to μ=8.04. So at a significance level 0.05 and probability 95% the accepted range is: 5.09<6<6.90 (figure 6.4b.).

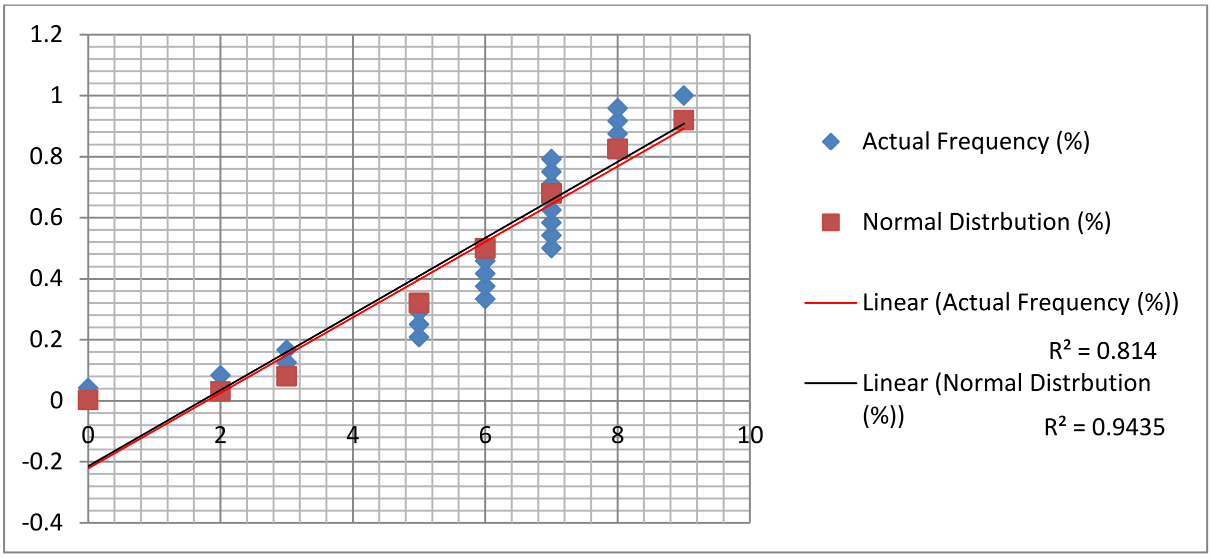


Figure 6.4b. Coefficient of Determination for sub-hypothesis H3d

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.81 and R^2 (Normal Distribution) = 0.94 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3d is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how flexible role could impact on project performance, which are presented below:

Design of the procurement strategy: it has been presented as a major impact of flexible role orientation. Interviewees have stated that “procurement strategy identifies alternatives and is the optimum way of achieving project objectives, taking account of the risks and constraints”. In addition, it has been said that “procurement strategy helps to control and fund a particular project”. Therefore, it is essential to know and understand who is involved and what activities have to be executed before, during and post construction procurement process. Interviewees stated that the selection process criteria differ but are based 50% on price and 50% on quality. So, by being flexible the project manager can orient the right people to the right project. *Note: the contractor can play the role of the client for selecting suppliers, and the city council can play the role of the client in selecting the right contractor.* As a result, by knowing who is involved during the design of the procurement strategy, the project manager, a) can define clearly what the client wants, b) based on team skill can negotiate deals that are justified on whole life value, c) ensure that the team members involved are in a competitive position to express how the industry works and to conduct market research, d) can select specialist suppliers and, e) can be more effective in building up and sharing knowledge about the suppliers' performance so as to make an efficient decision. As a result, by being flexible, a project manager is in a position to be most effective in design of the procurement strategy. The principal of spending more time and money in the design of a construction procurement strategy to identify the most suitable partners reduces project risks at the planning and construction stages of a project. Henceforth, project managers felt that "by pre-identifying who will be involved and what activities will need to be implemented, it is more possible to pre identify 'accurate' project time and costs, to raise quality issues in advance (using criteria/benchmarking) and also to predict 'accurately' the return on investment for the client.

Design of the construction project business plan: the project business plan is a formal statement of a set of business goals, including the plan for reaching those goals. The principle of completing a construction business plan is the quality and accuracy of the information provided to the project manager, while in the design of the project business plan there is a reflection/impact on the project life cycle. At the stage where the project manager is preparing to design the project plan he must "consider the construction business plan as well as who is involved at a senior level". The project manager has to be flexible and to search and select capable team members that are "leaders, who understand and raise project constraints, who are team players and share information". As a result a "flexible role orientation" antecedent of a project manager provides an added value to the project due to his capability to pre–identify key people that will help stakeholders - including the client - to predict 'accurate' project time and costs, to raise quality issues in advance (using criteria/benchmarking) and also to predict 'accurately' the return of investment for the client.

Conflict Avoidance: Interviewees mentioned that in a project it is, "common for stakeholders to have arguments". Henceforth, it is possible for this to impact on project progress and often, it is project time and costs that are the first two indicators to be directly affected. Moreover, a project manager being flexible so as to resolve disagreements concerned with the project or programme in order to arrive at a mutually satisfactory solution, was found to be an interesting point. However, their biggest challenge is at the stage where a project manager has to be flexible so to avoid conflict rather than resolving it. Therefore, by being flexible at an early stage the project manager can clarify who is who and who is doing what. Throughout this process he can identify possible project concerns at different project stages and thus will be more efficient in predicting ‘accurate’ project time and costs, raising quality issues in advance (using criteria/benchmarking) and in predicting ‘accurately’ the return of investment for the client.

Henceforth, the flexible role orientation antecedent can impact on project performance, as illustrated in table 6.1.

	IMPACT OF FLEXIBLE ROLE ON PROJECT PERFORMANCE
Flexible Role Orientation	• Design procurement strategy • Design project business plan • Conflict avoidance

Table 6.1. Impact of flexible role orientation antecedent on project performance

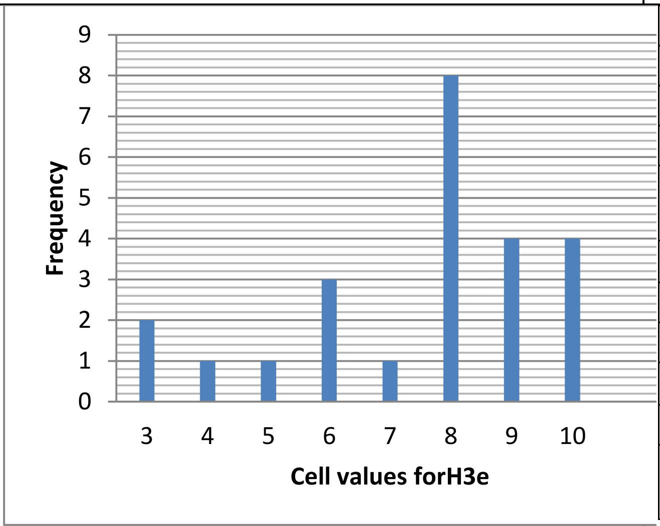
To sum up, a flexible role affects the extent to which various problems affect the longer term goals of projects (Parker, 2006). This statement is, in effect, saying that a project manager has to understand the problems that affect the long term goals of a project. In addition, he/she has to be confident about the staff involved in the project, including confidence in their skills (knowledge and experience). Moreover, in the project management world, as Pinto (2007) states, it is essential that team members (not just the project manager) are aware, according to their allocated tasks, of “what problems can occur and who the owner of the problem is”. Therefore, it would be advantageous for project managers to know how, and what, problems can affect the longer term project and to be in a flexible position to foresee these problems, to report them and to act in advance of them occurring. In addition, Akintoye (1999), Kerzner (2006), Pinto (2007), Koskela (2002) have stated that time, cost and quality issues have to be pre-identified. In addition Akintoye (1999) mentioned the importance of construction project ROI identification in order to secure a new project or recommendation to a new client. Thus, this research shows that when a project manager is flexible there is a high degree of influence between construction KPIs: the sub–hypothesis on predicting the time and cost to raise quality issues but a lower of influence on pre-identifying project ROI for the client (μ=5.91). Therefore, a project manager has to be flexible since, by predicting project times, costs, quality issues and client ROI he/she will be in a competitive position to design dynamic procurement strategies, to design dynamic project plans and to avoid conflicts.

6.2.2. Co-Worker Trust

H3e: Trust between team members can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of co–worker trust on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, μ=7.5. Moreover for this sample n=24, the minimum value was 3 and the maximum 10, and values between 8, 9 and 10 were quite frequent (figure 6.5a). There is a range of low values between 4, 5 and 7.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.5
Standard Error	0.429863477
Median	8
Mode	8
Standard Deviation	2.105892354
Skewness	-0.883693111
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.889240353

Figure 6.5a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3e

Moreover, another group of project managers provided answers with a frequency between 3 and 6. Finally, due to the atypically large value, the histogram (figure 6.5a) is slightly skewed to the left, or negatively skewed (-0.88). Without this value, the histogram would be reasonably symmetrical (figure 6.5a). Moreover the Standard Deviation (SD) between the data and the mean is SD=2.10. The confidence interval for the underlying population mean for flexible role lead to 'accurate time' equals ± 0.88 minutes, or μ=6.62 to μ=8.38. So, at a significance level of 0.05 and probability 95% the accepted range is: 6.62<7.5<8.38.

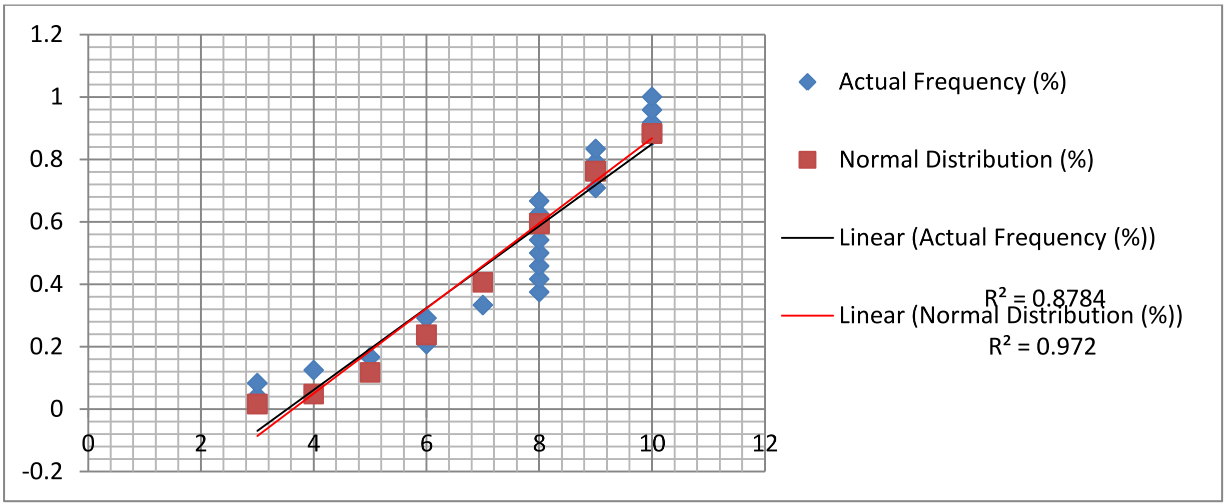


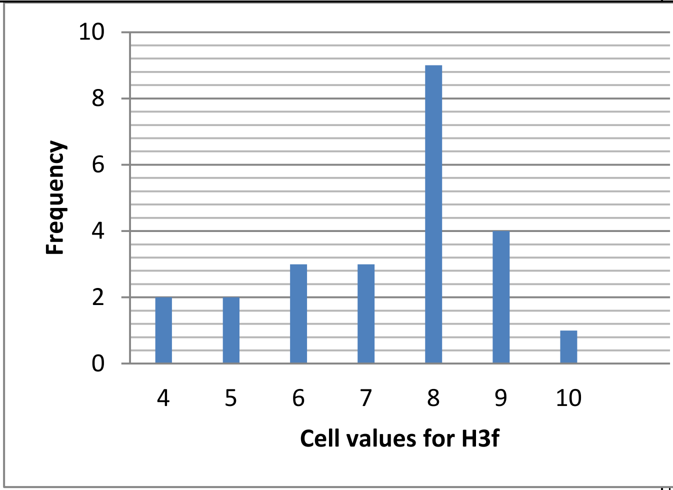
Figure 6.5b. Coefficient of Determination for sub-hypothesis H3e

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.87 and R^2 (Normal Distribution) = 0.97 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3e is accepted.

H3f: impact of trust between team members on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of co-worker trust leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is, μ=7.29. Moreover for this sample n=24, the minimum value was 4 and the maximum was 10 and the value of 8 was the most frequent. It is clear that the frequency is between the ranges 6 and 9 (figure 6.6a) in the second most popular area. Moreover a smaller group of project managers provided answers with frequency between 4, 5 and 10. Finally, due to the atypical large value, the histogram (figure 6.6a) is slightly skewed to the left, or negatively skewed (-0.64). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	7.291666667
Standard Error	0.332312749
Median	8
Mode	8
Standard Deviation	1.627993341
Skewness	-0.647841814
Range	6
Minimum	4
Maximum	10
Count	24
Confidence Level (95.0%)	0.687441298

Figure 6.6a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3f

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.62. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.68 minutes, or μ=5.48 to μ=7.09. So at a significance level 0.05 and probability 95% the accepted range is: 5.48<6.29<7.09 (figure 6.6b).

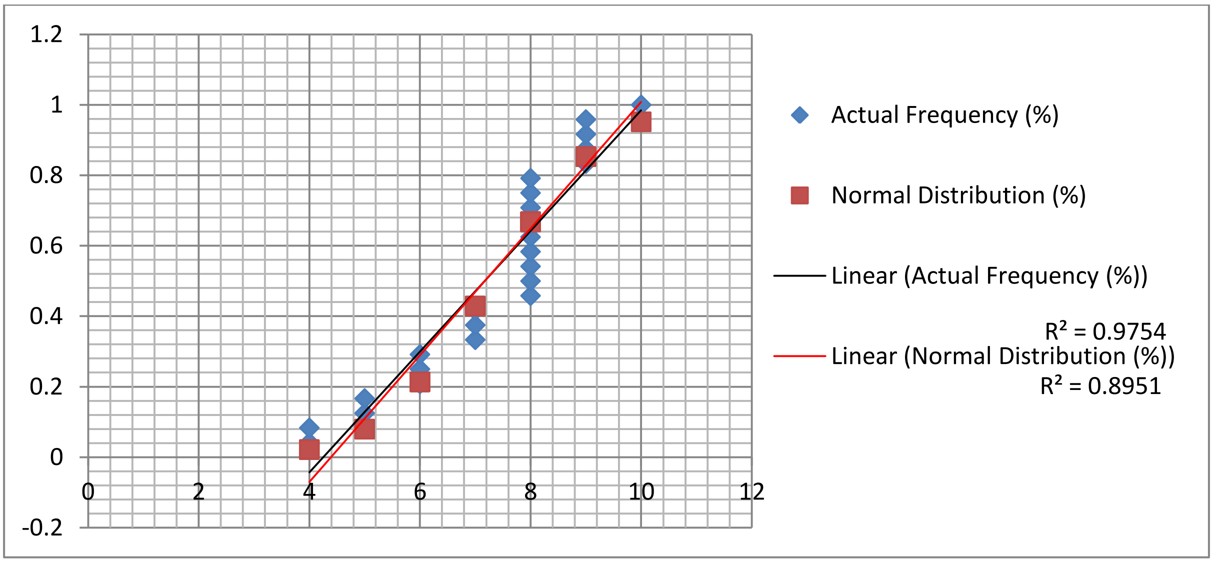


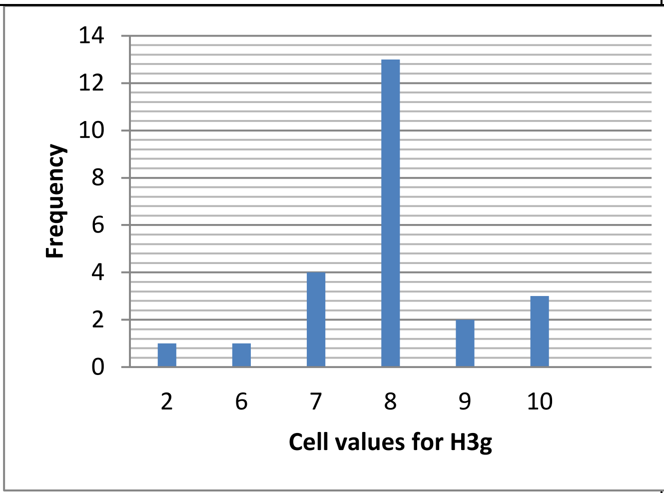
Figure 6.6b. Coefficient of Determination for sub-hypothesis H3f

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.97 and R^2 (Normal Distribution) = 0.89 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.6b). As a result the sub hypothesis H3f is accepted.

H3g: Trust between team members can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of co–worker trust leading to 'raising the quality *issues'* of the final output is equal to the mean value, that is, μ=7.83. Moreover for this sample n=24, the minimum value was 2 and the maximum 10. Values 7 and 8 were the most frequent, although 10 was also indicated (figure 6.7a). Moreover a smaller group of project managers provided answers with frequency between 2, 6 and 9. Finally, due to the atypically large value, the histogram (figure 6.7a) is slightly skewed to the left, or negatively skewed (-2.08). Without this value, the histogram would be reasonably symmetric.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.833333333
Standard Error	0.322280521
Median	8
Mode	8
Standard Deviation	1.578845662
Skewness	-2.087590426
Range	8
Minimum	2
Maximum	10
Count	24
Confidence Level (95.0%)	0.666688053

Figure 6.7a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3g

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.57. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.66 minutes, or μ=7.17 to μ=8.49. So at a significance level 0.05 and probability 95% the accepted range is: 7.17<7.83<8.49.

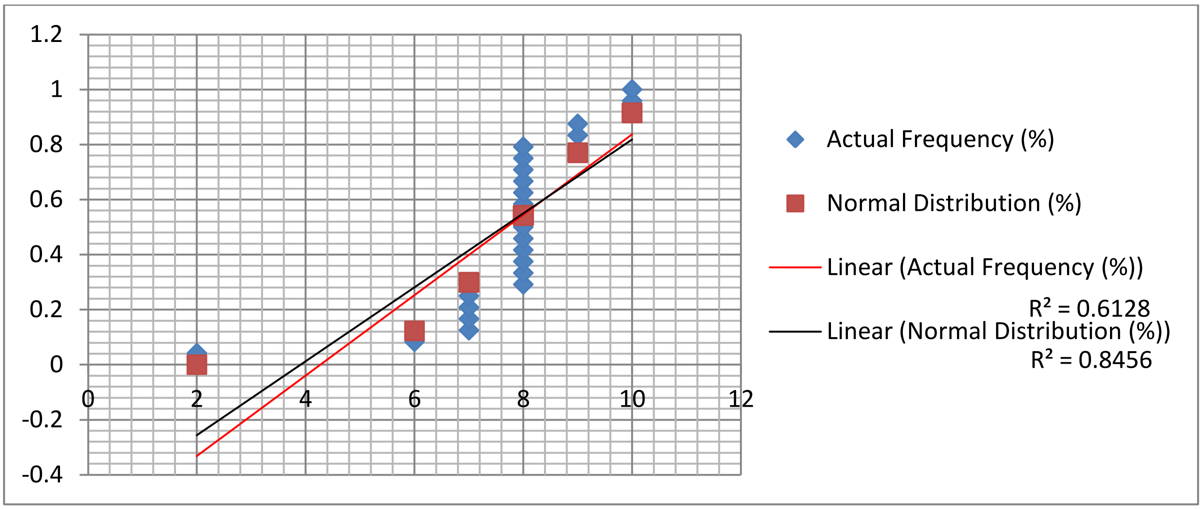


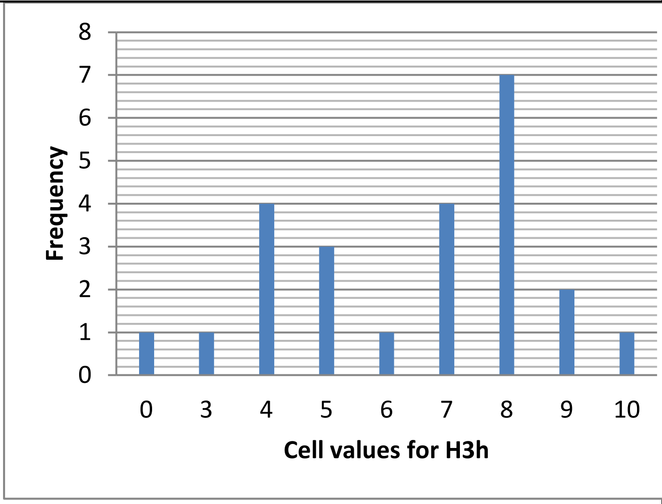
Figure 6.7b. Coefficient of Determination for sub-hypothesis H3g

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.61 and R^2 (Normal Distribution) = 0.84 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.7b). As a result the sub hypothesis H3g is accepted.

H3h: Trust between team members can have an impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of co–worker trust on leading to 'accurate comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=6.33 Moreover for this sample n=24, the minimum value was 0 and the maximum was 10, and the values between 4, 7 and 8 were quite frequent compared to the others. In contrast, the range between 5 and 9 in terms of the frequency was the second and third most popular (figure 6.8a), which makes sense since one group of project managers had a very good understanding of the question. In addition a smaller group of project managers provided answers with frequency between 0, 3, 6 and 10. Finally, due to the atypically large value, the histogram (figure 6.8a) is slightly skewed to the left, or negatively skewed (-0.83). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.333333333
Standard Error	0.480287756
Median	7
Mode	8
Standard Deviation	2.352919864
Skewness	-0.830992772
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	0.993550922

Figure 6.8a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3h

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.35. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.99, or μ=5.34 to μ=7.32. So at a significance level 0.05 and probability 95% the accepted range is 5.34<6.33<7.32 (figure 6.8b).

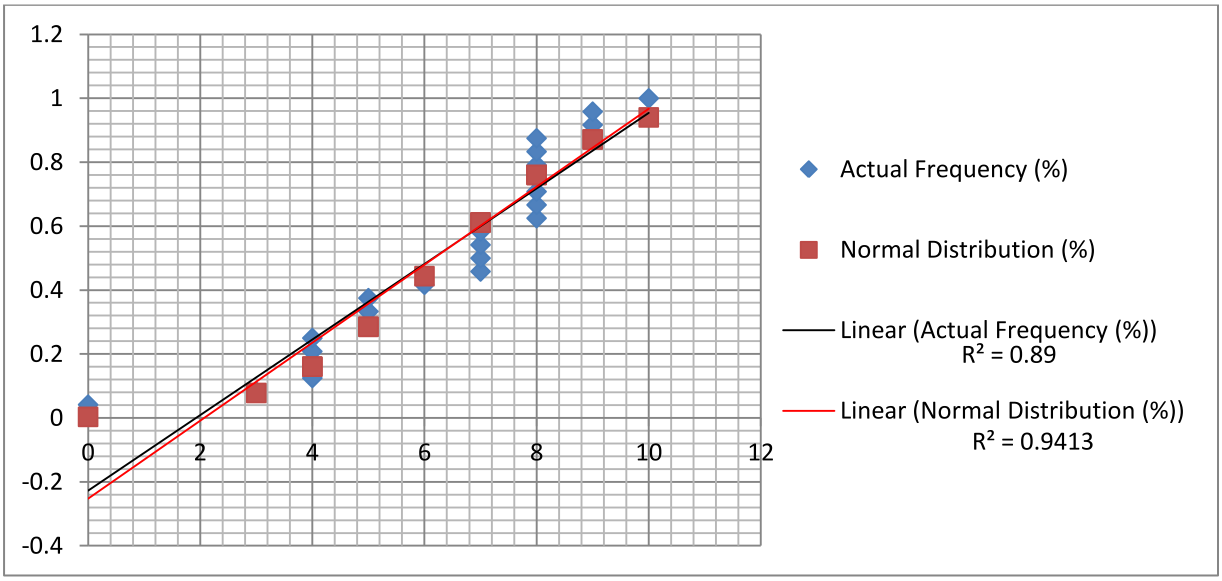


Figure 6.8b. Coefficient of Determination for sub-hypothesis H3h

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.89 and R^2 (Normal Distribution) = 0.94 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.8b). As a result the sub hypothesis H1a is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how flexible role could impact on project performance, which is presented below:

Data and information sharing: Interviewees stated that, “the more trust among members of a project team the more information is shared, leading to more project clarifications/details in the brief (design bid stage) of a potential project”. This situation causes the team members to feel more **confident** in ‘accurately’ predicting project time, cost and quality for planning, design and construction. As a result the calculation of the estimated **return on investment** could be determined in actual terms for the client.

Effective project meetings: The execution of project meetings helps in the development of co–worker trust due to the “need and willingness for **data and information sharing** among the stakeholders (team members)” and thus to support the relevant decisions. Hence, there are more chances to ‘accurately’ predict project time, cost and quality for planning, design and construction. As a result the calculation of the estimated **return on investment** could be determined in actual terms for the client.

Project Efficiency: It is the ability to use time and resources cost-effectively to produce the agreed deliverables and fulfil interested stakeholders’ expectations by using methods, systems and procedures in the most effective way. Interviewees mentioned that by developing co–worker trust the project manager and his team are operating according to the project’s strategic goals and aims. In addition, interviewees stated that in order to “ensure efficient use of their available resources so as to achieve the above goals, there is a need to provide detailed planning, scheduling and cost estimating”. Consequently, by securing project efficiency there are more chances to predict ‘accurately’ the time, cost and quality for planning, design and construction and hence the return on investment for the client to be representative.

Efficient project decisions: Interviewees found that enhancing co-worker trust encouraged confidence in the knowledge they have. This helps the project manager to be more **determined** and to make **efficient decisions**, which will help them predict ‘accurately’ the time, cost and quality for planning, design and construction and the return on investment for the client.

An additional comment of the interviewees was that "co-worker trust is the most important element of proactivity in project managers". Henceforth, there is an impact of how co-worker trust antecedent can impact on project performance and this is illustrated in table 6.2.

	IMPACT OF CO–WORKER TRUST ON PROJECT PERFORMANCE
Co-Worker Trust	• Data & Information Sharing • Effective project meetings • Project Efficiency • Efficient project decisions

Table 6.2. Impact of co-worker trust antecedent on project performance

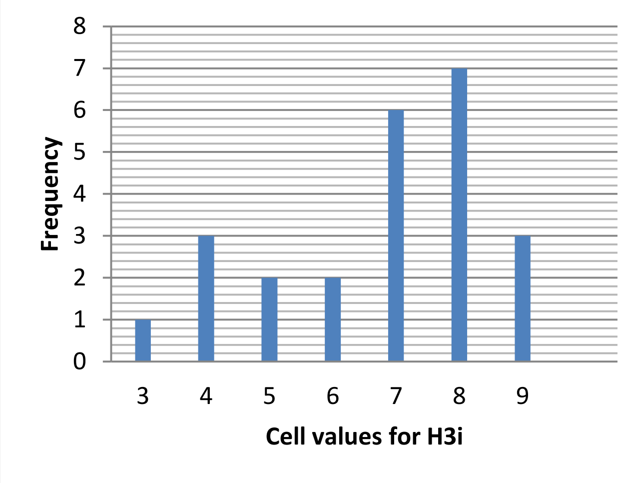
Walker (2011) stated that trust among team members can influence the degree of collaboration and vice versa. Moreover, it is crucial for a project manager and his/her team to develop a culture where trust is a major principle that affects both organisational and project performance. The reason is that trust engages and enables people when they are in business with each other. In addition, trust helps communication and sharing information and is a major factor in efficient collaboration. Collaboration, according to Koskela (2002), is a principle of lean management which aims to optimise project performance. This optimisation is in pre-identifying the time a project will take and the costs of a project, in order to raise a project's quality. Akintonye (1999) mentioned the importance of construction project ROI identification in order to secure a new project or recommendation for a new client. Therefore, a project manager has to establish trust among project partners so that he/she can predict project times and costs, raise quality issues and help identify client's ROI. This will give him/her the opportunity to share correct data & information, organise and have effective project meetings, ensure that projects run efficiently and allow him/her to make efficient project decisions.

6.2.3. Self-Efficacy

H3i: Self-efficacy can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of self-efficacy on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, μ=6.75. Moreover for this sample n=24, the minimum value was 3 and the maximum 9 and values 7 and 8 were quite frequent (figure 6.9a). There is a range of low values between 3, 4, 5, 6 and 9. Finally, due to the atypically large value, the histogram (figure 6.9a) is slightly skewed to the left, or negatively skewed (-0.69). Without this value, the histogram would be reasonably symmetrical (figure 6.9a).

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.75
Standard Error	0.3573757
Median	7
Mode	8
Standard Deviation	1.750776225
Skewness	-0.696016229
Range	6
Minimum	3
Maximum	9
Count	24
Confidence Level (95.0%)	0.739287963

Figure 6.9a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3i

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.75. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.73, or μ=6.02 to μ=7.48. So, at a significance level of 0.05 and probability 95% the accepted range is: 6.02<7.5<7.48.

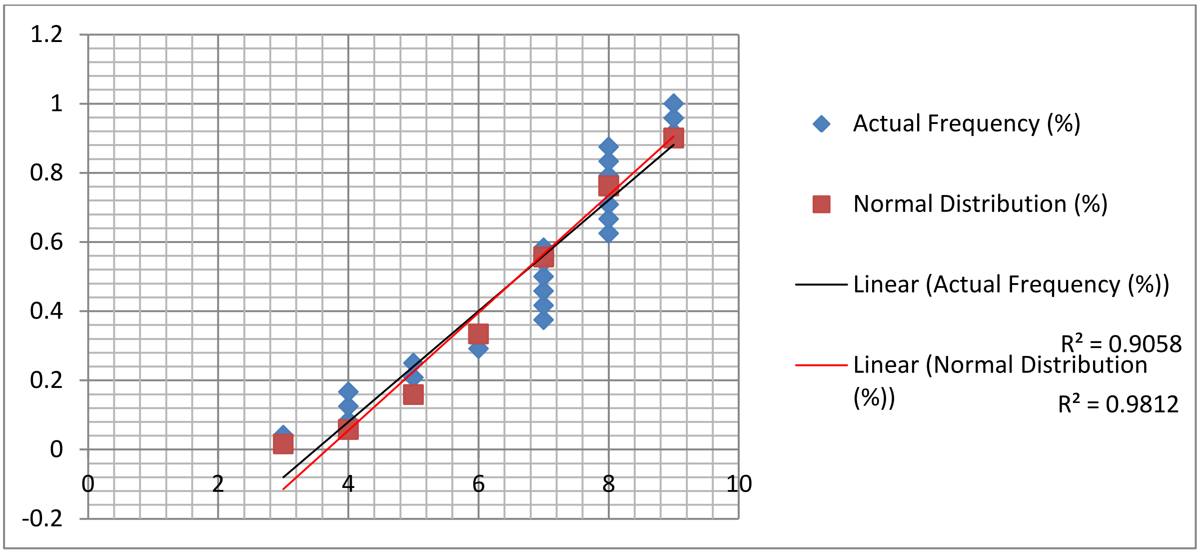


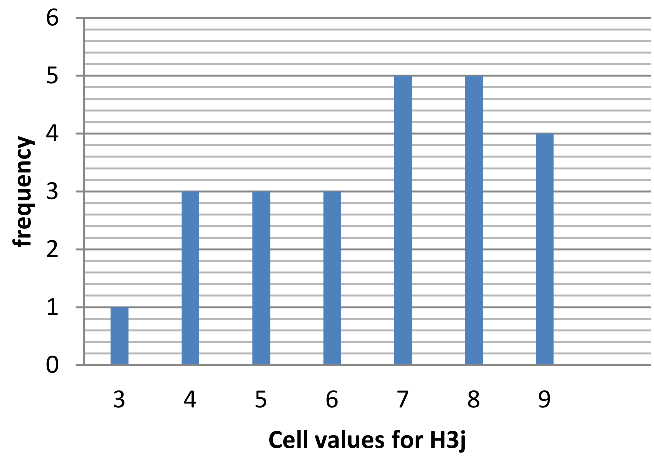
Figure 6.9b. Coefficient of Determination for sub-hypothesis H3i

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.90 and R^2 (Normal Distribution) = 0.98 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.9b). As a result the sub hypothesis H3i is accepted.

H3j: Self-efficacy can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of self-efficacy leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is, μ=6.62. Moreover for this sample n=24, the minimum value was 3 and the maximum was 9, and the values 7 and 8 are the most frequent. It is clear the frequency of the value 9 (figure 6.10a) is in the second most popular area.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.625
Standard Error	0.370137558
Median	7
Mode	8
Standard Deviation	1.813296302
Skewness	-0.387073137
Range	6
Minimum	3
Maximum	9
Count	24
Confidence Level (95.0%)	0.765687876

Figure 6.10a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3j

Moreover a smaller group of project managers provided answers with frequency between 3, 4, 5 and 6. Finally, due to the atypically large value, the histogram (figure 6.10a) is slightly skewed to the left, or negatively skewed (-0.38). Without this value, the histogram would be reasonably symmetrical. Moreover the Standard Deviation (SD) between the data and the mean is SD=1.81. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.76, or μ=5.86 to μ=7.38. So at a significance level 0.05 and probability 95% the accepted range is: 5.86<6.62<7.38.

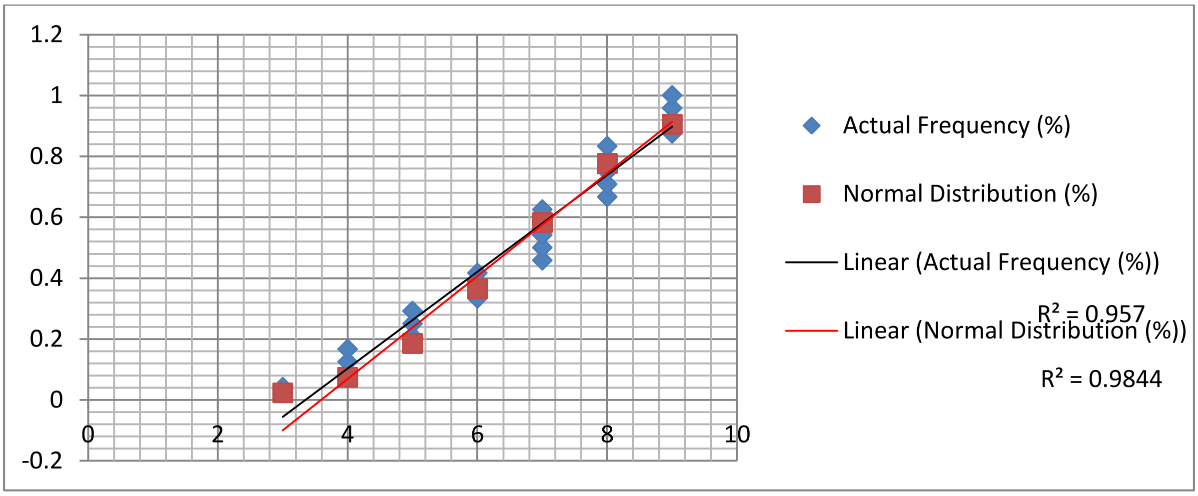


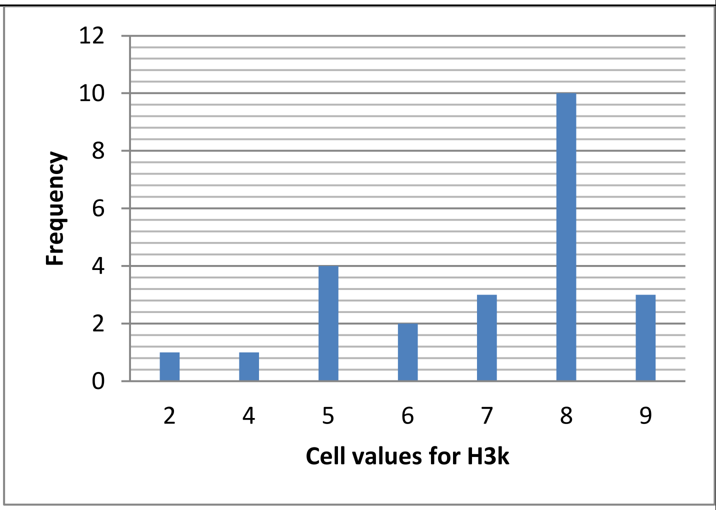
Figure 6.10b. Coefficient of Determination for sub-hypothesis H3j

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.95 and R^2 (Normal Distribution) = 0.98 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3j0 is accepted.

H3k: Self-efficacy can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of self-efficacy on leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=6.91. Moreover for this sample n=24, the minimum value was 2 and the maximum was 9. Values 5 and 8 were the most frequent, although 7 and 9 were also indicated (figure 6.11a). Moreover a smaller group of project managers provided answers with frequency between 2, 4, 6 and 7. Finally, due to the atypically large value, the histogram (figure 6.11a) is slightly skewed to the left, or negatively skewed (-1.10). Without this value, the histogram would be reasonably symmetric.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	6.916666667
Standard Error	0.365726727
Median	8
Mode	8
Standard Deviation	1.791687732
Skewness	-1.10114722
Range	7
Minimum	2
Maximum	9
Count	24
Confidence Level (95.0%)	0.756563377

Figure 6.11a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3k

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.79. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.75, or μ=6.42 to μ=7.66. So at a significance level 0.05 and probability 95% the accepted range is 6.42<6.91<7.66.

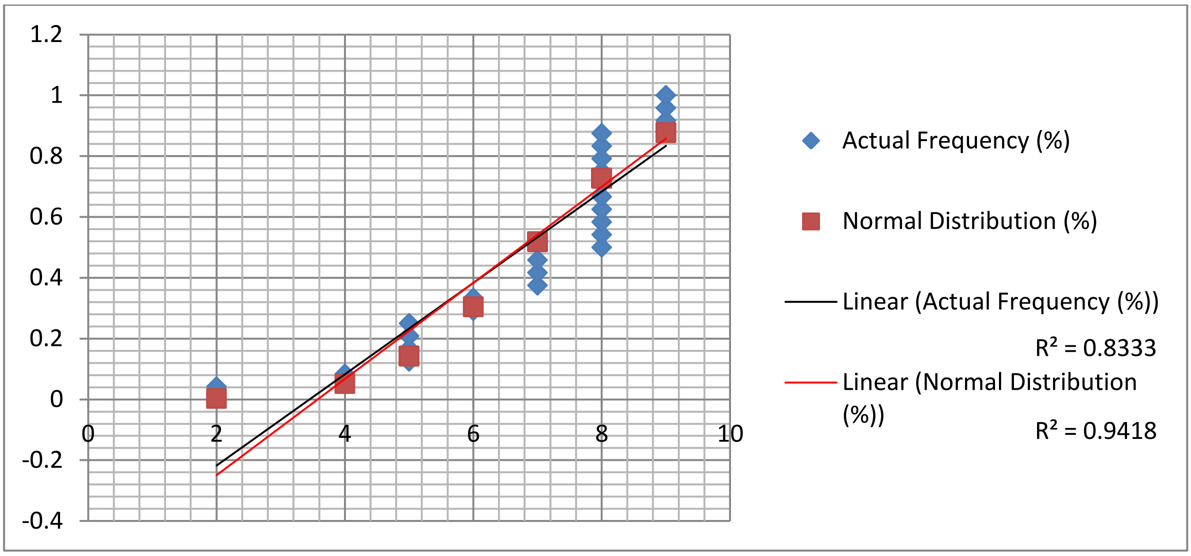


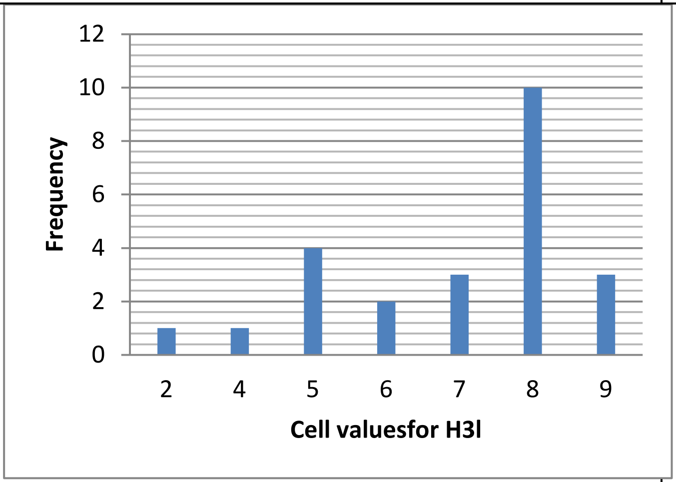
Figure 6.11b. Coefficient of Determination for sub-hypothesis H3k

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.83 and R^2 (Normal Distribution) = 0.94 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.11b). As a result the sub hypothesis H3k is accepted.

H3l: Self-efficacy can have an impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of self-efficacy on 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=5.26 Moreover for this sample n=24, the minimum value was 0 and the maximum was 10, and the value 5 was quite frequent compared to the others. In contrast, in terms of frequency, the values 6 and 7 (equal) and 5 was the second and third most popular (figure 6.12a). In addition a smaller group of project managers provided answers with frequency between 0, 1, 4 and 10. Finally, due to the atypically large value, the histogram (figure 6.12a) is slightly skewed to the left, or negatively skewed (-0.43). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	5.625
Standard Error	0.502935225
Median	6
Mode	5
Standard Deviation	2.46386935
Skewness	-0.439690569
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	1.040400781

Figure 6.12a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3l

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.46. The confidence interval for the underlying population mean for flexible role leading to ‘accurate time’ equals ± 1.04, or μ=4.22 to μ=7.32. So at a significance level 0.05 and probability 95% the accepted range is: 5.34<6.33<6.30 (figure 6.12a)

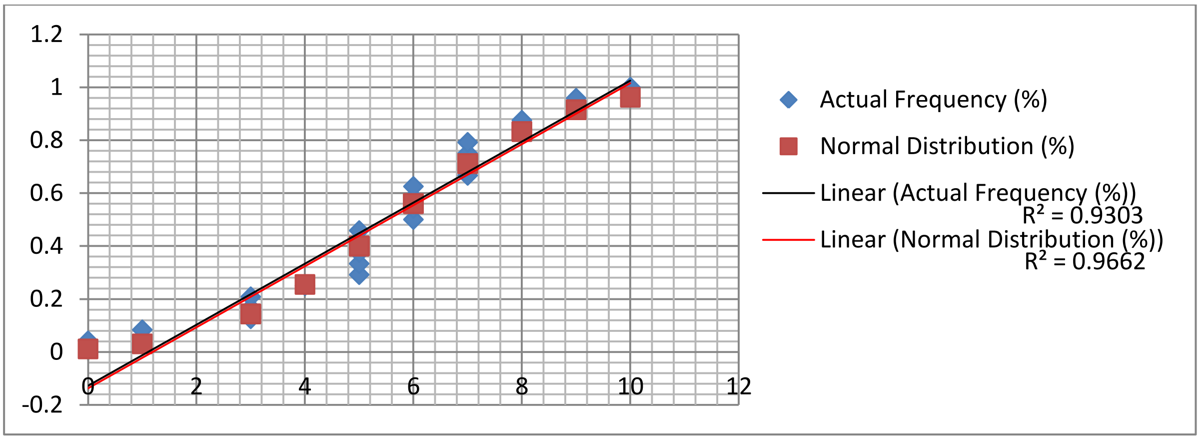


Figure 6.12b. Coefficient of Determination for sub-hypothesis H3l

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.93 and R^2 (Normal Distribution) = 0.96 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.12b). As a result the sub hypothesis H3l is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how self - efficacy could impact on project performance, which is presented below:

Project risk identification: The identification of project risk is a major task of the feasibility study of a project. That requires the harmonious collaboration of the project partner in order to identify these risks. However, the biggest challenge during this process has been stated by the interviewees as, "carrying out a range of proactive, interpersonal and integrative project tasks, i.e., the project risk management assessment". Therefore, according to the same group of interviewees, it is necessary to employ a project manager with the capability of being "self–efficant in order to coordinate and collaborate with project stakeholders in project risk identification".

Identify project's political factors: The identification of project political factors is a task under investigation during the feasibility study of a project due to the nature of "identifying possible barriers that could reflect project progress and project viability/cash flow". Normally this is part of the risk assessment and requires the harmonious collaboration of the project partners in order to identify those particular factors. However, as stated by interviewees, the biggest challenge during this process is to recruit a "self–efficant project manager in order to maintain communication with project stakeholders at a high level (public relations) so that the project will not be affected". Henceforth, the need to improve communication between the stakeholders in order to identify and deal with political factors that could distract project progress helps the project manager to predict more 'accurately' project time delivery, project cost, and to raise quality issues and assist the client in identifying possible return on investment.

Clarify project requirements: The clarification of project requirements is an additional element that must be identified during the feasibility study of a project. Interviewees found this factor to be a catalyst that could reflect the prediction of project time, cost, delivery and ROI for the client. Their belief is that, "if they are not familiar with project requirements they have increased possibilities to fail at later project management life cycle stages". Therefore, by being "self–efficant", a project manager can ask as many questions as needed of the client in order to ensure that he can "carry out a range of proactive, interpersonal and integrative project tasks, i.e., the project requirements". Henceforth, the clarification of project requirements by a self–efficant project manager could increase the probability of predicting more ‘accurately’ project time delivery and cost, raising quality issues and assisting the client in identifying the possible return on investment.

Efficient design of the project process: The design of the project process is an additional task which must take place at the very beginning of the feasibility study of a project (pre-feasibility study in particular). Interviewees stated that the design of the project process in the pre-feasibility study “works as a catalyst to pre-identify whether the project is worthy of investment”. Therefore it was found that, before entering into the feasibility study, a project manager “must be very careful, proactive, interpersonal, and have the capability to integrate project tasks”. This self–efficant behaviour allows him to take the initiative to move the project one stage ahead by increasing the probability of predicting more ‘accurately’ project time delivery and cost, raising quality issues and assisting the client to identify possible return on investment.

Clarify project business model: The clarification of the project business model has been presented as an additional element which impacts on project performance. In particular it has been said that by being in a position to pre–identify the business/commercial outcome of a project, the project manager can “motivate the client to work closer and to avoid clashes and conflict of interest”. This as a task which must take place at the very beginning of the feasibility study of a project (pre- feasibility study in particular). Interviewees stated that the design of the project process in the pre-feasibility study “works as a catalyst to pre-identify whether the project is worthy of investment”. Therefore it was found that before entering into the feasibility study a project manager “must be very careful, proactive, interpersonal, and have the capability to integrate project tasks”. This self–efficant behaviour allows him to take the initiative to move the project one stage ahead by increasing the probability to predict more ‘accurately’ project time delivery and cost, to raise quality issues and to assist the client to identify possible return on investment.

Henceforth, self–efficact antecedent can have an impact on project performance, as illustrated in table 6.3.

IMPACT OF SELF-EFFICACY ON PROJECT PERFORMANCE	
Self – Efficacy	• Project risk identification • Identify project's political factors • Clarify project requirements • Efficient design of the project process • Clarify project business model

Table 6.3. Impact of self - efficacy antecedent on project performance

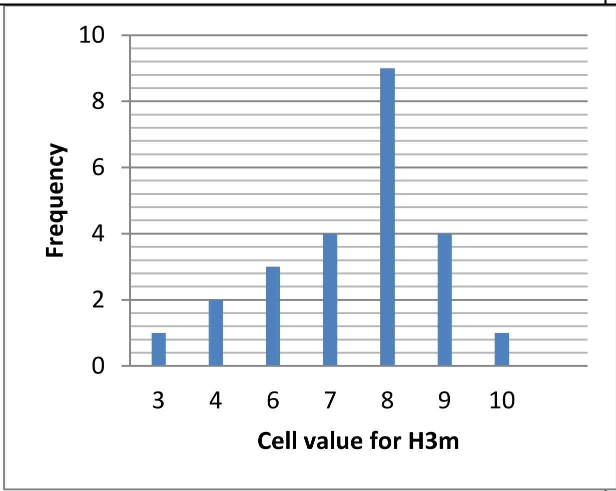
A project manager has to design, control and execute project tasks according to PMBoK (2008). In addition to the Eye of Competence (International Project Management Association) a project manager, amongst other things, has to be self-efficant in order to be able to design, control and execute a task. Furthermore, it is expected that the more self-efficant a project manager is, the less problems will occur because he/she has the skills to pre-identify and control project indicators, i.e. time, cost, quality, etc. In addition to these skills, he/she is required to foresee problems and to integrate task processes (Parker, 2006). Furthermore, this research shows that, by a project manager being self-efficant, he/she is in a more competitive position to predict project times and costs, raise quality issues and is more likely to help identify clients' ROI (μ=5.60) and thus to identify the project risks and the project's political factors, to clarify project requirements, to efficiently design the project's process and to clarify the project business model.

6.2.4. Control Appraisal

H3m: A control appraisal process can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of the control appraisal on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, μ=7,29. Moreover for this sample n=24, the minimum value was 3 and the maximum 10, and the value 8 was quite frequent (figure 6.13a). There is a range of low values between 3, 4, 6 and 10. It is clear that the frequency of the values 7 and 9 are in the second most popular area. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.04). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	7.291666667
Standard Error	0.353446625
Median	8
Mode	8
Standard Deviation	1.731527766
Skewness	-1.040940234
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.731160051

Figure 6.13a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3m

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.73. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.73, or μ=6.56 to μ=8.02. So, at a significance level of 0.05 and probability 95% the accepted range is 6.56<7.5<8.02.

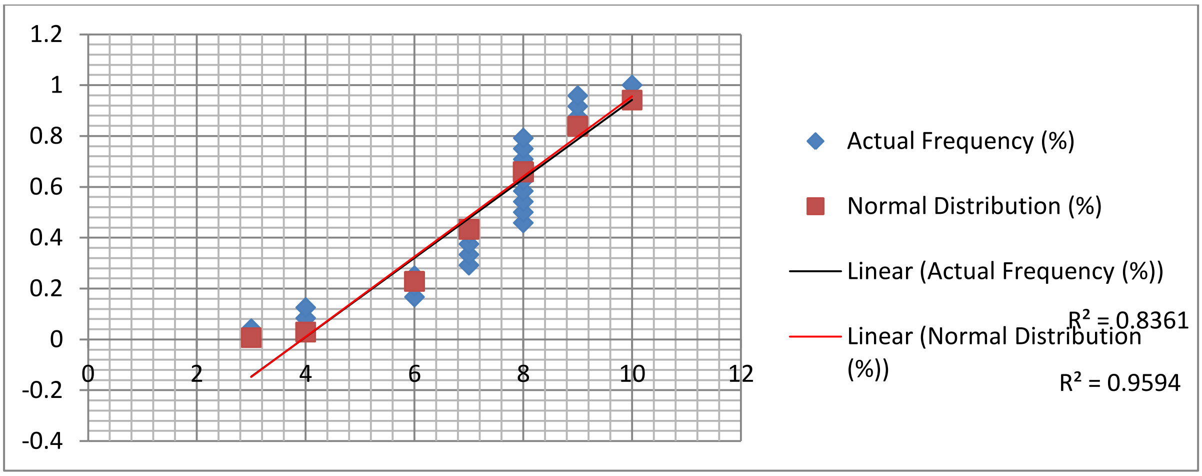


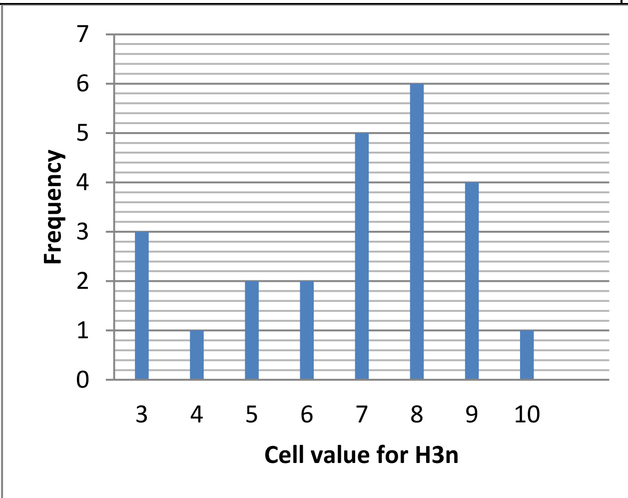
Figure 6.13b: Coefficient of Determination for sub-hypothesis H3m

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.83 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1(figure 6.13b). As a result the sub hypothesis H3m is accepted.

H3n: A control appraisal process can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of the control appraisal leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is μ=6.83. Moreover for this sample n=24, the minimum value was 3 and the maximum 10, while the value 8 is the most frequent. It is clear the frequency of the value 7 (figure 6.14a) is in the second most popular area. Moreover a smaller group of project managers provided answers with frequency between 3, 4, 5, 6, 9 and 10. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.67). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.833333333
Standard Error	0.419914875
Median	7
Mode	8
Standard Deviation	2.057154359
Skewness	-0.671350197
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.868660102

Figure 6.14a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3n

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.05. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.86, or μ=5.97 to μ=7.69. So at a significance level 0.05 and probability 95% the accepted range is 5.97<6.83<7.69.

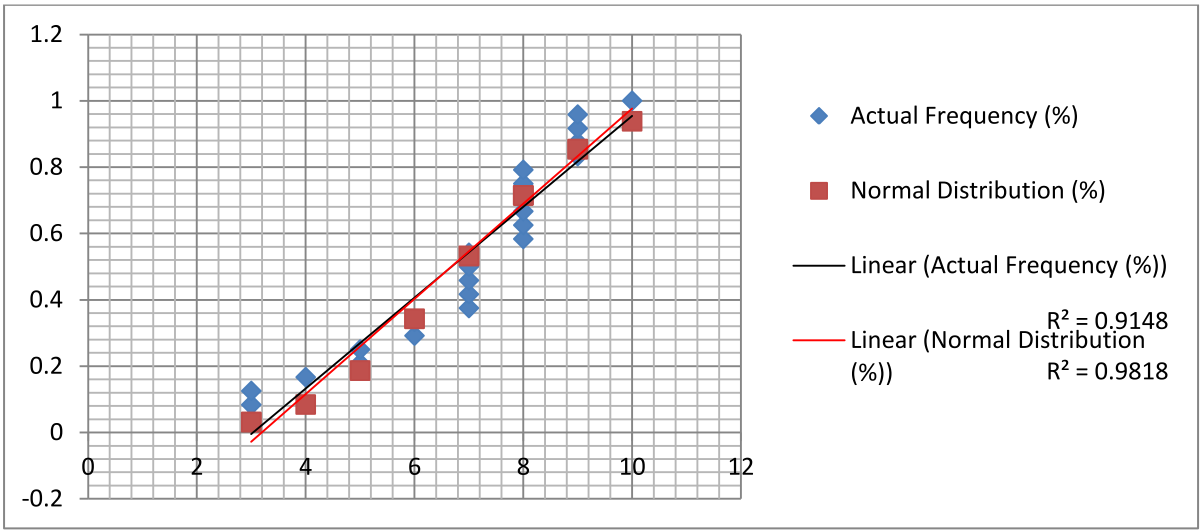


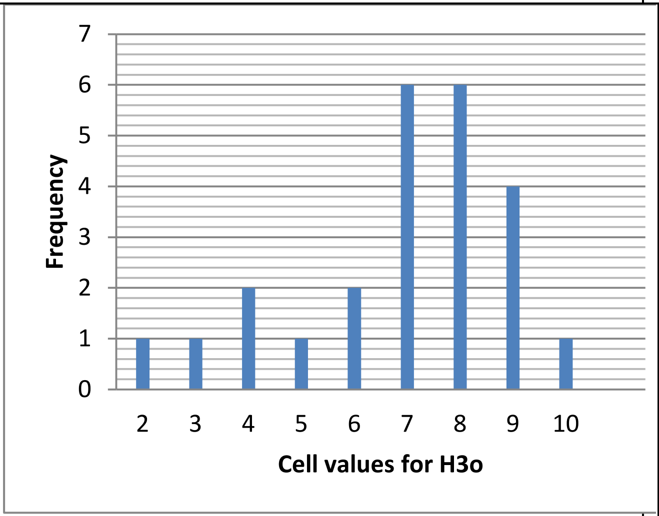
Figure 6.14b. Coefficient of Determination for sub-hypothesis H3n

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.91 and R^2 (Normal Distribution) = 0.98, the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3n is accepted.

H3o: A control appraisal process can have an impact on ''raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of the control appraisal leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=6.91. Moreover for this sample n=24, the minimum value was 2 and the maximum 10. Values 7 and 8 were the most frequent, although values of 9 and 4 were also indicated (figure 6.15a). Moreover a smaller group of project managers provided answers with frequency between 2, 3, 5, 6 and 10. Finally, due to the atypically large value, the histogram (figure 6.15a.) is slightly skewed to the left, or negatively skewed (-0.91). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.916666667
Standard Error	0.416666667
Median	7
Mode	7
Standard Deviation	2.041241452
Skewness	-0.914734351
Range	8
Minimum	2
Maximum	10
Count	24
Confidence Level (95.0%)	0.861940671

Figure 6.15a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3o

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.04. The confidence interval for the underlying population mean for flexible role lead to ‘accurate time’ equals ± 0.86, or μ=6.05 to μ=7.77. So at a significance level 0.05 and probability 95% the accepted range is: 6.86<6.91<7.77 (figure 6.15b).

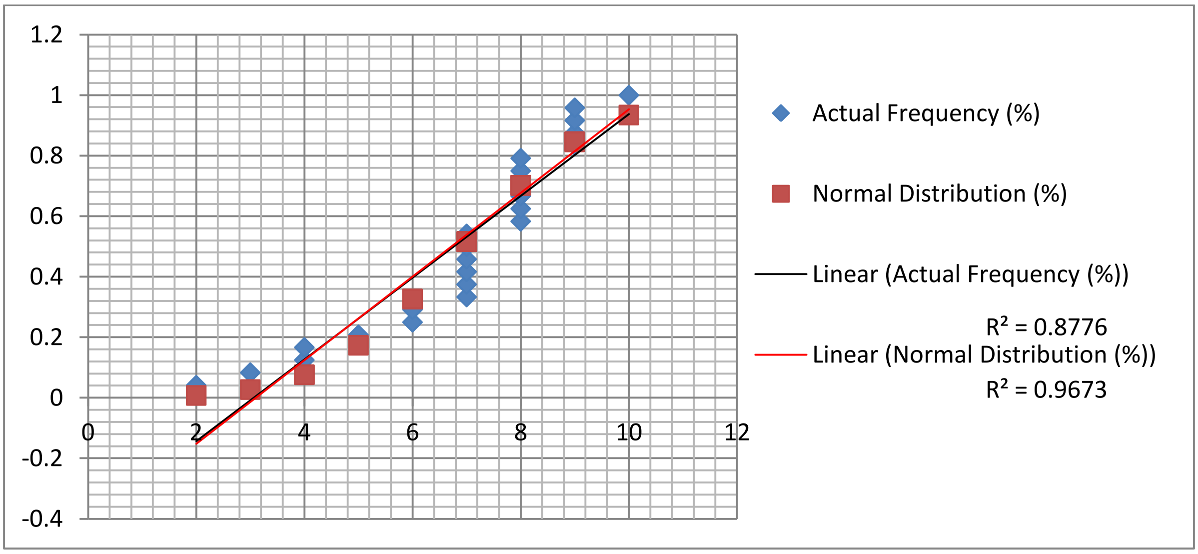


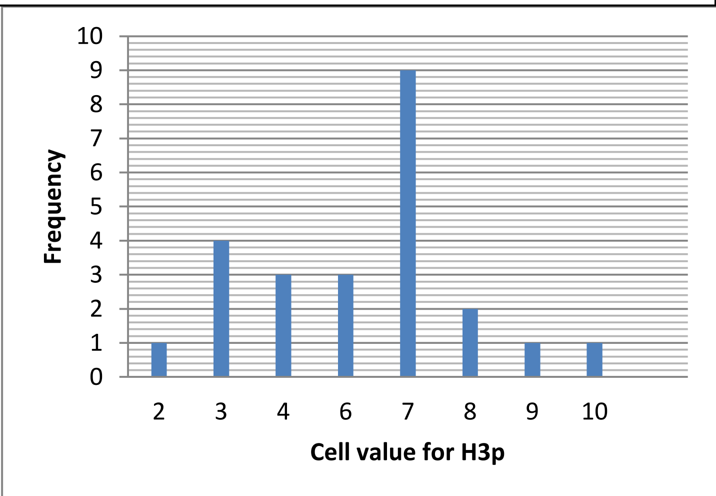
Figure 6.15b. Coefficient of Determination for sub-hypothesis H3o

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.87 and R^2 (Normal Distribution) = 0.96 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.15b). As a result the sub hypothesis H3o is accepted.

H3p: impact of control appraisal process on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of the control appraisal leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value that is μ=5.91 Moreover for this sample n=24, the minimum value was 2 and the maximum was 10, and the value 7 was quite frequent compared to the others. In contrast, the values 3, 4 and 6 (equal) values in terms of the frequency were the second and third most popular (figure 6.16a) In addition a smaller group of project managers provided answers with frequency between 2, 5, 9 and 10. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.25). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	5.916666667
Standard Error	0.437866479
Median	7
Mode	7
Standard Deviation	2.145098896
Skewness	-0.257216
Range	8
Minimum	2
Maximum	10
Count	24
Confidence Level (95.0%)	0.905795823

Figure 6.16a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3p

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.14. The confidence interval for the underlying population mean for flexible role lead to 'accurate time' equals ± 0.90, or μ=5.01 to μ=6.81. So at a significance level 0.05 and probability 95% the accepted range is 5.01<5.91 <6.81.

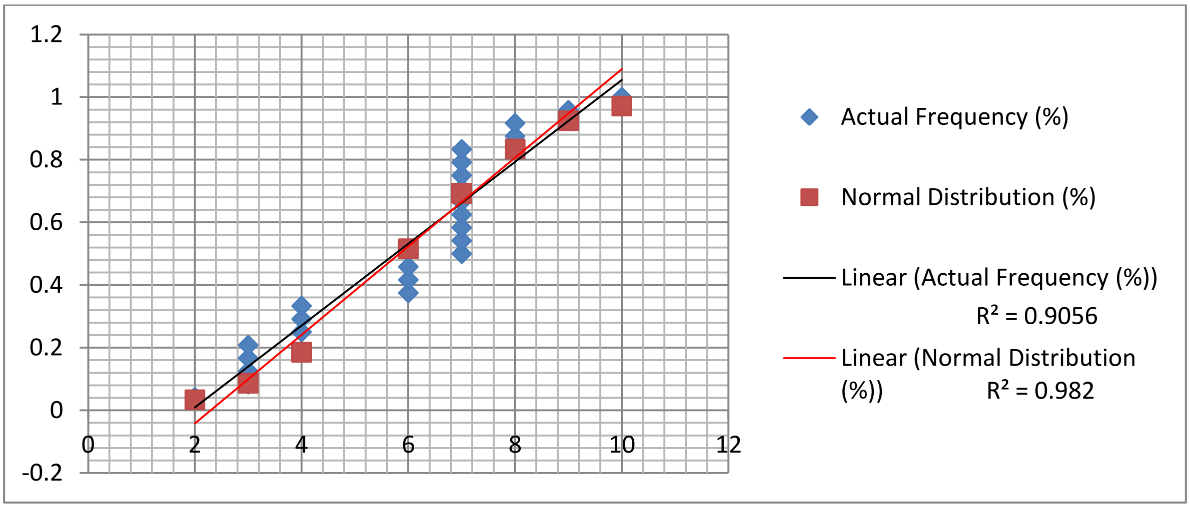


Figure 6.16b. Coefficient of Determination for sub-hypothesis H3p

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.90 and R^2 (Normal Distribution) = 0.98, the regression line from both models and their data tend to match and both their values are close to 1(figure 6.16b). As a result the sub hypothesis H3p is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how self-efficacy could impact on project performance, and this is presented below:

Efficient project control process: Project managers within construction project managerial functions such as planning, scheduling, construction and fit-out have the ability to check possible errors and to take corrective action so that deviation from standards is minimised and the stated goals of the organization are achieved successfully. Interviewees mentioned that by controlling and having an impact on project outcomes, a project manager could help a project to operate smoothly. As a result the more control oriented a project manager the more possibilities he has to predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Eliminate project risks: The identification of project risk is a major task of the feasibility study of a project, and it requires the harmonious collaboration of the project partner in order to identify these risks. However, the biggest challenge during this process, as stated by the interviewees is, "to control and have an impact on project outcomes". Therefore, according to the same group of interviewees, it is necessary to employ a project manager that has the capability of being a "critical thinker, able to criticise and coordinate project stakeholders so to maintain project risks at a minimum". Henceforth, because of this skill, a critically oriented project manager has more possibilities to reduce project risks and so to control the project. As a result the probability to predict more 'accurately' project time delivery and cost, to raise quality issues and to assist the client to identify the possible return on investment is increased significantly.

Project optimisation process: The optimisation process aims to minimise cost and maximise outputs and/or efficiency. Interviewees stated that, "optimisation is achieved by improving the project process and the control process". It has been said that it is advantageous if a project manager has the knowledge and understanding of why, when and how optimisation is required during the construction project management life cycle. This will help him to set and predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Henceforth, the control appraisal antecedent can have an impact on project performance, and this is illustrated in table 6.4.

IMPACT OF CONTROL APPRAISAL ON PROJECT PERFORMANCE	
Control Appraisal	• Efficient project control process • Eliminate project risks • Project optimisation process

Table 6.4. Impact of control appraisal antecedent on enhancing project progress

A project manager can control and have an impact on project outcomes according to Cleland (1999). Moreover, a project manager has to be in a position to identify the key project stages (gates) when decisions will be made from time to time during the project process (Cooper et al, 2008). The biggest challenges for the design and execution of the control appraisal process are to identify these key points and to propose changes (Cooper et al, 2008). Changes during the design of the control appraisal process can reflect on the project indicators' performance.

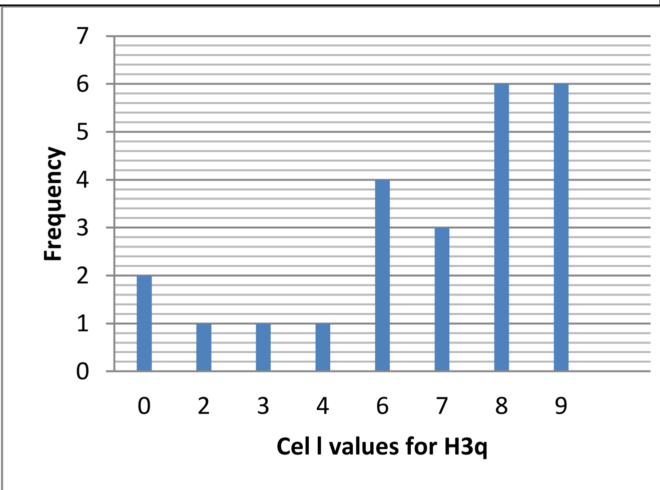
In particular, this research shows that there is a high degree of influence on predicting project time (μ=7.30), cost (μ=7.0), raising problems (μ=6.86) and pre-identifying client ROI (μ=5.86). Therefore, the more critically oriented belief a project manager has, the more likely it is that he/she will pre-identify "accurately" time and costs, raise quality problems and identify client ROI. The impact of a project manager having such ability is to efficiently set up a project control process, eliminate project risks and optimise project process.

6.2.5. Change Oriented

H3q: Identification of any possible type of changes can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of change orientation on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, μ=6.5. Moreover for this sample n=24, the minimum value was 0 and the maximum 9, and values 8 and 9 were quite frequent (figure 6.17a). There is a range of low values between 0, 2, 3, 4, and 7. It is clear the frequency of the value 6 is in the second most popular area. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.31). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.5
Standard Error	0.564659703
Median	7.5
Mode	9
Standard Deviation	2.766256299
Skewness	-1.310808785
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.168087591

Figure 6.17a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3q

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.76. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.16, or μ=5.34 to μ=7.66. So, at a significance level of 0.05 and probability 95% the accepted range is 5.34<6.5<7.66.

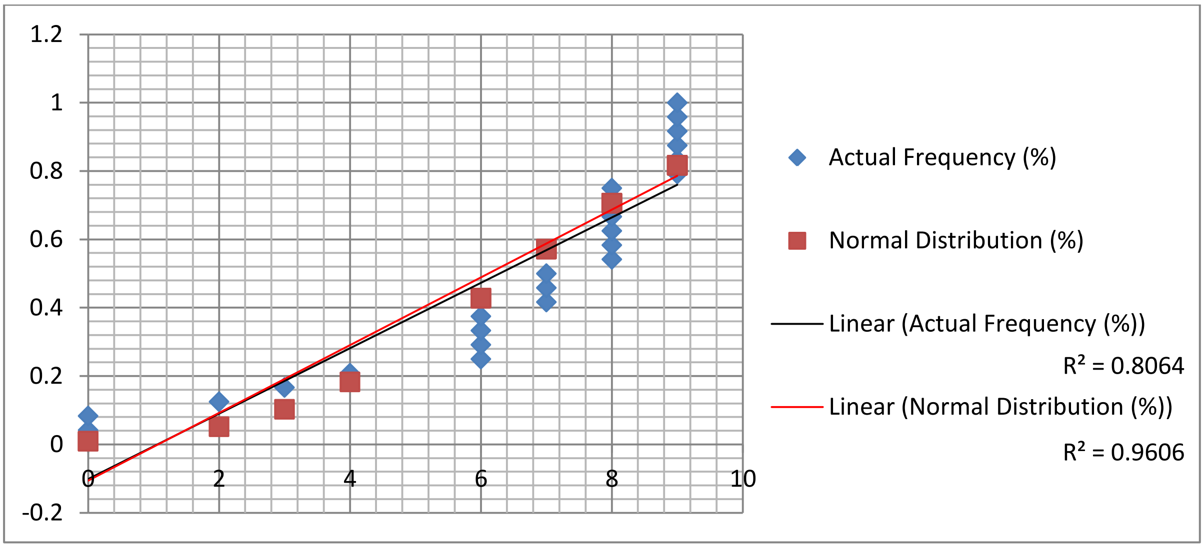


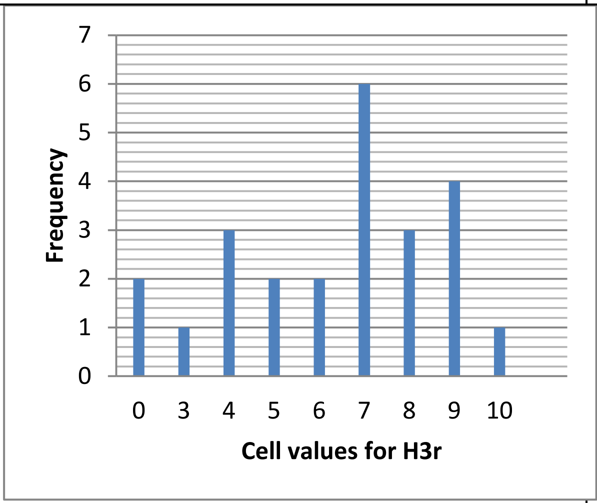
Figure 6.17b. Coefficient of Determination for sub-hypothesis H3q

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.80 and R^2 (Normal Distribution) = 0.96 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.17b). As a result the sub hypothesis H3q is accepted.

H3r: Identification of any possible type of changes can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of change orientation leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is, μ=6.20. Moreover for this sample n=24, the minimum value was 0 and the maximum 10, and the value 7 was the most frequent. It is clear the frequency of the value 9 (figure 6.18a) is in the second most popular area. Moreover a smaller group of project managers provided answers with frequency between 0, 3, 4, 5, 6, 8 and 10. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.96). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.208333333
Standard Error	0.545000886
Median	7
Mode	7
Standard Deviation	2.669948162
Skewness	-0.961151194
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	1.127420231

Figure 6.18a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3r

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.66. The confidence interval for the underlying population mean for flexible role lead to ‘accurate time’ equals ± 1.12, or μ=5.08 to μ=7.32. So at a significance level 0.05 and probability 95% the accepted range is: 5.08<6.20<7.32.

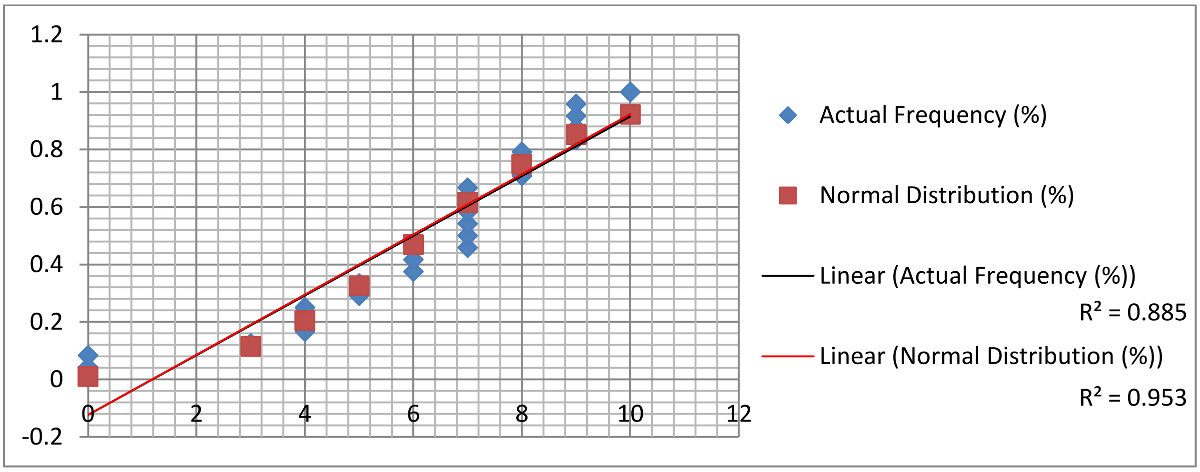


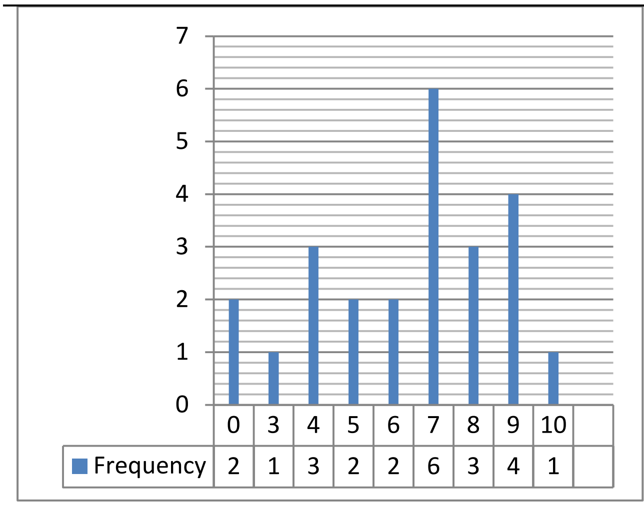
Figure 6.18b. Coefficient of Determination for sub-hypothesis H3r

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.88 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.18b). As a result the sub hypothesis H3r is accepted.

H3s: Identification of any possible type of changes can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of change orientation leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=6.87. Moreover for this sample n=24, the minimum value was 2 and the maximum was 10. Value 8 was the most frequent, although the values 5, 6 and 9 (equal) and 7 were also indicated (figure 6.19a). Moreover a smaller group of project managers provided answers with frequency between 2, 4, and 10. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.61). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.875
Standard Error	0.391543305
Median	7
Mode	8
Standard Deviation	1.918162617
Skewness	-0.613039662
Range	8
Minimum	2
Maximum	10
Count	24
Confidence Level (95.0%)	0.809969037

Figure 6.19a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3s

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.91. The confidence interval for the underlying population mean for flexible role lead to 'accurate time' equals ± 0.80, or μ=6.07 to μ=7.67. So at a significance level 0.05 and probability 95% the accepted range is 6.07<6.87<7.67.

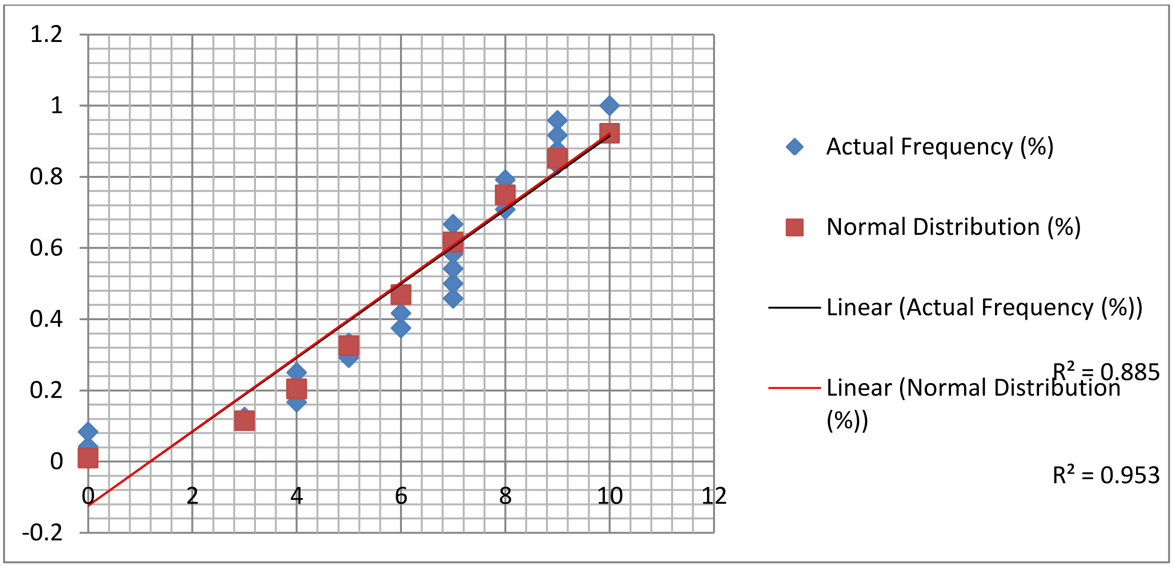


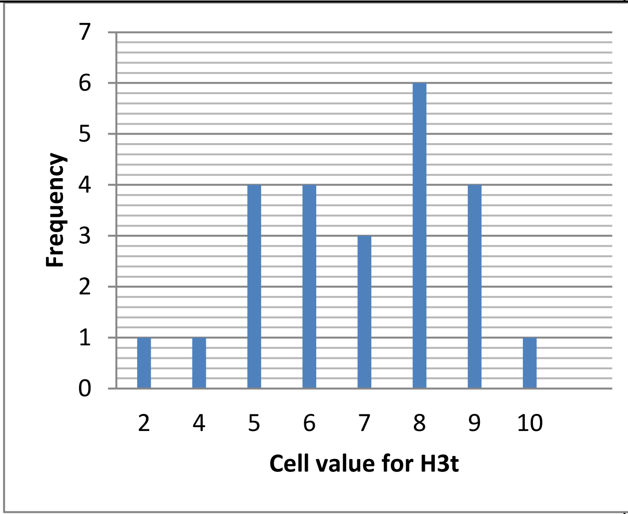
Figure 6.19b. Coefficient of Determination for sub-hypothesis H3s

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.88 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1 figure (6.19b). As a result the sub hypothesis H3s is accepted.

H3t: Identification of any possible type of changes can have an impact on 'estimating the return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of change orientation leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, $\mu=5.87$ Moreover for this sample $n=24$, the minimum value was 0 and the maximum 9, and the value 7 was quite frequent compared to the others. In contrast, the values 6 and 8 (equal) and 10 were the second and third most popular in terms of the frequency (figure 6.20a). In addition a smaller group of project managers provided answers with frequency between 0, 1, 2, 3 and 9. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.99). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	5.875
Standard Error	0.501130967
Median	7
Mode	7
Standard Deviation	2.455030328
Skewness	-0.996797381
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.036668389

Figure 6.20a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3t

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.45. The confidence interval for the underlying population mean for flexible role leading to ‘accurate time’ equals ± 1.03, or μ=4.84 to μ=6.90. So at a significance level 0.05 and probability 95% the accepted range is 4.84<5.87 <6.90.

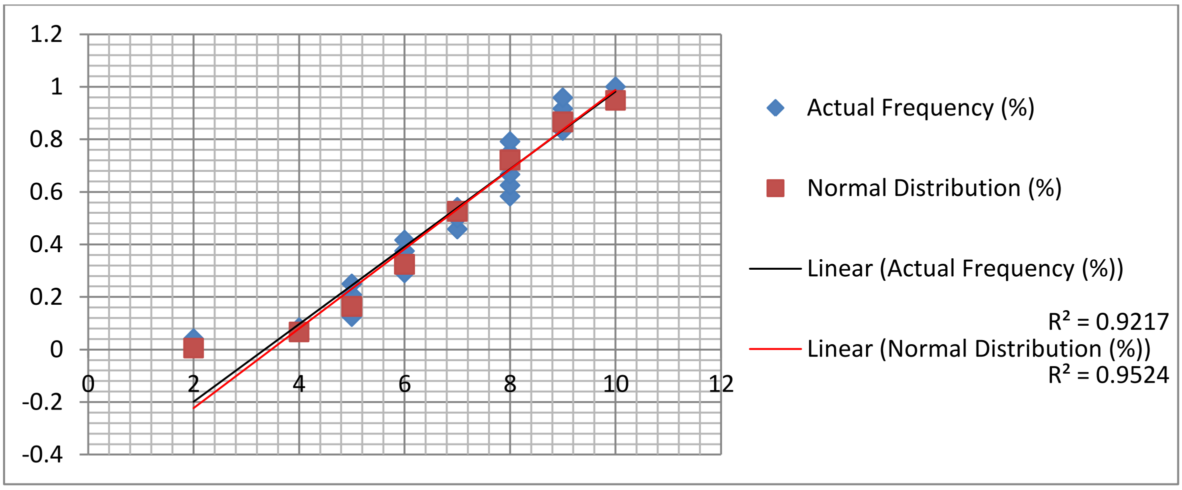


Figure 6.20b. Coefficient of Determination for sub-hypothesis H3t

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.92 and R^2 (Normal Distribution) = 0.95 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3t is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how change orientation could impact on project performance, and this is presented below:

Project and process change management: Changes in a project and its process could reflect on individuals, teams and organisations, according to the interviewees. As a result it is believed that the outcome of these changes could impact "groups/tasks/clients expectations, communication effectiveness, team integration, leadership commitments and operational efficiency". What makes the difference, according to their answers, is "how and why a project manager has to make a change". In addition, it has been recognised that a project manager must be "willing, self–motivated and visionary in order to achieve these changes". Moreover, even where the benefit is clear in the short-term, what interviewees felt was that a project manager "needs to think long-term and see the big picture". As a result of project and process change management, what is required is willing and self-motivated project managers that can use techniques, methods and technologies so as to improve initially their own performance, and then predict more 'accurately' project delivery time and costs, raise quality for planning, design and construction and hence to predict the return on investment for the client.

Efficient project change decisions: The decision itself is considered by the interviewees as the "cognitive process resulting in the selection of a sequence of actions among several alternative scenarios". Within a project environment where changes have to take place, a project manager must feel self–efficant that he can deliver this process initially. This relies on "self–confidence, good knowledge and understanding of the current situation and the ability to identify any potential risks. Therefore, it has been suggested by the interviewees that it is necessary to ensure that a project manager has a certain set of skills, i.e., "leadership, responsibility, accountability", so as to foresee these changes and thereafter validate them. In addition, they have stated that sometimes the suggestions for changes are not the most efficient due to possible costs being incurred. According to interviewees, efficiency comes in changing the organisational culture (impact on project environment also) and using technologies to allow the project manager to predict more 'accurately' project delivery time and costs, raise quality for planning, design and construction and hence predict return on investment for the client.

Knowledge management for making changes: According to the interviewees knowledge plays a significant role in making a change within a project. They stated that this may include "facts, information, descriptions or skills acquired through experience or education". Moreover, they believe that knowledge management is a vital factor in project management in the case where the project manager has to make changes. The reason is that knowledge will secure a high quality of understanding, thus leading to efficient decisions and changes. The knowledge management process of a project is comprised of a range of strategies and practices used to identify, create, represent, distribute, and enable adoption of insights and experiences. Therefore, this process will help a project manager to re-think project performance indicators by considering knowledge management techniques, methods and technologies and thereafter predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence predict the return on investment for the client.

Henceforth, control appraisal antecedent can have an impact on project performance, and this is illustrated in table 6.5.

	IMPACT OF CHANGE ORIENTATION ON PROJECT PERFORMANCE
Change Orientation	• Project and process change management • Efficient project change decisions • Knowledge for making changes

Table 6.5. Impact of control appraisal antecedent on enhancing the project progress

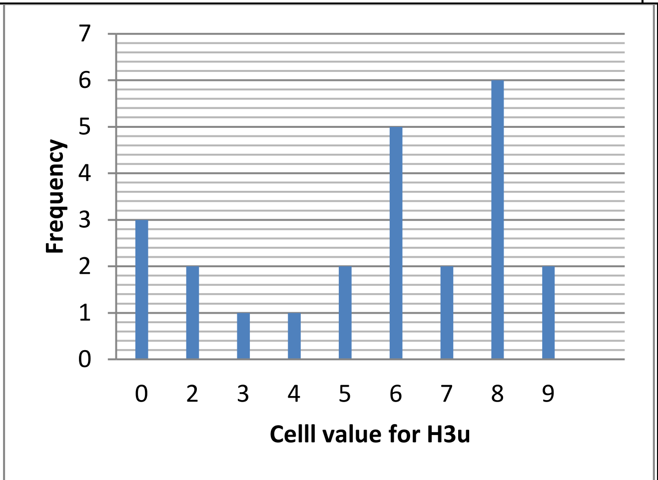
Kotter (2011) stated that change management is an "approach to transitioning individuals, teams and organisations to a desired future state". In the construction industry changes are taking place on a regular basis, e.g. regulations, engineering techniques, new technologies (Cooper et al, 2008). Therefore, if problems cannot be dealt with, change cannot occur. According to the KPI (2012), time, cost, quality and ROI are still cited as problems in the construction industry,. The industry is deficient in making changes in a period when the economic environment is not growing fast. According to the findings of this research, it has been shown that there is high degree of influence on strength of developing a project manager's mind-set so as to predict time (μ=6.69) and cost (μ=6.30). However, the most important impact of this is the capability of raising project quality problems (μ=6.82) and pre- identifying client ROI (μ=6.04). Having a project manager who can pre-identify any possible type changes in a project will impact on the design of the project and on the process change management, as efficient change management decisions will be made and he/she will have an understanding of how to make changes.

6.2.6. Job Autonomy

H3u: The power to make decisions (job autonomy) can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of job autonomy on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, μ=5.45. Moreover for this sample n=24, the minimum value was 0 and the maximum is 9 and value 8 was quite frequent (figure 6.21a). There is a range of low values between 0, 2, 3, 4, 5, 7 and 9, and it is clear the frequency of the value 6 is in the second most popular area. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.77). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	5.458333333
Standard Error	0.589703827
Median	6
Mode	8
Standard Deviation	2.888946952
Skewness	-0.773596665
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.21989531

Figure 6.21a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3u

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.88. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.21, or μ=4.24 to μ=6.66. So, at a significance level of 0.05 and probability 95% the accepted range is 4.24<6.5<6.66.

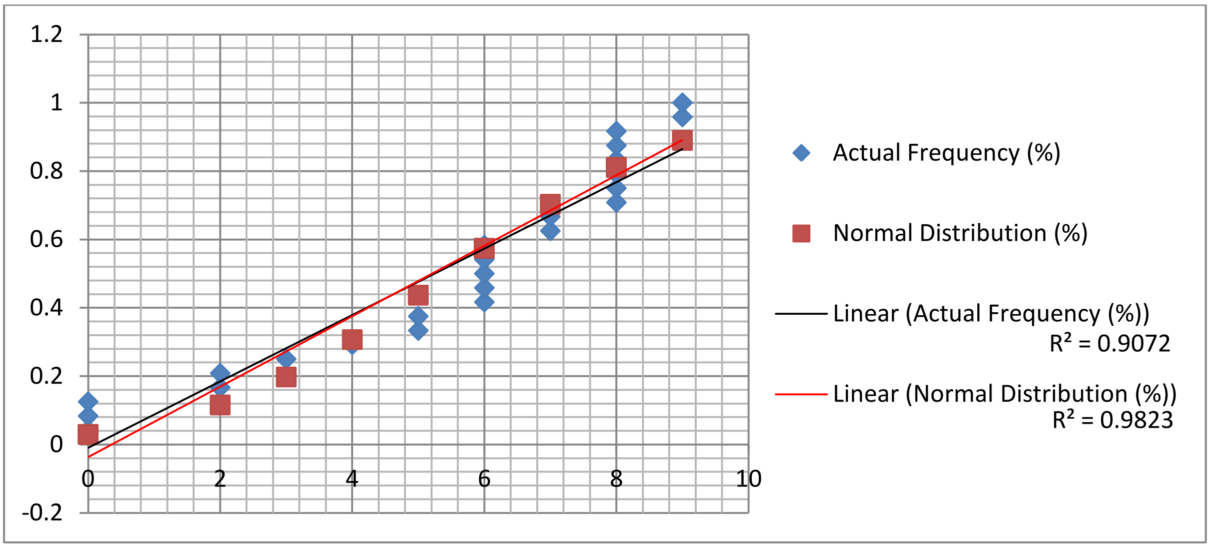


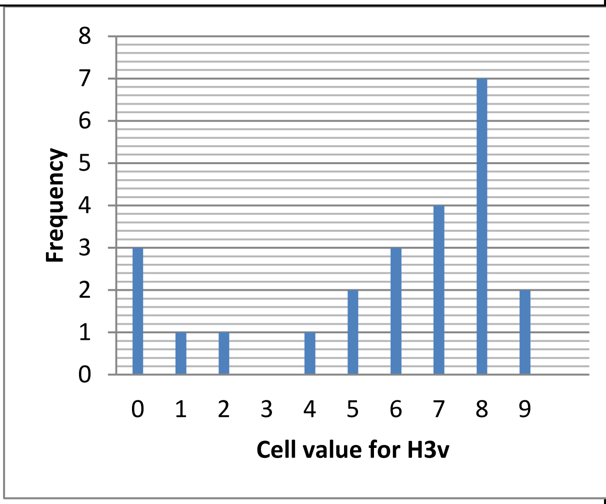
Figure 6.21b. Coefficient of Determination for sub-hypothesis H3u

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.90 and R^2 (Normal Distribution) = 0.98 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.21b). As a result the sub hypothesis H3u is accepted.

H3v: The power to make decisions (job autonomy) can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of job autonomy leading to accurately predicting the cost for planning, design and construction is equal to the mean value, that is, μ=5.70. Moreover for this sample n=24, the minimum value was 0 and the maximum is 9 and the value 8 is the most frequent. It is clear that the frequency of the value 7 (figure 6.22a) is in the second most popular area. Moreover a smaller group of project managers provided answers with frequency between 0, 1, 2, 3, 4, 5, 6 and 9. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.00). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	5.708333333
Standard Error	0.606364692
Median	7
Mode	8
Standard Deviation	2.970568188
Skewness	-1.003901498
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.254360935

Figure 6.22a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3v

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.97. The confidence interval for the underlying population mean for flexible role lead to 'accurate time' equals ± 1.25, or μ=4.46 to μ=6.95. So at a significance level 0.05 and probability 95% the accepted range is 4.46<5.70<6.95.

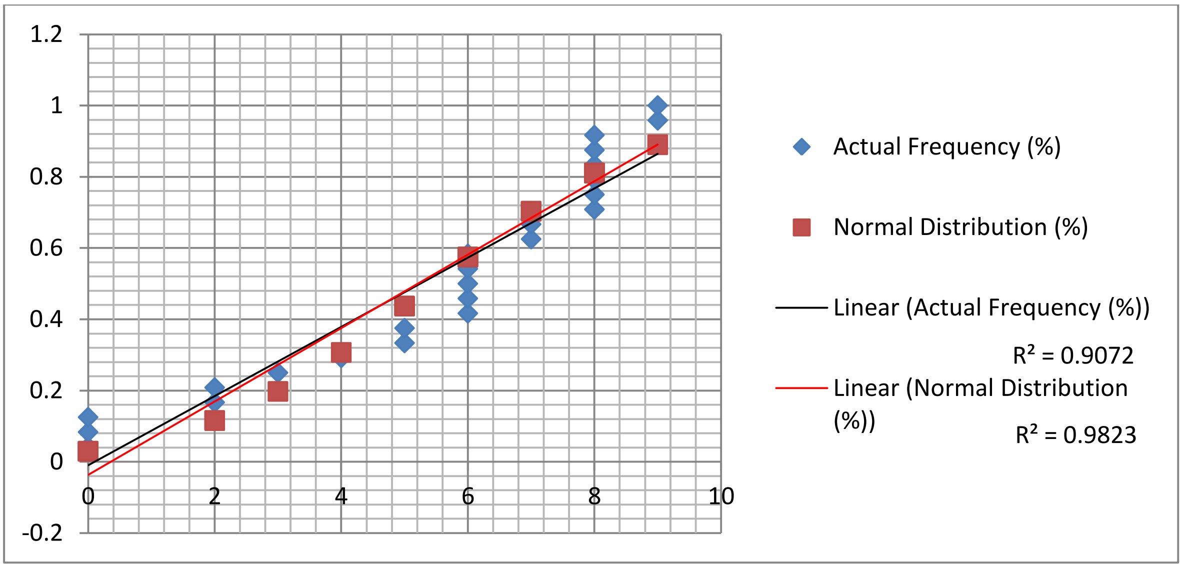


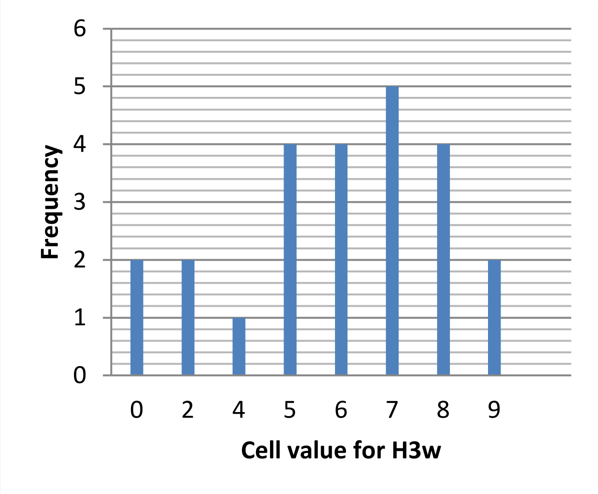
Figure 6.22b. Coefficient of Determination for sub-hypothesis H3v

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.90 and R^2 (Normal Distribution) = 0.98, the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3v is accepted.

H3w: The power to make decisions (job autonomy) can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of job autonomy leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=5.70. Moreover for this sample n=24, the minimum value was 0 and the maximum 9. Value 7 was the most frequent, although values 5, 6 and 8 (equal) and 9 were also indicated (figure 6.23a). Moreover a smaller group of project managers provided answers with frequency between 0, 2 and 4. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.00). Without this value, the histogram would be reasonably symmetric.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	5.708333333
Standard Error	0.519472861
Median	6
Mode	7
Standard Deviation	2.544886889
Skewness	-1.007407477
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.074611487

Figure 6.23a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3w

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.54. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.07, or μ=4.63 to μ=6.77. So at a significance level 0.05 and probability 95% the accepted range is 4.63<5.70<6.77.

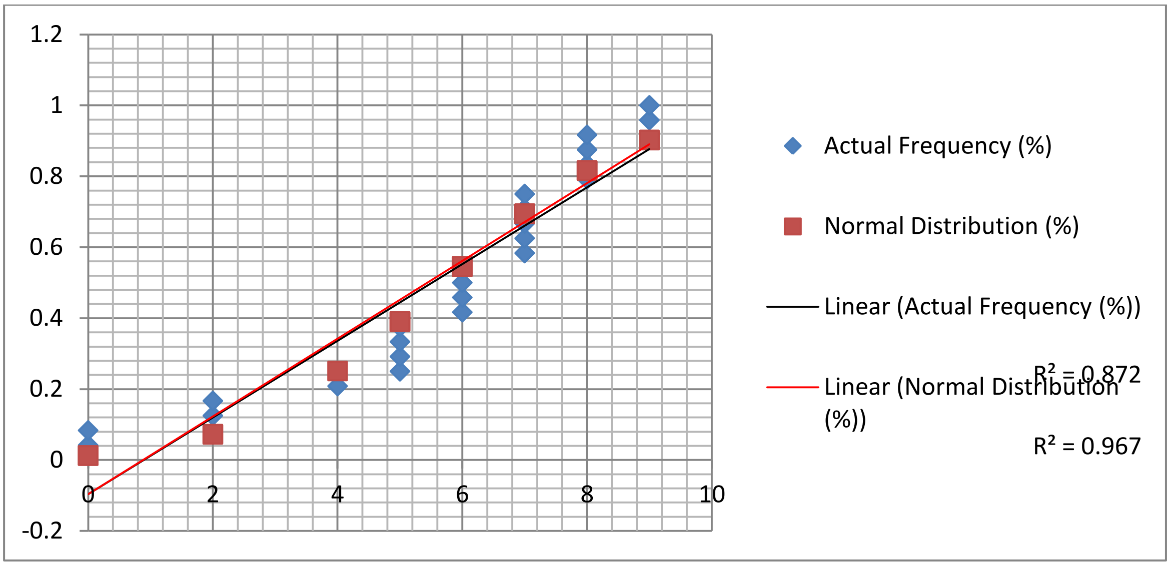


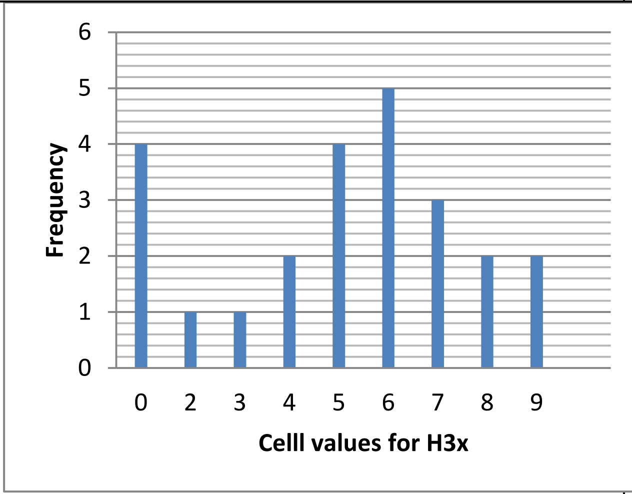
Figure 6.23b. Coefficient of Determination for sub-hypothesis H3w

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.87 and R^2 (Normal Distribution) = 0.96, the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3w is accepted.

H3x: The power you have to make decisions (job autonomy) can have an impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of job autonomy leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=4.91 Moreover for this sample n=24, the minimum value was 0 and the maximum 9, while the value 6 was quite frequent compared to the others. In contrast, the values 0 and 5 (equal) and 7 were the second and third most popular in terms of the frequency (figure 6.24a). In addition a smaller group of project managers provided answers with frequency 2, 3, 4, 8 and 9. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.59). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	4.916666667
Standard Error	0.573940949
Median	5.5
Mode	6
Standard Deviation	2.811724933
Skewness	-0.598574346
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	1.187287311

Figure 6.24a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3x

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.81. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.18, or μ=4.84 to μ=6.09. So at a significance level 0.05 and probability 95% the accepted range is 3.73<4.91 <6.09.

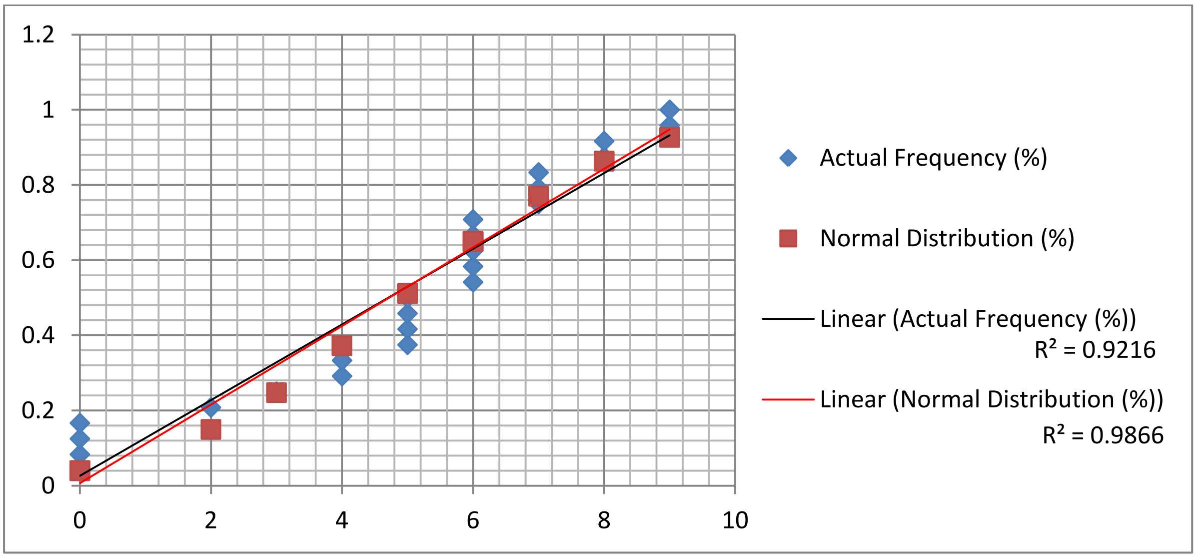


Figure 6.24b. Coefficient of Determination for sub-hypothesis H3x

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.92 and R^2 (Normal Distribution) = 0.98, the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3x is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how job autonomy could impact on project performance, which is presented below:

Design efficient project decisions process: The decision itself is considered by the interviewees as the "cognitive process resulting in the selection of a sequence of actions among several alternative scenarios". Within a project environment where decisions have to take place, a project manager must feel self–efficant so as to design a decision making process that will lead to "rational decisions". In order to design a decision process, interviewees mentioned, that "knowledge" is the key towards both design and making decisions in a project. Construction companies rely on well-known project protocols/management life cycle, i.e., Project Management Body of Knowledge, PIBA Model, and Process Protocol, etc., and, according to the interviewees, they "have been influenced by these models but most of them prefer to design their own models, including the decision gates". So far, senior organisational staff design these processes although their knowledge is "superficial", according to interviewees. Therefore, it is suggested that this task be made available to project managers so they will be in a more competitive position to design stronger decision processes. This would be achieved by having the "feeling of how the project will work" and hence the project manager will be able to predict more 'accurately' project delivery time and costs, raise quality for planning, design and construction and hence predict the return on investment for the client.

Management of project knowledge: According to the interviewees, knowledge plays a significant role in making a change in a project. This can include "facts, information, descriptions or skills acquired through experience or education", according to interviewees. Moreover, they found that knowledge management is a vital factor for a project manager in the case where he/she has to make changes in a project, the reason being that knowledge will secure a high quality of understanding, thus leading to efficient decisions and changes. The knowledge management process of a project compromises a range of strategies and practices used to identify, create, represent, distribute, and enable adoption of insights and experiences.

Therefore, this process will help a project manager to re-think project performance indicators by considering knowledge management techniques, methods and technologies and thereafter predicting more ‘accurately’ project delivery time and costs, in order to raise quality for planning, design and construction and hence predicting the return on investment for the client.

Henceforth, the job autonomy antecedent can impact project performance and this is illustrated in table 6.6.

	IMPACT OF JOB AUTONOMY ON PROJECT PERFORMANCE
Job autonomy	• Efficient project decisions • Management of project knowledge

Table 6.6. Impact of control appraisal antecedent on enhancing the project progress

For a project manager it is vital to understand under which circumstances he/she has to make a decision as well as realising if he/she can make decisions (Coope et al, 2008). If he/she is not in a position of understanding how a problem has occurred (Kerzner, 1999), why (Pinto, 2007) and by whom (Morris, 2006), then this person causes project deficiencies to progress. According to this research, it has been found that the strength to make a decision does not impact on “accurately” predicting time (μ=5.69) and cost (μ=5.95), “raising quality (μ=5.95)” and on predicting “client ROI (μ=5.13)”. In particular, the degree of influence is the lowest when compared to any other sub-hypothesis in this research. This validates what Foucault (1980:154) said in terms of the power in the project management process. Therefore, there is no need to ensure that a project manager has the power to make changes in a project, rather that he/she is in a position to have the ability to justify his/her decisions without affecting project progress. Otherwise, the impact will be inefficient project decisions and difficulties in generating and managing project knowledge.

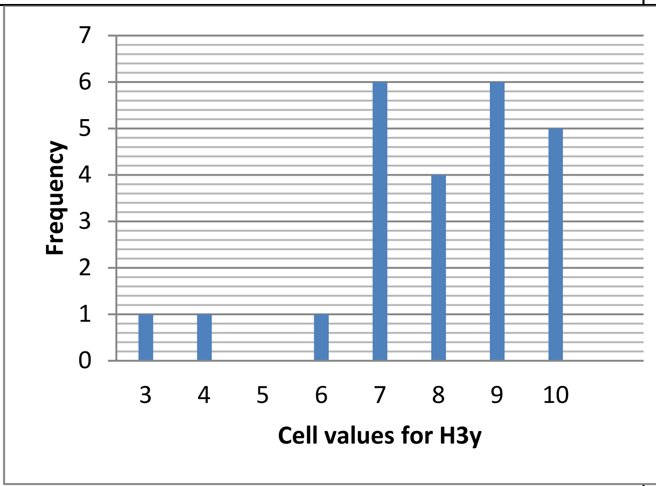
6.2.7. Proactive personality

H3y: Proactive personality can have an impact on ‘accurate’ prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of proactive personality to identify problems is equal to the mean value, that is, μ=7.95.

Moreover for this sample n=24, the minimum value was 3 and the maximum 10, while values 7 and 9 were quite frequent (figure 6.25a). There is a range of low values 3, 4, 6 and 8. It is clear that the frequency of the value 10 is in the second most popular area. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.14). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	7.958333333
Standard Error	0.373386222
Median	8
Mode	9
Standard Deviation	1.82921144
Skewness	-1.142097152
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.772408249

Figure 6.25a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3y

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.89. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.77, or μ=7.18 to μ=8.72. So, at a significance level of 0.05 and probability 95% the accepted range is: 7.18<7.95<8.72.

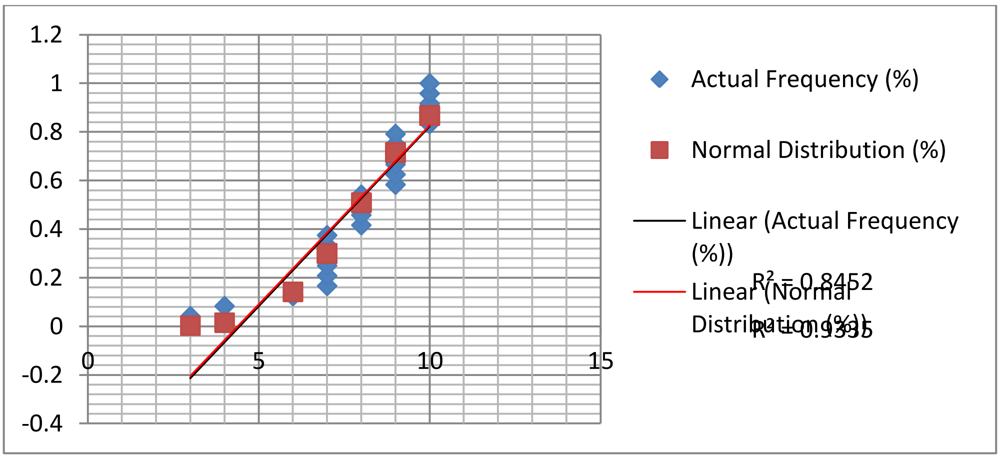


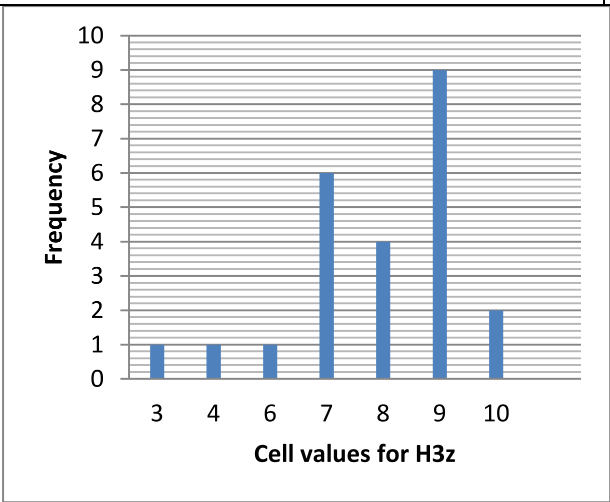
Figure 6.25b Coefficient of Determination for sub-hypothesis H3y

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.84 and R^2 (Normal Distribution) = 0.93, the regression line from both models and their data tend to match and both their values are close to H3y (figure 6.25b). As a result the sub hypothesis H3y is accepted.

H3z: Proactive personality can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of proactive personality leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is, $\mu=7.83$. Moreover for this sample $n=24$, the minimum value was 3 and the maximum 10, while the value 9 is the most frequent. Due to the frequency of the value 7 (figure 6.26a), it is clear that it is in the second most popular area. Moreover a smaller group of project managers provided answers with frequency 3, 6 and 8. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-1.36). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	7.833333333
Standard Error	0.349257321
Median	8
Mode	9
Standard Deviation	1.711004451
Skewness	-1.365650254
Range	7
Minimum	3
Maximum	10
Count	24
Confidence Level (95.0%)	0.722493815

Figure 6.26a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3z

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.71. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.72, or μ=7.11 to μ=8.55. So at a significance level 0.05 and probability 95% the accepted range is 7.11<7.83<8.55.

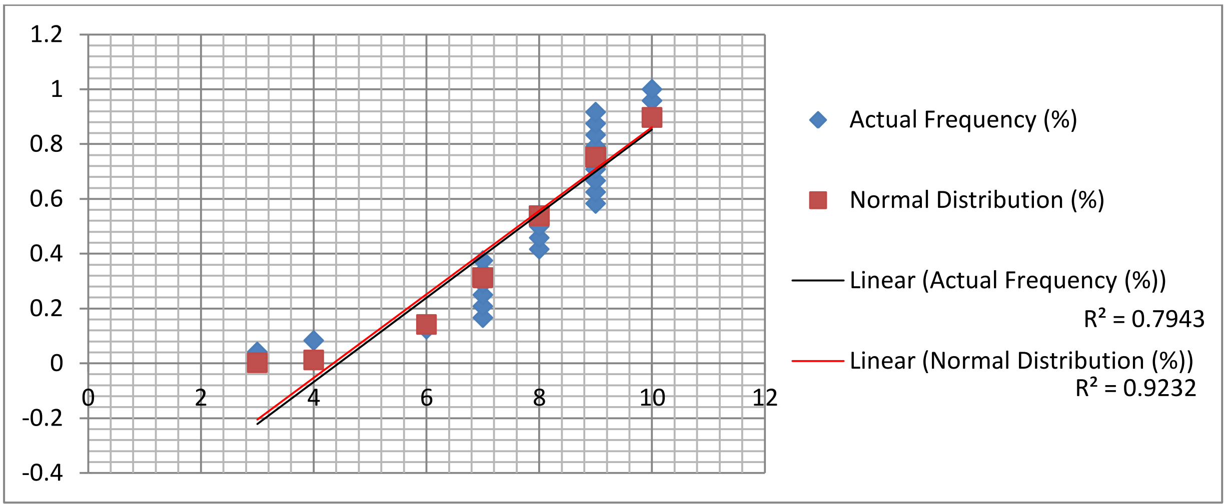


Figure 6.26b Coefficient of Determination for sub-hypothesis H3z

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.79 and R^2 (Normal Distribution) = 0.92 the regression line from both models and their data tend to match and both their values are close to 1 (Figure 6.26b). As a result the sub hypothesis H3z is accepted.

H3aa: Proactive personality can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of proactive personality to identify problems leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=7.87. Moreover for this sample n=24, the minimum value was 4 and the maximum 10, while value 8 was the most frequent, although 6 is also indicated (figure 6.27a) and a smaller group of project managers provided answers with frequency 4, 7 and 10. Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.67). Without this value, the histogram would be reasonably symmetric.

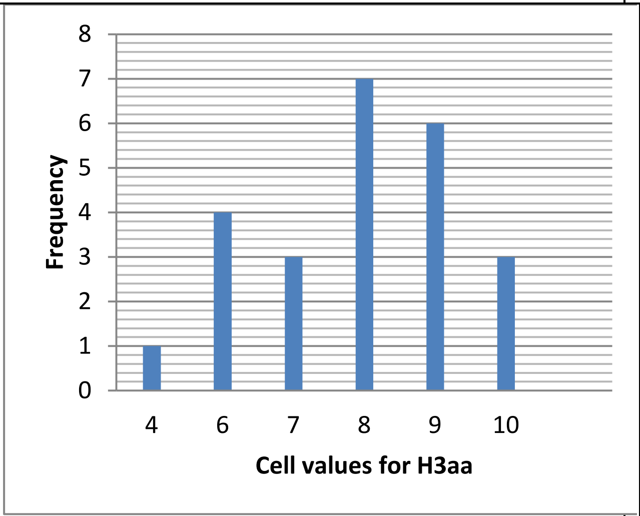
Normal Distribution	***Descriptive Statistical Analysis***	
	Mean	7.875
	Standard Error	0.308763898
	Median	8
	Mode	8
	Standard Deviation	1.512628004
	Skewness	-0.6745201
	Range	6
	Minimum	4
	Maximum	10
	Count	24
	Confidence Level (95.0%)	0.638726788

Figure 6.27a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3aa

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.51. The confidence interval for the underlying population mean for flexible role leading to ‘accurate time’ equals ± 0.63, or μ=6.90 to μ=8.50. So at a significance level 0.05 and probability 95% the accepted range is 6.90<7.87<8.50.

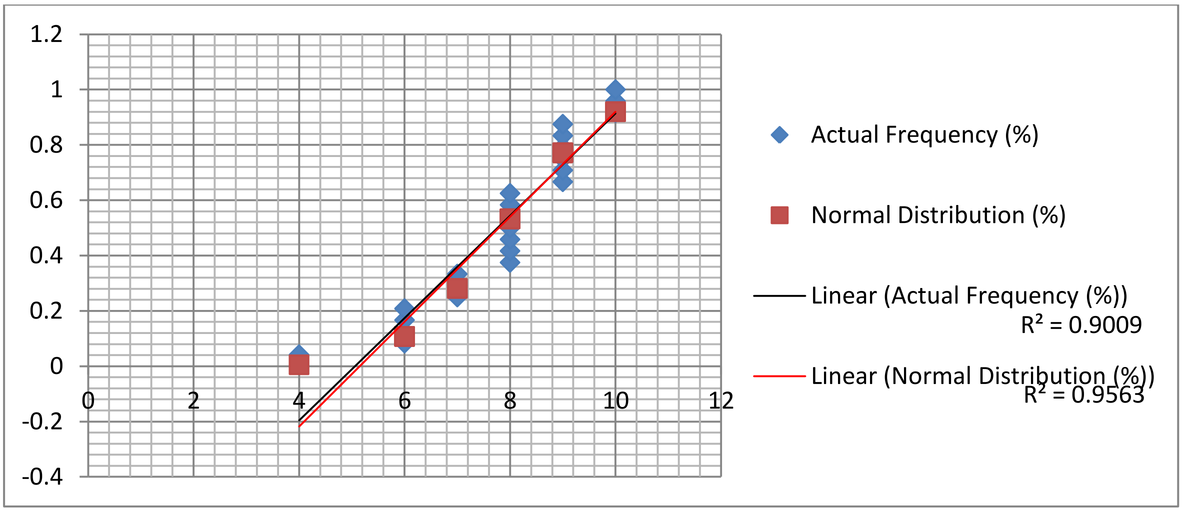


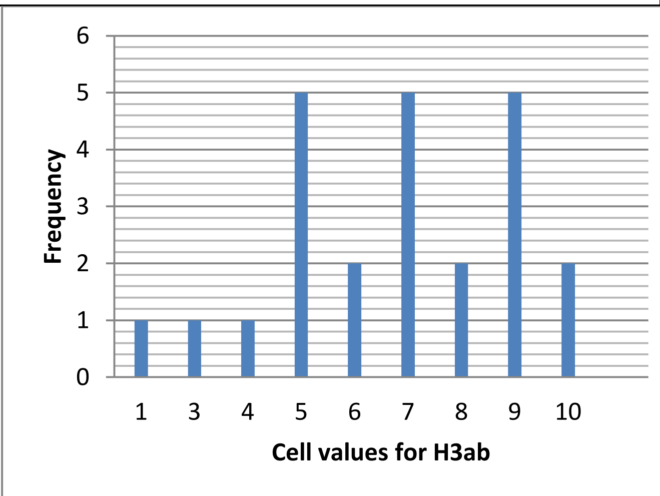
Figure 6.27b. Coefficient of Determination for sub-hypothesis H3aa

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.90 and R^2 (Normal Distribution) = 0.95, the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.27b). As a result the sub hypothesis H3aa is accepted.

H3ab: Proactive personality can have an impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of proactive personality to identify problems leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=6.70 Moreover for this sample n=24, the minimum value was 1 and the maximum was 10, and the values 5, 7 and 9 were quite frequent compared to the others. In contrast, the values 6, 8 and 10 (equal) and 1, 3 and 4 (equal) were the second and third most popular in terms of the frequency (figure 6.28a) Finally, due to the atypically large value, the histogram (figure 6.28a) is slightly skewed to the left, or negatively skewed (-0.57). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.708333333
Standard Error	0.468110474
Median	7
Mode	9
Standard Deviation	2.293263607
Skewness	-0.576410576
Range	9
Minimum	1
Maximum	10
Count	24
Confidence Level (95.0%)	0.968360294

Figure 6.28a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3ab

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.29. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.96, or μ=5.74 to μ=7.66. So at a significance level 0.05 and probability 95% the accepted range is 5.74 <6.70 <7.66.

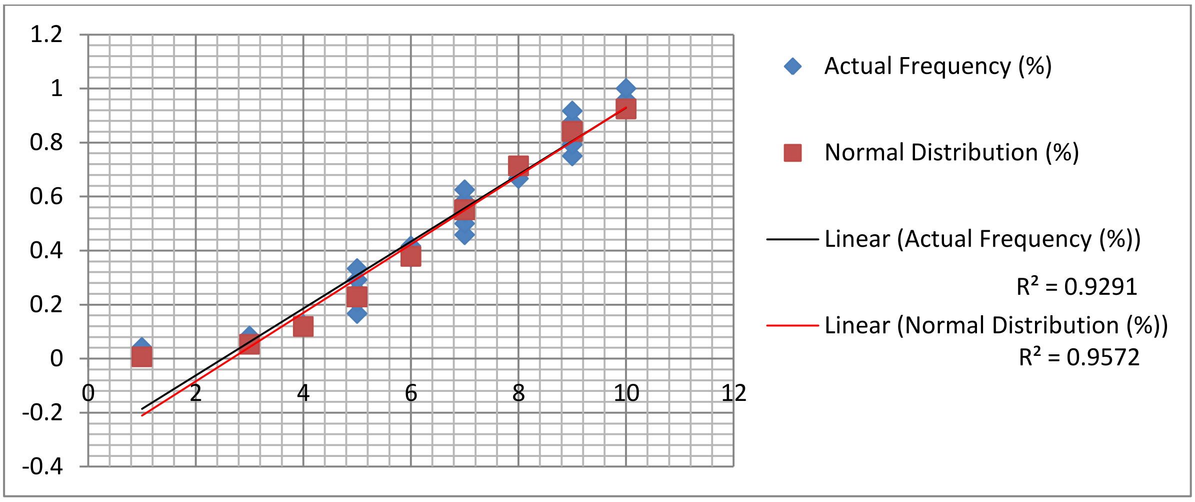


Figure 6.28b. Coefficient of Determination for sub-hypothesis H3ab

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.96 and R^2 (Normal Distribution) = 0.83 the regression line from both models and their data tend to match and both their values are close to 1(figure 6.28b). As a result the sub hypothesis H3ab is accepted. By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how proactive personality could impact on project performance, and these are presented below:

Pre–identify project culture: Culture includes the organisation/project "values, visions, norms, working language, systems, symbols, beliefs and habits". In construction projects the culture is changing on a regular basis due to the "need to work on international projects or in national projects where foreigners are working". This environment reflects the project process and consequently the project performance. Therefore companies are looking for a group of people that adapt easily to fast-changing cultural environments so as to eliminate relevant risks. Hence, according to the interviewees, construction companies should make it a priority "to change project culture strategy in order to establish interoperability between project stakeholders and thus meet project goals". Consequently, the development or enhancement of proactive personality of a project manager to pre–identify project culture would be advantageous in order to predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Pre–identify how to collaborate: Interviewees have identified collaboration and its pre–identification process as an additional factor in project performance. In particular collaboration is a recursive process where two or more people or organisations work together to achieve common goals. In construction projects it is a common phenomenon for project stakeholders and their teams to communicate and collaborate on a daily basis. However, what has been gathered during the interviews was the fact that there is no clear collaboration process between project stakeholders. Therefore, there is a need for a project manager to learn how to collaborate and to set up a collaborative strategy so as to significantly reduce communication risks. According to the interviewees, this lack of collaboration "negatively affects team members' performance and thus project performance". Therefore, in enhancing or developing the proactive personality of a project manager, he is more likely to predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Pre–identify project risks: The identification of project risk is a major feature of the feasibility study of a project, requiring harmonious collaboration amongst project partners in order to identify these risks. However, the biggest challenge during this process, as stated by the interviewees, is "to carry out a range of proactive, interpersonal and integrative project tasks, i.e., the project risk management assessment". Therefore, according to the interviewees it is necessary to employ a project manager that has the capability of "thinking proactively" and "being self–efficant in order to coordinate and collaborate with project stakeholders in project risk identification". Henceforth, the pre–identification of project risks as well as mitigation provision aims to increase the probability of predicting more 'accurately' project time delivery and cost, of raising quality issues and assisting the client to possibly identify the return on investment.

Henceforth, proactive personality antecedent can have an impact to project performance, and this is illustrated in table 6.7.

	IMPACT OF PROACTIVE PERSONALITY ON PROJECT PERFORMANCE
Proactive Personality	• Pre – identify project culture • Pre – identify how to collaborate • Pre – identify project risks

Table 6.7. Impact of proactive personality antecedent on enhancing the project progress

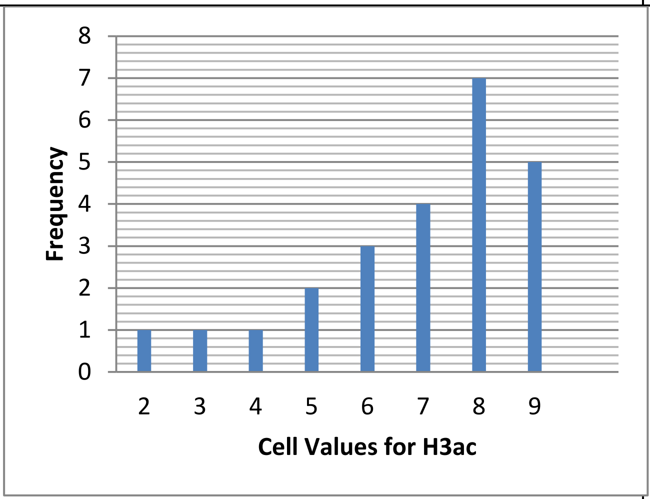
Parker (2006) stated that a proactive personality has the relatively stable tendency to identify problems in advance. RIBA (2013) stated that a modern project manager has to predict project problems in advance in order to eliminate project risks at different project stages, even where technology exists to support the proactive process. If a project manager is not proactive this does not help much in improving project progress and reducing the relevant risks. Moreover, in this research it has been found that the degree of strength of a proactive personality is the most important factor compared to the other sub-hypotheses. Therefore, it is vital to develop proactive awareness within construction project managers which will help in the pre-identification of a project culture, and assist in promoting collaboration and in pre-identifying project risks respectively.

6.2.8. Supportive Supervision

H3ac: The development of team members' skills can have an impact on 'accurate' prediction of the time for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of supportive supervision on accurate prediction of the time for planning, design and construction is equal to the mean value, that is, $\mu=6.91$. Moreover for this sample $n=24$, the minimum value was 2 and the maximum 9, while value 8 was quite frequent. It is clear that the frequency of value 9 (figure 6.29a) is in the second most popular area and there is a range of low values between 2 and 7. Finally, due to the atypically large value, the histogram (figure 6.29a) is slightly skewed to the left, or negatively skewed (-1.05). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	*Descriptive Statistical Analysis*



Mean	6.916666667
Standard Error	0.398896425
Median	7.5
Mode	8
Standard Deviation	1.954185401
Skewness	- 1.055222849
Range	7
Minimum	2
Maximum	9
Count	24
Confidence Level (95.0%)	0.825180124

Figure 6.29a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3ac

Moreover the Standard Deviation (SD) between the data and the mean is SD=1.95. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.82, or μ=6.09 to μ=7.73. So, at a significance level of 0.05 and probability 95% the accepted range is 6.09 <7.73<8.72.

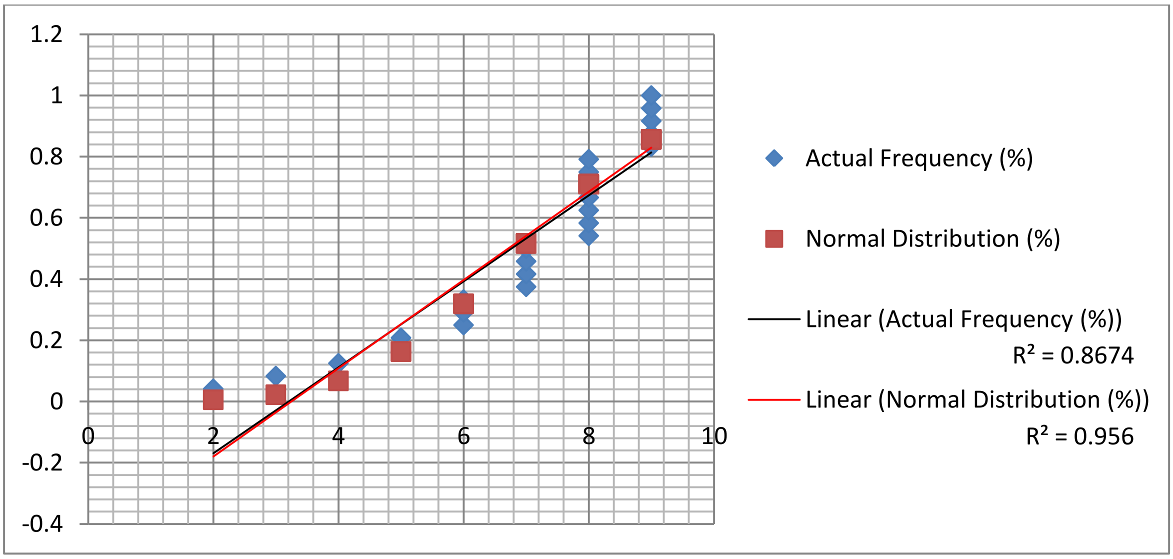


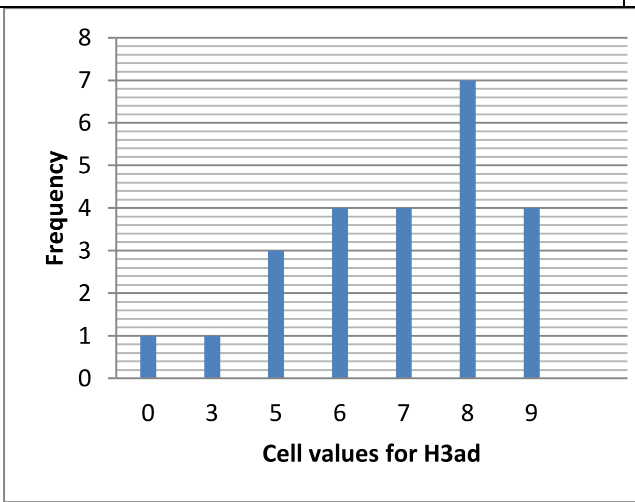
Figure 6.29b. Coefficient of Determination for sub-hypothesis H3ac

Furthermore, by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.86 and R^2 (Normal Distribution) = 0.95, the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.29b). As a result the sub hypothesis H3ac is accepted.

H3ad: The development of team members' skills can have an impact on 'accurate' prediction of the cost for planning, design and construction

According to the descriptive statistical analysis it has been found that the degree of influence of supportive supervision leading to accurate prediction of the cost for planning, design and construction is equal to the mean value, that is, μ=6.75. Moreover for this sample n=24, the minimum value was 0 and the maximum 9, while value 8 is the most frequent. It is clear that the frequency of the values 5, 6 and 9 (figure 6.30a) are equally in the second most popular area. Moreover a smaller group of project managers provided answers with frequency 0, 3 and 5. Finally, due to the atypically large value, the histogram (figure 6.30a) is slightly skewed to the left, or negatively skewed (-1.60). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution	***Descriptive Statistical Analysis***



Mean	6.75
Standard Error	0.430915776
Median	7
Mode	8
Standard Deviation	2.111047545
Skewness	-1.607003691
Range	9
Minimum	0
Maximum	9
Count	24
Confidence Level (95.0%)	0.891417199

Figure 6.30a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3ad

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.11. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 0.89, or μ=5.86 to μ=7.64. So at a significance level 0.05 and probability 95% the accepted range is: 5.86<6.75<7.64.

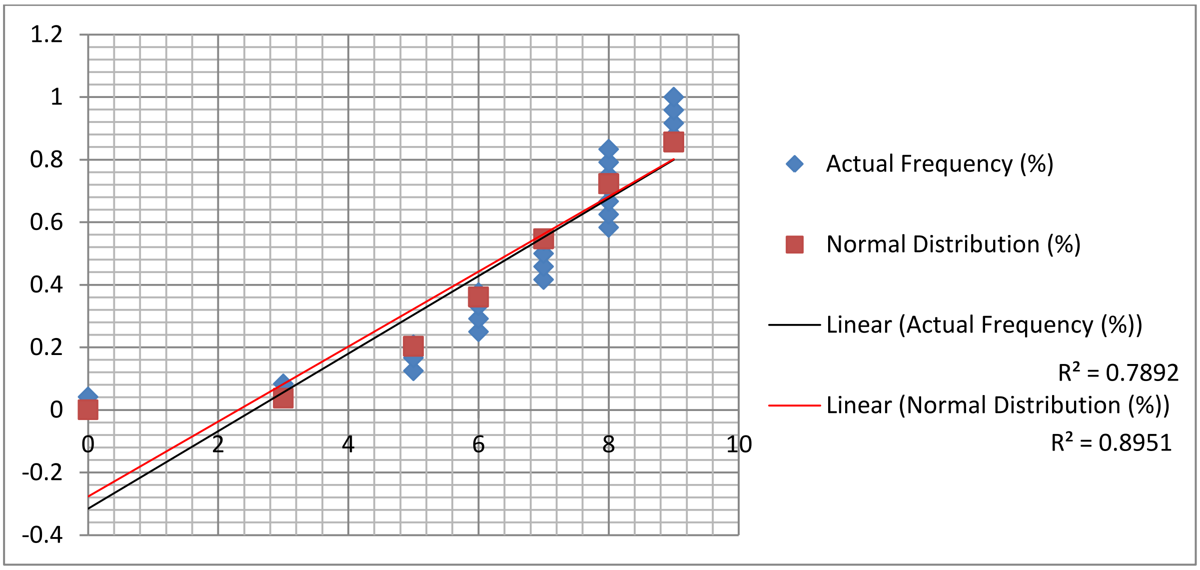


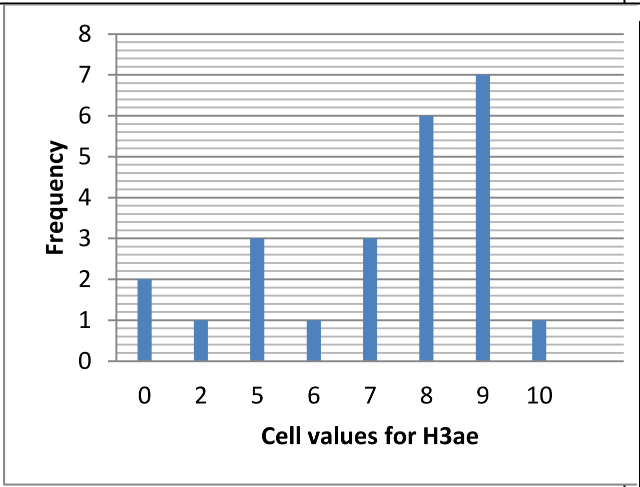
Figure 6.30b. Coefficient of Determination for sub-hypothesis H3ad

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.78 and R^2 (Normal Distribution) = 0.89 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.30b). As a result the sub hypothesis H3ad is accepted.

H3ae: The development of team members' skills can have an impact on 'raising the quality issues' of the final output

According to the descriptive statistical analysis it has been found that the degree of influence of development of team members' skills leading to 'raising the quality issues' of the final output is equal to the mean value, that is, μ=6.87. Moreover for this sample n=24, the minimum value was 0 and the maximum 10. Value 9 was the most frequent, although 8 is also indicated (figure 6.31a) as the second most popular frequency. Moreover a smaller group of project managers provided answers with frequency 0, 2, 5, 6, 7 and 10. Finally, due to the atypically large value, the histogram (figure 6.31a) is slightly skewed to the left, or negatively skewed (-1.49). Without this value, the histogram would be reasonably symmetric.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.875
Standard Error	0.568855003
Median	8
Mode	9
Standard Deviation	2.78680899
Skewness	-1.490143422
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	1.176766231

Figure 6.31a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3ae

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.76. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.17, or μ=5.70 to μ=8.04. So at a significance level 0.05 and probability 95% the accepted range is: 5.70<6.87<8.04.

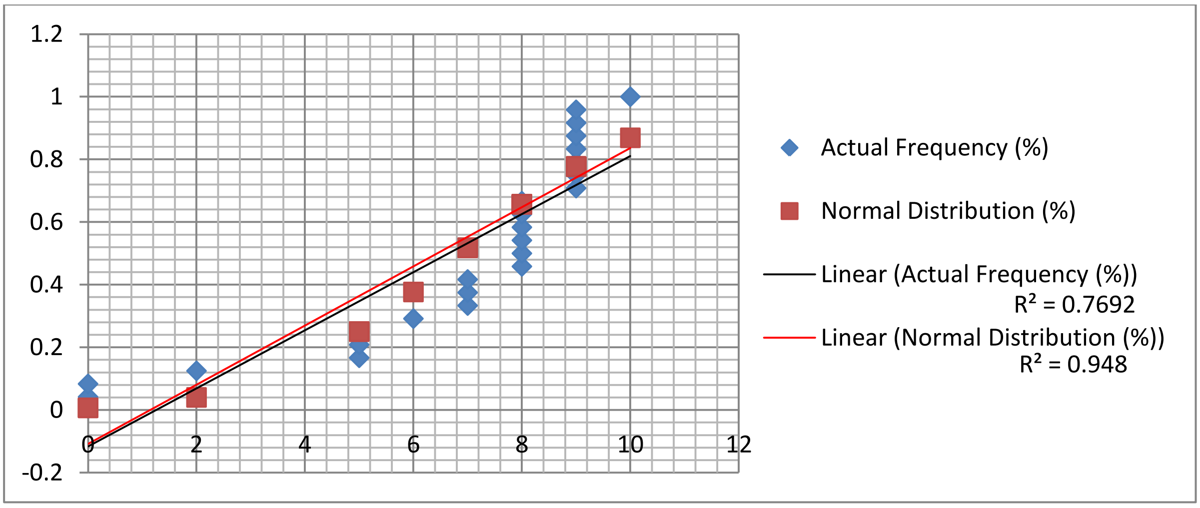


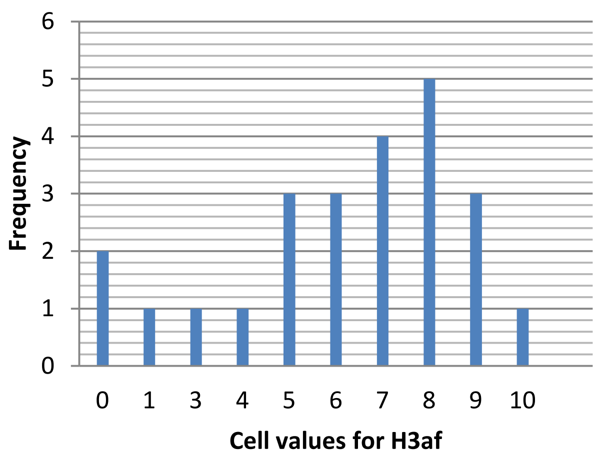
Figure 6.31b. Coefficient of Determination for sub-hypothesis H3ae

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.76 and R^2 (Normal Distribution) = 0.94 the regression line from both models and their data tend to match and both their values are close to 1. As a result the sub hypothesis H3ae is accepted.

H3af: The development of team members' skills can have an impact on 'comparing the estimated return on investment' for the client

According to the descriptive statistical analysis it has been found that the degree of influence of the development of team members' skills leading to 'accurate 'comparison of the estimated return on investment' for the client is equal to the mean value, that is, μ=6.08. Moreover for this sample n=24, the minimum value was 0 and the maximum 10, and the value 8 was quite frequent compared to the others. In contrast, the values 7 and 5, 6 and 9 (equal) were the second and third most popular in terms of the frequency (figure 6.32a). Finally, due to the atypically large value, the histogram is slightly skewed to the left, or negatively skewed (-0.97). Without this value, the histogram would be reasonably symmetrical.

Normal Distribution



Descriptive Statistical Analysis

Mean	6.083333333
Standard Error	0.570775809
Median	7
Mode	8
Standard Deviation	2.796218979
Skewness	-0.978356151
Range	10
Minimum	0
Maximum	10
Count	24
Confidence Level (95.0%)	1.180739721

Figure 6.32a. Normal Distribution and Descriptive Statistical Analysis for sub hypothesis H3af

Moreover the Standard Deviation (SD) between the data and the mean is SD=2.79. The confidence interval for the underlying population mean for flexible role leading to 'accurate time' equals ± 1.18, or μ=4.90 to μ=7.26.

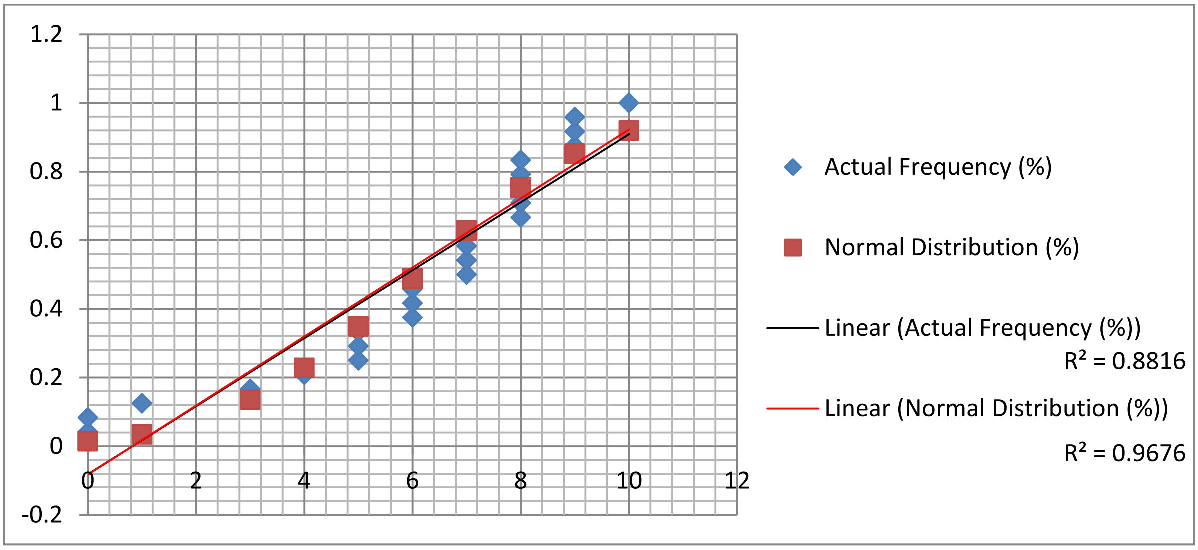


Figure 6.32b. Coefficient of Determination for sub-hypothesis H3af

Furthermore by accessing the coefficient of determination where R^2 (Actual Frequency) = 0.88 and R^2 (Normal Distribution) = 0.96 the regression line from both models and their data tend to match and both their values are close to 1 (figure 6.32b). As a result the sub hypothesis H3af is accepted.

By applying the content analysis technique on the feedback received from the subjects, the researcher identified the effects of how supportive supervision could impact on project performance, which are presented below:

Develop efficient and effective productive team members: During the process of development of skills the project manager and his team learn how to "communicate, collaborate, lead, behave, negotiate, manage their time and self-motivate". All these skills, as mentioned by interviewees, 'impact on team members' productivity performance and thus project progress.' In addition the need to enhance the above skills via training was mentioned. It was suggested that training takes place, either physically or virtually (on–line), where the project manager learns and improves his/her knowledge and understanding on how to work efficiently. Henceforth, this improvement will impact on their own performance and thus on project progress. Therefore, the project manager will feel more confident in predicting more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Management of project knowledge: According to the interviewees, knowledge plays a significant role in developing team members' skills. This can include "facts, information, descriptions or skills acquired through experience or education". Moreover, they found knowledge management vital for a project manager in moving their career one stage ahead. The reason is that knowledge will secure a high quality of understanding and thus lead to learning how to deal with problems, to pre–identify problems and to learn from past mistakes. The knowledge management process of a project is comprised of a range of strategies and practices used in order to identify, create, represent, distribute, and enable adoption of insights and experiences. Therefore, this process will help a trained project manager to re-think project performance indicators by considering knowledge management techniques, methods and technologies. Thereafter he will be technically capable of predicting more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Develop future leaders: A project manager has been identified as a leader when he can influence a group of people to accomplish a common task by maintaining high quality in the deliverable side of the project. Interviewees stated that there is a need for a project manager, as a leader, to be "effective, self-motivated and available". In addition, interviewees stated that through supportive supervision project managers must develop their skills. These improved skills will improve personal performance and thus to give them the technical capability to predict more 'accurately' project delivery time and costs, to raise quality for planning, design and construction and hence to predict the return on investment for the client.

Henceforth, supportive supervision antecedent can have an impact on project performance, and this is illustrated in table 6.8.

IMPACT OF SUPPORTIVE SUPERVISION ON PROJECT PERFORMANCE	
Supportive Supervision	• Develop efficient and effective productive team members • Management of project knowledge • Develop future leaders

Table 6.8. Impact of supportive supervision antecedent on project performance

Egbu (1999) stated that a project manager has to be a leader. A leader has to be effective in order to ensure that his/her team will allow him/her develop their skills (Eye of Competence, 2006). By developing project management skills there is a strong possibility of developing efficient, effective and productive team members who can manage project knowledge and develop future leaders' characteristics, e.g., passion, motivation, confidence, etc. In this research, the degree of influence of the impact of supportive supervision on project performance is high in terms of identifying "accurately" time (μ=6.91) and cost (μ=6.73), in raising project quality problems (μ=6.82) and in pre-identifying client ROI (μ= 6.21) compare to other sub-hypotheses.

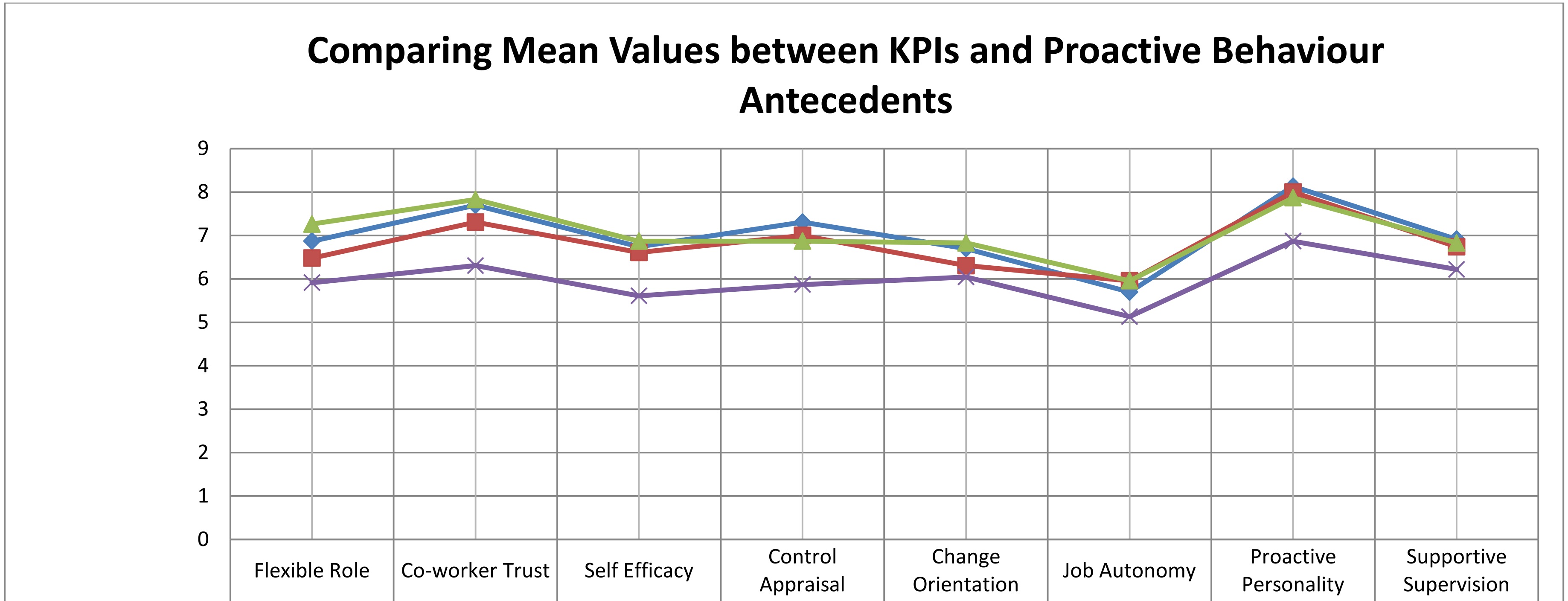
6.3 A Comparative Proactive Behaviour and Project Performance Data Analysis

The relationship value (means) between proactive behaviour antecedents and the key performance indicators are listed in table 6.9.

	Time	*Cost*	*Quality*	*ROI*
Flexible Role	*6.869565217*	*6.47826087*	*7.260869565*	*5.913043478*
Co-worker Trust	*7.695652174*	*7.304347826*	*7.826086957*	*6.304347826*
Self-Efficacy	*6.739130435*	*6.608695652*	*6.869565217*	*5.608695652*
Control Appraisal	*7.304347826*	*7*	*6.869565217*	*5.869565217*
Change Orientation	*6.695652174*	*6.304347826*	*6.826086957*	*6.043478261*
Job Autonomy	*5.695652174*	*5.956521739*	*5.956521739*	*5.130434783*
Proactive Personality	*8.130434783*	*8*	*7.869565217*	*6.869565217*
Supportive Supervision	*6.913043478*	*6.739130435*	*6.826086957*	*6.217391304*

Table 6.9 Proactive Behaviour impact on Key Performance Indicators

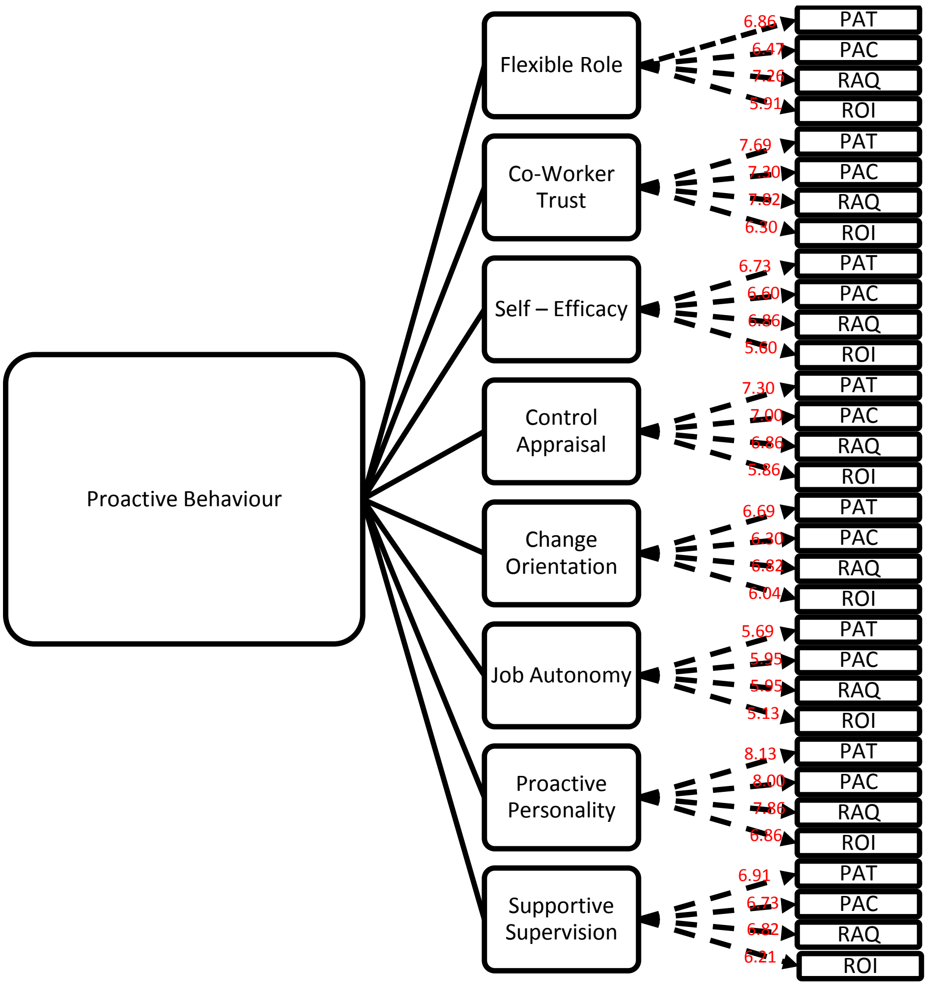
The above table shows that the maximum mean is μ=8.13 and this is the degree of influence between proactive personality and time. The second highest is μ=8 and represents the degree of influence between cost and proactive personality. Moreover the degree of influence is overlapped/matched between job autonomy and quality as well as job autonomy and cost with μ=5.95. Very close to this value is the degree of influence between job autonomy and time. As a result, it is clear that there is a need to enhance project managers' proactive behavior antecedents.



	Flexible Role	Co-worker Trust	Self Efficacy	Control Appraisal	Change Orientation	Job Autonomy	Proactive Personality	Supportive Supervision
Mean Time	6.869565217	7.695652174	6.739130435	7.304347826	6.695652174	5.695652174	8.130434783	6.913043478
Mean Cost	6.47826087	7.304347826	6.608695652	7	6.304347826	5.956521739	8	6.739130435
Mean Quality	7.260869565	7.826086957	6.869565217	6.869565217	6.826086957	5.956521739	7.869565217	6.826086957
Mean ROI	5.913043478	6.304347826	5.608695652	5.869565217	6.043478261	5.130434783	6.869565217	6.217391304

Figure 6.33. Comparing KPI values between KPIs and Proactive behaviour antecedents.

A summary of the findings of the degree of influence between proactive behaviour and project performance are listed below.



Where

PAT=Predict Accurate Time

PAC= Predict Accurate Cost

RAQ=Raise Accurate Quality

ROI=Return on Investment

Figure 6.34: Degree of influence strength between proactive behaviour antecedents and project performance

Furthermore the influencing factors of the impact of proactive behaviour on project performance are listed in the following table 6.10

IMPACT OF PROACTIVE BEHAVIOUR ON PROJECT PERFORMANCE*	
Flexible Role Orientation	• Design procurement strategy • Design project business plan • Conflict avoidance
Co-Worker Trust	• Data & Information Sharing • Effective project meetings • Project Efficiency • Efficient project decisions
Self–Efficacy	• Project risk identification • Identify project's political factors • Clarify project requirements • Efficient design of the project process • Clarify project business model
Control Appraisal	• Efficient project control process • Eliminate project risks • Project optimisation process
Change Orientation	• Project and process change management • Efficient project change decisions • Knowledge for making changes
Job autonomy	• Efficient project decisions • Management of project knowledge
Proactive Personality	• Pre–identify project culture • Pre–identify how to collaborate • Pre–identify project risks
Supportive Supervision	• Develop efficient and effective productive team members • Management of project knowledge • Develop future leaders

Table 6.10. How proactive behaviour can have an impact on project performance

*Project performance relies on the four indicators: time, cost, quality and return on investment.

The potential map of the development of team collaboration and proactive behaviour of construction project managers, necessary in order to have a collaborative culture, has been shown. In particular it has been shown that by being skilful during the process of a task a team can successfully secure project completion. However, due to a number of external constraints that could reflect on project process, support and interactive procedures are required. Both aim to provide continues feedback to each team member during the task process, which impacts on the development of those who require power to influence the project process (job autonomy). Also required are the ability to think proactively (proactive personality), leadership skills to support his/her team (supportive supervision) and the development of trust between team members (co – worker trust), giving to this person access to task information. In such a situation the person is self–efficant (self–efficacy), understands project status, and hence is in a position to pre–identify and undertake issues (flexible role) promptly. Furthermore, the leading person has to take initiation to make changes (change orientation and simultaneously to control the whole process in order to secure project performance. Hence, the collaborative environment enhances the possibilities of developing proactive behaviour in construction project managers.

6.4 Summary

The proactive behaviour of construction project managers impacts considerably on project performance. In particular in the chapter shown that by developing proactive personality of construction project managers is more likely to pre – identify "accurately" project time and costs following by to identify project culture, collaboration strategy and pre – identification of project risks. Moreover, co – worker trust as a proactive behaviour antecedent has been shown that impact on raising quality issues in a project. Furthermore, project managers' flexibility could assist them to design procurement strategies as well as to design project business plan and to avoid conflict. Nevertheless, flexibility including self – efficacy, control appraisal, change orientation, job autonomy and supportive supervision play significant role to the development of proactive behaviour to construction project managers and thus to enhance project performance respectively.

Chapter 7 -Conclusion and Contribution to Knowledge

7.1. Thesis Summary

The aim of this research was to investigate a conceptual framework that describes the relationship between team collaboration, integrated collaborative technologies, proactive behaviour and project performance in construction projects. In particular, the research investigated whether and how team collaboration and integrated collaborative technologies can support proactive behaviour and thus enhance the efficiency and effectiveness of construction project performance.

7.2. Research Assessment

In order to assess this PhD research, the following objectives, identified in Section 1.2, were examined to determine whether the research aim has been achieved.

7.2.1. Integrated Collaborative Technologies' Impact on Team Collaboration

The first objective of this research was to identify whether integrated collaborative technologies impact on team collaboration. In order to answer the above objective, the researcher designed the survey and the questionnaire considering information and communication technologies and team collaboration. Furthermore, from a sample of 24 professional project managers it has been shown that the enhancement of the understanding of roles within a construction project team by making extensive use of integrated collaborative technologies features impacts on the clarification of problem ownership, the avoidance of conflicts, and the pre-identification and clarification of team members' responsibilities, roles, background, culture and skills. Moreover, it has been shown that technological features can enhance the relationships between stakeholders by providing opportunity to access information (a)synchronously from anywhere at any time. Hence stakeholders learnt to trust co–workers, to enhance communication and to pre-identify project problems. In addition the enhancement of sharing knowledge and awareness between stakeholders contributes towards the development of a collaborative culture where project risks and client requirements can be identified and records for best practices created. Also, it has been found that the use of these technologies during the understanding process of the project brief strongly impacts on the decision-making process, to design project procurement strategy and to pre–identify project risks similarly. This is achieved due to the capability these technologies allow to cross check information from different systems and to make it available to project stakeholders during a (virtual) meeting. Likewise the technological features impact on the deployment of the group process in such a manner as to allow enhanced human interaction and communication, enhanced project team performance, to identify project risks as well as to manage the supply chain and the data process respectively. The collaboration in terms of heterogeneity and the size of a construction project team is also impacted by allowing members to be self-developed and efficiently managed.

An additional competitive advantage of the use of integrated collaborative technology features is the enhancement of the interaction process between project stakeholders in terms of learning by setting up key success factors, coordinating by pre–identifying project and design constraints, strong communication (μ=8.54) by efficiently improving collaboration and trust, and decision making by solving and pre–identifying project problems. The design of both WBS and OBS are also enhanced, where (a)synchronous technology features allow team members to communicate and access information from anywhere at any time. As a result clarification of roles and responsibilities as well as the opportunity to develop a collaborative culture are achieved. Moreover, it has been shown that enhanced stakeholder access to project information during a (virtual) meeting impacts on the design of appropriate interoperable strategies and teaches stakeholders how to provide problem solutions.

Hence, the key driver for the development of a collaborative culture in a project is achievable by using integrated collaborative technologies such as Building Information Modelling. This is due to the access to information, either synchronous or asynchronous, from anywhere where stakeholders can share and access knowledge and awareness between themselves and thus be able to understand common ground in the project brief, to control the project process, and to enhance the interaction and networking processes. In addition, it is possible to pre–identify and promptly respond to project errors and uncertainties, who is involved (Organisational Breakdown Structure) and what type of activities/tasks (Work Breakdown Structure). The above elements allow them to significantly enhance the collaborative culture within a construction project. Moreover, project stakeholders within this collaborative culture can also learn and make efficient decisions that will impact project process. Henceforth, the impact of integrated collaborative technologies on team collaboration is the deployment of a collaborative culture in a construction project.

7.2.2. Impact of Team Collaboration on Proactive Behaviour

The second objective of this research was to identify whether team collaboration impacts on proactive behaviour. In order to achieve this, the researcher collected secondary data in order to identify the interrelationships between team collaboration and proactive behaviour. Hence, the key driver that proactive behaviour in construction project managers seems to develop within a team is at the stage where project stakeholders share knowledge and awareness. In addition, project managers can enhance their skills to be proactive in such a manner as to be flexible; to trust; to be self–efficant; to control project process; to make efficient decisions; to be a leader and to pre–identify, track and share project problems. As a result teams perform effectively and efficiently due to the enhancement of individual skills and hence project managers can operate and manage interactive process (learning, coordination, communication and decisions). Furthermore, the accessibility to information that is offered to project managers causes them to operate and manage the project (task) process. To sum up, a proactive construction project manager has to collaborate with other team members in order to operate and manage a project process efficiently and effectively.

7.2.3. Impact of Proactive Behaviour on Construction Project Performance

The third objective of this research was to identify whether proactive behaviour impacts on project performance. In order to answer the above objective, the researcher designed the survey and the questionnaire considering proactive behaviour and project performance. Furthermore, from a sample of 24 professional project managers it has been shown that proactive behaviour of construction project managers impacts considerably on project performance. In particular it has been shown that by developing a proactive personality in construction project managers they are more likely to pre–identify “accurately” project time and costs and to identify project culture, collaboration strategy and pre – identification of project risks. Moreover, co – worker trust as a proactive behaviour antecedent has been shown to impact on raising quality issues in a project. Furthermore, project managers' flexibility could assist them in designing procurement strategies and project business plans, and in avoiding conflict. Nevertheless, flexibility including self – efficacy, control appraisal, change orientation, job autonomy and supportive supervision, play a significant role in the development of proactive behaviour in construction project managers and thus in enhanced project performance.

In particular, the development of proactive behaviour in construction project managers has been shown to impact on the design of the procurement strategy and on the project business plan by being flexible so as to delegate project roles to team members. Thus conflict between team members is avoided and project performance risks are significantly reduced. In addition, by encouraging the sharing of information and developing trust among team members a project manager can obtain direct access to project information and can run more effective project meetings .The project process is more efficient due to the trust element between team members, while barriers are broken down through direct communication between team members, leading to efficient decisions that reflect on the project performance.

Moreover, by feeling more confident in dealing with potential project faults, a self-efficant project manager has a competitive advantage. He is therefore also in a position to pre-identify those faults, as well as those political factors that will affect the project process. Additionally, he/she has the capability to clarify project requirements and thus be in a position to design efficient project processes and to clarify key aspects of the project business model so as to prepare a new project in collaboration with a client. Furthermore, when a project manager is in a position to undertake control appraisal in a project then he/she is in a competitive position to control the appraisal process efficiently and to identify those risks that could harm the project's process. This is achieved due to his/her capability to feel self-confident (in having the right skills, both in terms of knowledge and experience). Furthermore, as the person that controls the appraisal process, the project manager can feel and articulate when and why an optimisation is required. As a result, he/she is in a competitive position and can view the 'big picture' of a project.

By being a change-oriented person, a project manager has the capability to know and understand certain changes in a project so as to be in a position to process changes at the project level with the support of his/her team. In addition, he/she will be competent enough to make efficient change decisions and manage project knowledge in a manner so as to support project progress and the design of future projects. Moreover, in having power/control in a project a project manager is in a position to influence decisions in a more efficient manner, while due to the capability of sharing project data/information amongst project stakeholders, he/she is able to manage project knowledge in order to support an existing or future project.

In addition to the above proactive antecedents, by having a proactive personality a project manager can pre-identify three main elements that affect the project process: project culture, the team collaboration process and project risk identification. By pre-identifying these three elements he/she is able to build a new project kernel that will assist projects in working efficiently and effectively. Finally, a supportive supervision antecedent allows project managers to develop efficient and effective productive team members, to manage project knowledge and to develop future leaders. Their willingness and passion for creation gives project managers the capability of being leaders who develops new leaders.

7.3. Research Contribution and Impact

The main contribution of this research is in enhancing the understanding of the relationships between integrated collaborative technologies, team collaboration, proactive behaviour and project performance. This research has made assumptions that integrated collaborative technologies can enhance team collaboration; team collaboration can enhance proactive behaviour and proactive behaviour can consequently enhance project performance. It has tested these assumptions and elaborated the fundamental characteristics of team collaboration, proactive behaviour and project performance to explain their impact on project performance.

In addition, elaboration of the basic features of collaboration, proactive behaviour and project performance provided the author with a conceptual framework that illustrates how various features could lead to the enhancement of project performance. The research conducted also validated the “strength of influence” of these characteristics and answered “how” these features could lead to proactive behaviour and project performance. It captures the subjective view of many experienced project managers and provides a conceptual framework that can be used by project managers to deploy the various key characteristics identified in the research to enhance their proactive behaviour, leading to project performance.

Moreover, the development of a collaborative culture in a construction project is a further contribution to knowledge. This culture presents the main features of integrated collaborative technologies, collaboration, proactive behaviour and performance indicators, including the interrelationships between them. Hence, the developed collaborative culture could be incorporated in existing construction projects with the aim of enhancing their project performance.

7.4. Recommendations for Future Work

In order to complete this thesis, a few recommendations for further research are made. The following topics have been selected from the many different perspectives available and these could offer future expansion opportunities in the project management world. In particular in the risk management world it could be possible to **identify whether and how integrated collaborative technologies could mitigate construction risks in different levels within the project life cycle.** In this case, the researcher has to consider the conceptual framework (collaborative culture and its environment) as the backbone in enhancing the mitigation process of construction risks.

In addition, in this research, data have not been collected to investigate the interrelationship between team collaboration and proactive behaviour. Hence **the impact of team collaboration on the proactive behaviour of a construction project manager could be investigated.** In this area the researcher could identify in detail those characteristics of team collaboration that could impact on the development of proactive behaviour of a construction project manager.

Furthermore the existing collaborative culture could be the kernel of communication between the construction supply chain and other stakeholders. In other words **the extent to which a collaborative culture in a construction project could enhance the involvement of the construction supply chain with other project stakeholders**

could be identified. This is applied to small and medium construction enterprises where there is a lack of engagement with other project stakeholders, with the current conceptual framework as the basis of this subject.

An additional subject for future work could be the design of a further conceptual framework to enhance construction business performance, allowing enterprises to exit financial difficulties and thus sustain their business in a competitive environment. In terms of research there is a gap between construction business performance and its enhancement. Hence the **design of a conceptual framework that enables collaborative culture to enhance construction business performance** could be a subject for research.

Finally, a comparison could be made as to **how the conceptual framework could be applicable with and without integrated collaborative technologies between two construction projects**. This research could show whether the role of integrated collaborative technologies is vital to construction projects.

7.5. Concluding Comments

This research has resulted in a novel conceptual framework that can enhance project performance. It has taken a holistic view as to how the framework could operate in a construction project by highlighting three main principles: project team collaboration, proactive project managers and integrated collaborative technologies.

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Appendixes

Appendix I – Research's impact

The impact of the research has resulted in further research, publications, invitations to talks/presentations and collaboration with several academic and industrial organisations.

Organisations: a major investor in the North West UK region has expressed an interest in reviewing partners' project performance by using this model (2 years' research has already been conducted, from 2010 to 2012).

Publications: Between 2009 and 2013 parts of the research have been published in peer reviewed international conferences, journals and books, notably the eJournal PMForum (2009); International Conference on Interoperability for Enterprise Software & Application, IEEE (2009); Interoperability for Enterprise Software and Application (2010), Wiley Publications; Enterprise for Interoperability IV, Springer (2010); CIB W078 – W102 (2011), World Building Congress (2013) and the International Conference of Sustainable Buildings (2013).

Research and Education: In addition, the results of this research have influenced the design of new research in the area of 'the socio-economic impact of Building Information Modelling on the Architecture, Engineering and Construction sector' by a team at the University of Salford (2012). This research proposal secured a grant of 2,500 Euros and won the International Sebastyan Award Competition in 2012. The findings were published at the International Research Council for Building and Construction World Congress in May 2013 with excellent feedback for the team and there is a proposition to further publish the findings in an international journal. Also, an International Research Grant proposal is under review together by leading Universities, i.e., Royal Melbourne Institute (Australia), Queensland University of Technology (Australia), Curtin University (Australia), Coventry University (United Kingdom), University of Salford (United Kingdom), Leeds Metropolitan University (United Kingdom) and University of Lorraine (France) for the amount £160,000 for a mobility project and the development of an International Project Management Practices module where the main aim is to prepare the next generation of project managers – proactive project managers. Furthermore, at Coventry University it has been agreed (May 2013) to involve discussion on project team collaboration, proactive project managers and integrated collaborative technologies in the course Building Information Modelling and Management (MSc in Low Impact Building Performance and Evaluation). More recently, the researcher was involved in the FP7 EU funded project called PEESEPE to examine organisational behaviour (team collaboration and proactive behaviour mainly) in retrofit systems as well as giving an input to the return of investments in retrofitting systems in public buildings.

Invitation to meetings and talks: The author was invited to talk at the University of Central Lancashire (UCLan) on “A Framework for Collaborative Environments for Project Managers in the Construction Industry” (2011), and to deliver the lecture “Proactive Management of Construction Projects” for the Module: Virtual Technologies at the University of Salford for three consecutive years (2009 – 2012). He has recently been invited to join a meeting in the House of Commons on Supply Chain Resilience and the Environment (June 2013).

Prizes and Awards: The researcher won the International Sebastyan Award Competition in 2012 which is awarded by the International Research Council for Building and Construction. The submission paper was on the “Socio-economic impact of Building Information Modelling on the Architecture, Engineering and Construction sector”. In addition, he has been nominated and shortlisted for best BIM paper at the SB13 conference 2013 at Coventry. The submission paper was on “The organisational and project added value of the Building Information Modelling in the AEC community”. The judging panel consisted of Dr Robby Sontento (Loughborough University), Dr David Kerr (Vinci Construction) and Dr Neil Tsang (Coventry University).

Appendix II – Interviewees Comments

In addition to the answers given to the questions, interviewees made various comments on the added value of the proactive conceptual framework. Details are presented in the following table, table 7.1. The responses are grouped based on their companies' professional status: architects, contractors, consultant, clients and suppliers.

Sector	Interviewees Comments
Architects	From an architect's perspective it was mentioned that "construction does not use technologies correctly" and, therefore, there is a need to change organisational culture to enable people "to use these technologies correctly, to be collaborative and to think proactively". Furthermore, it is believed that there is a need to "communicate effectively" with project stakeholders and to be trained on state-of-the-art technologies, e.g., Building Information Modelling (BIM).
Clients	From the clients' perspective the added value of the above process is that they can "ensure that the brief is right and is shared within the team; the problem is shared; the procurement process is supported and improved; it helps to clarify the client's vision/aim/requirements and, most importantly, to engage the supply chain". In addition, this process helps clients to "understand the place and the politics of a project (they can analyse peoples' attitudes)". Also public clients can learn from private companies as regards "how to design a business plan, to do an economo-technical analysis and to set realistic political objectives". Moreover, it was mentioned that "better performance" could be achieved in both the project and organisational world. In addition, they believed that there was a need to "train team members and project managers on a regular basis so as to enhance their understanding and thinking capabilities" and to empower both "job autonomy and

	proactive personality when it is needed to develop proactive behaviour. It was recommended also that "contractors have to consider customer satisfaction standards" as part of the key project performance indicators as well as bearing in mind "how to keep ROI for the client at a good level in the primary stage of the investment life cycle". In addition, it was mentioned that "construction does not use technologies correctly" and, therefore, there is a need to change organisational culture to enable people "to use these technologies correctly, to be collaborative and to think proactively". However, clients find it difficult to make this happen. Due to the high risks in large scale projects it was said that it is "vital for an investor to capture and measure (qualitatively or quantitatively) project data by using a blend of technologies."
Consultants	From a consultant's perspective it was commented that "feedback can give a competitive advantage to the project due to sharing information between team members". In addition, project managers believed that the "development of job autonomy, co-worker trust and flexibility" could provide more effective project performance. Furthermore, "team members have to be trained and to change their mind set" in order to maintain the proposed model operationally. However, due to limited available funding it is difficult for training to take place because of the "cost of change".
Contractors	From a contractor's perspective it was mentioned that "you cannot be proactive if a project manager is not collaborative" or, in other words, "team collaboration reinforces proactive behaviour". Furthermore, it was mentioned that "efficiency exists in construction projects but not at the right level. Therefore, there is a need for improvement". In addition "Health, Environment and Safety are three principal concepts in construction projects that have to be measured". Moreover, the need to "invest in integrated collaborative technologies, e.g., connecting with GeoTechnical Information, BIM, 3D Visualisation, will allow the reduction of relevant client risks". It was also mentioned that the

	technical capability of both Virtual Videos and Virtual Design Teams to run a "scenario gives an added value to both project & client due to: utilisation, self-development, evaluation investment and developing knowledge" Also, contractors can look at project risks in advance in order to ensure that project times and costs are realistic and to ensure that "the client is satisfied". Additionally, "technologies help the design and organisation of virtual meetings". One company stated that team members meet twice a week and found these technologies are "cost effective because they do not have to travel and it helped them in the management of a project". Furthermore, it is believed that the balance in a project is hidden between "quality and time with cost" Additionally, "job autonomy helps them control the project process."
Suppliers	From a supplier perspective it was commented that "the biggest threat for suppliers are contracts", while "proactive personality and co-worker trust" are the two most important aspects of proactive behaviour for the supply chain. In addition, they found this proposed model useful in order to "enhance the communication between the supply chain/manufacturer and the architect and the client. As a result, suppliers could sign more efficient trade agreements due to the strength of making better negotiations with the client". Furthermore, because the supply chain is characterised as "routine – why change?" it is believed that the proposed model could solve this problem. However, the limitation of the proposed model is that "it could be equally very strong or very weak due to individuals' impact on it, e.g., politics in the design process of a project". Suppliers have to consider "health, safety and environment" is compatible with the proposed model due to the dire need to be competitive and to survive in the current climate.

Appendix III – Questionnaire

University of Salford MANCHESTER

THINKlab

PROFILE

Company Name:

Specialisation:

Gender:

Work Experience:

Profession:

Any Additional Comment(s):

To,

Project Manager

Salford, 28/05/12

Mr ……..

The effective identification of risk and uncertainties in modern construction projects undoubtedly incurs significant costs. Failure to address project risks leads to poor performance. There is also a relationship between proactive behaviour and project performance. In addition, proactive behaviour allows for the possibility of improved identification of risks and uncertainties. The risks and uncertainties of effective collaboration between key stakeholders can be managed by the use of integrated collaborative technologies. The prerequisite of proactive behaviour as a result of the need to eliminate the risks and the uncertainties requires team collaboration. Team collaboration is supported by integrated collaborative technologies. Arguably, the need for supporting collaboration via integrated collaborative technologies leads to enhancement of proactive behaviour and hence positive impact on project progress. The **aim** of this research is to investigate how collaboration supported by integrated collaborative technologies could enhance project managers' proactive behaviour and thus impact on positively construction project's progress.

Therefore I am pleased to invite you for an Interview regarding my PhD research in the domain of 'THINKProAct: A Theoretical Model for Construction Project Managers'. The interview could take place either in your offices or at the University of Salford campus and I would appreciate if you could propose a day and time according to your schedule. The interview will not take longer than 1hour 30 minutes (max) and will be recorded.

For confidentiality reasons all the data will be anonymous and the results will be disseminated and published respectively.

If you are willing to be interviewed, please let me know your availability.

If you have any question please do not hesitate to contacting me.

I hope to hear from you soon.

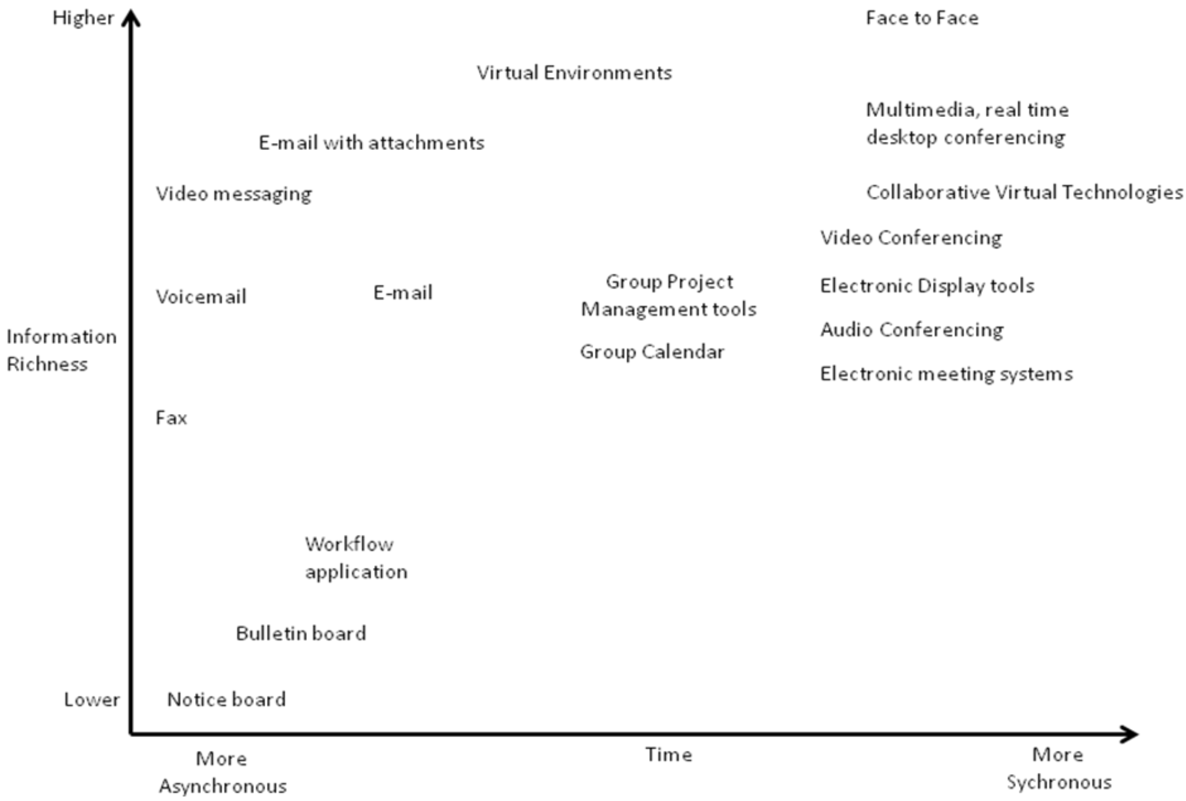
Kindest Regards,

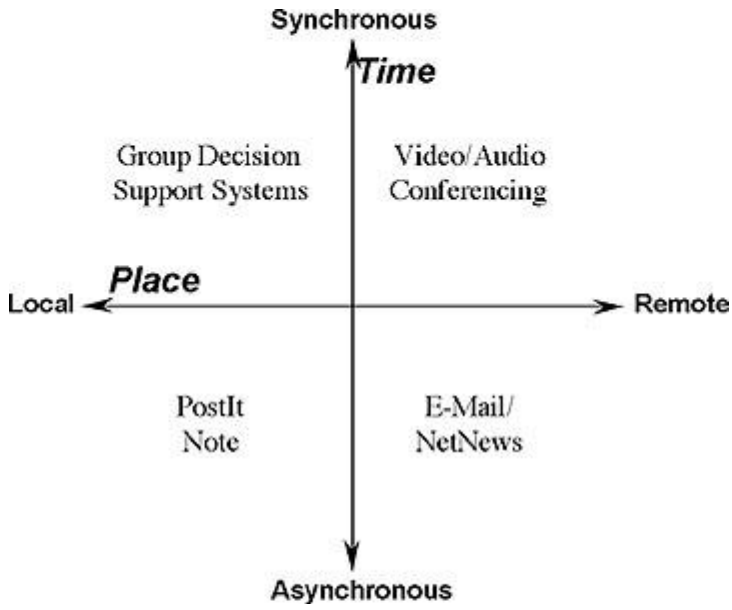
Georgios

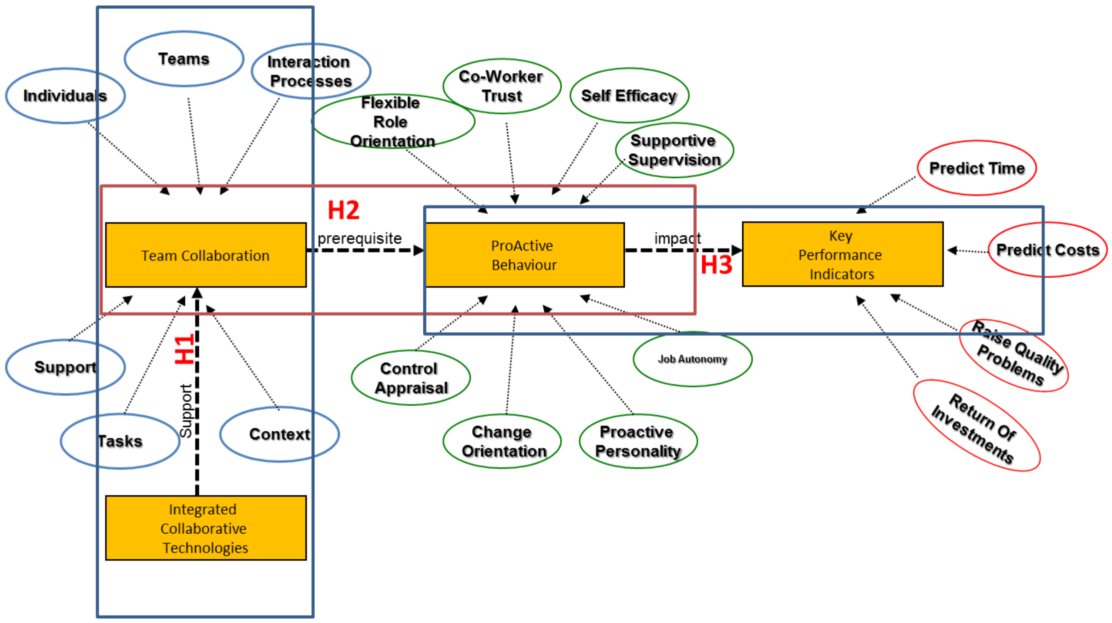
Collaborative tools helps facilitate action-oriented teams working together over geographical distances by providing tools that aid communication, collaboration and the process of problem solving. Technology Integration is the use of technology tools in general content areas in businesses in order to allow stakeholders to apply computer and technology skills to learning and problem-solving. Collaboration requires individuals working together in a coordinated fashion, towards a common goal. ***Arguably the Integrated Collaborative Technologies are those tools that can help stakeholders to work collectively towards the problem solving without considering the geographic distance.*** *These technologies could work either synchronous (real time) or asynchronous (no real time) so allowing the stakeholders or the team members to share documents or files from anywhere at any time.*

Proactive Behaviour is defined by Crant (2000, p.436) as "taking initiative in improving current circumstances; it involves challenging the status quo rather than passively adapting present conditions". Parker, Williams & Turner (2006, p. 636) defined proactive behaviour as "self-initiated and future-oriented action that aims to change and improve the situation or oneself". Grant, & Ashford (in press, p. 13) defined proactive behaviour as "anticipatory action that employee take to impact themselves and/or their environments".

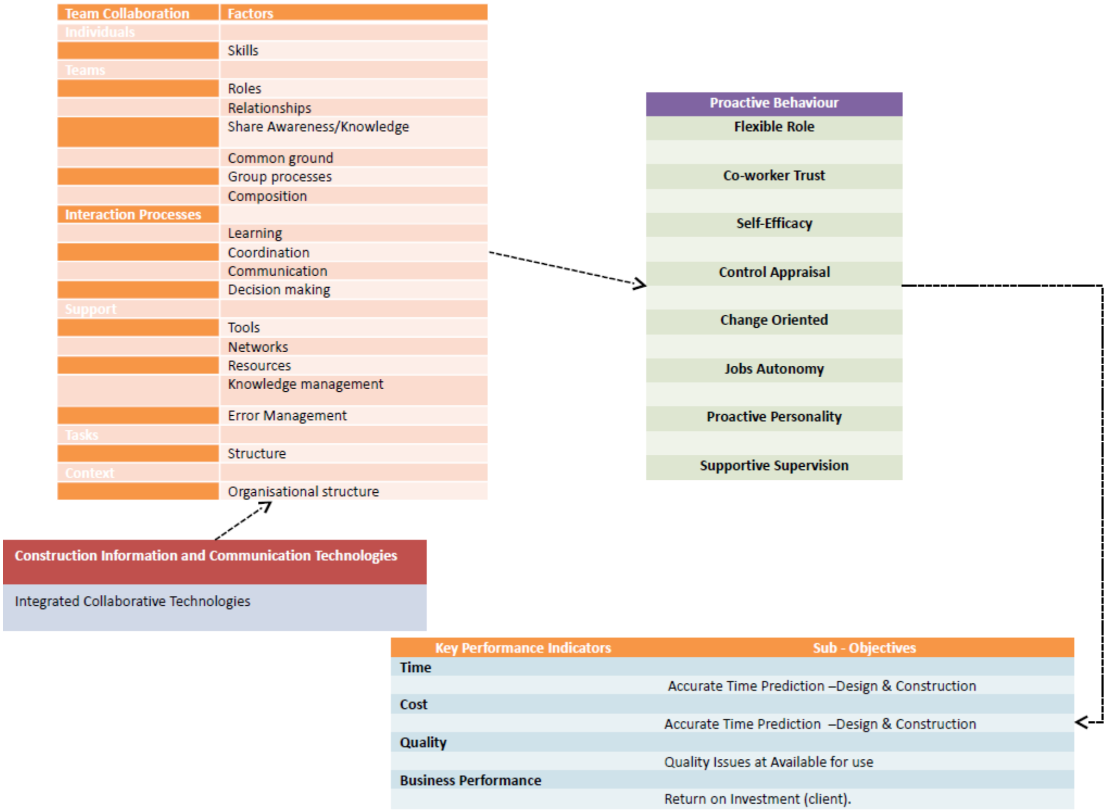
Comparison of technologies in terms of synchronicity and the Information Richness







Rate the framework between 1-10



Team Collaboration
Factors
Individuals
Skills
Teams
Roles
Relationships
Share Awareness/Knowledge
Common ground
Group processes
Composition
Interaction Processes
Learning
Coordination
Communication
Decision making
Support
Tools
Networks
Resources
Knowledge management
Error Management
Tasks
Structure
Context
Organisational structure
Proactive Behaviour
Flexible Role
Co-worker Trust
Self-Efficacy
Control Appraisal
Change Oriented
Jobs Autonomy
Proactive Personality
Supportive Supervision
Construction Information and Communication Technologies
Integrated Collaborative Technologies
Key Performance Indicators
Sub - Objectives
Time
Accurate Time Prediction –Design & Construction
Cost
Accurate Time Prediction –Design & Construction
Quality
Quality Issues at Available for use
Business Performance
Return on Investment (client).

Integrated Collaborative Technologies – Team Collaboration (H1 – Part A)

The aim of this in depth interviews is to investigate and analyse the impact of the integrated collaborative technologies to the team collaboration within a construction project environment.

1. How Integrated Collaborative Technologies could enhance the understanding of the projects roles within a team?
2. How Integrated Collaborative Technologies could enhance the relationships between the project partners (stakeholders)?
3. How Integrated Collaborative Technologies could enhance the knowledge sharing and awareness between the project partners (stakeholders)?
4. How Integrated Collaborative Technologies could enhance the common ground / understanding of the project brief (scope, aim, objectives, budget, timeline, stakeholders)?
5. How Integrated Collaborative Technologies could enhance the group processes (group effectiveness and performance)?
6. How Integrated Collaborative Technologies could enhance the collaboration in terms of the heterogeneity and the size of a team?
7. How the Integrated Collaborative Technologies could enhance the interaction processes between the project's stakeholders in terms of
    a. Learning
    b. Coordination
    c. Communication
    d. Decision Making
8. How the Integrated Collaborative Technologies could enhance the structure of a project:
    a. Organisational Breakdown Structure
    b. Work Breakdown Structure
9. How the Integrated Collaborative Technologies could enhance the accessibility of projects' stakeholders to information?

10. How the Integrated Collaborative Technologies could enhance the networking accessibility and capability between the projects' stakeholders?
11. How the Integrated Collaborative Technologies could enhance project managers' access to projects knowledge required in order do/control/manage their job?
12. How the Integrated Collaborative Technologies could enhance project managers' capability to identify, analyse and manage/control both errors and violation of a project/task?

Integrated Collaborative Technologies – Team Collaboration (H1 – Part B)

The aim of this survey is to validate how strong is the link between integrated collaborative technologies and team collaboration within a construction project environment.

1. Integrated Collaborative Technologies could enhance the understanding of roles within a team.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

2. Integrated Collaborative Technologies could enhance the relationships between the project partners (stakeholders).

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

3. Integrated Collaborative Technologies could enhance the knowledge sharing and awareness between the project partners (stakeholders).

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

4. Integrated Collaborative Technologies could enhance the common ground / understanding of the project brief (scope, aim, objectives, budget, timeline, stakeholders). *Terrence*

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

5. Integrated Collaborative Technologies could enhance the group processes (group effectiveness and performance).

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

6. Integrated Collaborative Technologies could enhance the collaboration in terms of the heterogeneity and the size of a team.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

7. Integrated Collaborative Technologies could enhance the interaction processes between the project's stakeholders in terms of

   a. Learning

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

   b. Coordination

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

   c. Communication

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

   d. Decision Making

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

8. Integrated Collaborative Technologies could enhance the structure of a project:
    a. Organisational Breakdown Structure

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

    b. Work Breakdown Structure

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

9. Integrated Collaborative Technologies could enhance the accessibility of projects' stakeholders to information.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

10. Integrated Collaborative Technologies could enhance the networking accessibility and capability between the projects' stakeholders.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

11. Integrated Collaborative Technologies could enhance project managers' access to projects knowledge required in order do/control/manage their job.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

12. Integrated Collaborative Technologies could enhance project managers' capability to identify, analyse and manage/control both errors and violation of a project/task.

The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

Proactive Behaviour – Key Performance Indicators (H3 – Part A)

The aim of this survey is to check how strong the link between the proactive behaviour and project's performance is.

- ***Flexible role orientation*** *indicates the extent to which various problems reflecting longer term goals of projects would be of personal concern to them rather than to someone else.*

1. **Flexible role orientation** *can lead to* 'accurate' prediction of the time for planning, design and construction.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

2. **Flexible role orientation** *can lead to* 'accurate' prediction of the cost for planning, design and construction.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

3. **Flexible role orientation** can lead to 'raising the quality issues' of the final output.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

4. **Flexible role orientation** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Co-worker trust** refers to trust among members of a project team.*

5. **Co-worker trust** between the team members can lead to 'accurate' prediction of the time for planning, design and construction.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

6. **Co-worker trust** between the team members can lead to 'accurate' prediction of the cost for planning, design and construction.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

7. **Co-worker trust** between the team members can lead to 'raising the quality issues' of the final output.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

8. **Co-worker trust** between the team members can lead to accurate 'comparison of the estimated return on investment' for the **client.**
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

- **Self-efficacy** *refers to how confident a project manager feels carrying out a range of proactive, interpersonal and integrative project tasks.*

9. **Self-efficacy** can lead to 'accurate' prediction of the time for planning, design and construction.
   The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

10. **Self-efficacy** can lead to 'accurate' prediction of the cost for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

11. **Self-efficacy** can lead to 'raising the quality issues' of the final output.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

12. **Self-efficacy** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Control appraisal** refers to a belief that a project manager can control and have an impact on project outcomes.*

13. **Control appraisal** can lead to 'accurate' prediction of the time for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

14. **Control appraisal** can lead to 'accurate' prediction of the cost for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

15. **Control appraisal** can lead to raising the quality issues' of the final output.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

16. **Control appraisal process** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Change orientation** refers to those project managers that have the intention of initiating/proposing changes in a project/task so as to optimise projects/tasks procedures and or performance(s).*

17. **Change orientation** can lead to 'accurate' prediction of the time for planning, design and construction.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

18. **Change orientation** can lead to 'accurate' prediction of the cost for planning, design and construction.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

19. **Change orientation** can lead to 'raising the quality issues' of the final output.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

20. **Change orientation** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Job autonomy** refers to the extent to which the project manager is involved in making decisions within the team.*

21. **Job autonomy** can lead to 'accurate' prediction of the time for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

22. **Job autonomy** can lead to 'accurate' prediction of the cost for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

23. **Job autonomy** can lead to 'raising the quality issues' of the final output.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

24. **Job autonomy** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Proactive personality** refers to the relatively stable tendency to identify problems in advance.*

25. **Proactive personality** can lead to 'accurate' prediction of the time for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

26. **Proactive personality** can lead to 'accurate' prediction of the cost for planning, design and construction.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

27. **Proactive personality** can lead to 'raising the quality issues' of the final output.
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

28. **Proactive personality** can lead to accurate 'comparison of the estimated return on investment' for the **client.**
    The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	**No**	**Yes**									
Degree	0	1	2	3	4	5	6	7	8	9	10

- ***Supportive supervision** refers to the enhancement of leader effectiveness in a self-management context.*

29. **Supportive supervision** can lead to ‘accurate’ prediction of the time for planning, design and construction.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

30. **Supportive supervision** can lead to ‘accurate’ prediction of the cost for planning, design and construction.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

31. **Supportive supervision** can lead to ‘raising the quality issues’ of the final output.
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

32. **Supportive supervision** can lead to accurate ‘comparison of the estimated return on investment’ for the **client.**
The strength of influence is between 0 (no influence) and 10 (high influence)

Influence	No	Yes									
Degree	0	1	2	3	4	5	6	7	8	9	10

Proactive Behaviour – Key Performance Indicators (H3 – Part B)

The aim of the in depth interviews is to check how proactive behaviour impacts on project performance.

- ***Flexible role orientation** indicates the extent to which various problems reflecting longer term project goals would be of personal concern to them rather than to someone else.*

1. How does the **flexible role orientation** impact on 'accurate' prediction of the time for planning, design and construction?
2. How does the **flexible role orientation** impact on 'accurate' prediction of the cost for planning, design and construction?
3. How does the **flexible role orientation** impact on 'raising the quality issues' of the final output?
4. How does the **flexible role orientation** impact on 'comparing the estimated return on investment' for the **client**?

- ***Co-worker trust** refers to trust among members of a project team.*

5. How does the **trust** between the team members' impact on 'accurate' prediction of the time for planning, design and construction?
6. How does the **trust** between the team members' impact on 'accurate' prediction of the cost for planning, design and construction?
7. How does the trust between the team members' impact on 'raising the quality issues' of the final output?
8. How does the **trust** between the team members' impact on 'comparing the estimated return on investment' for the **client**?

- **Self-efficacy** *refers to how confident a project manager feels in carrying out a range of proactive, interpersonal and integrative project tasks.*

9. How does **self-efficacy** impact on 'accurate' prediction of the time for planning, design and construction?
10. How does **self efficacy** impact on 'accurate' prediction of the cost for planning, design and construction?
11. How does **self efficacy** impact on 'raising the quality issues' of the final output?
12. How does **self efficacy** impact on 'comparing the estimated return on investment' for the **client**?

- ***Control appraisal*** *refers to a belief that a project manager can control and have an impact on project outcomes.*

13. How does the **control appraisal process** impact on 'accurate' prediction of the time for planning, design and construction?
14. How does the **control appraisal process** impact on 'accurate' prediction of the cost for planning, design and construction?
15. How does the **control appraisal process** impact on ''raising the quality issues' of the final output?
16. How does the **control appraisal process** impact on ''comparing the estimated return on investment' for the **client**?

- ***Change orientation*** *refers to those project managers that have the intention of initiating/proposing changes in a project/task so as to optimise projects/tasks procedures and or performance(s).*

17. How does the **identification of any possible type of changes** impact on 'accurate' prediction of the time for planning, design and construction?
18. How does the **identification of any possible type of changes impact** on 'accurate' prediction of the cost for planning, design and construction?
19. How does **the identification of any possible type of changes** impact on 'raising the quality issues' of the final output?
20. How does **the identification of any possible type of changes** impact on 'estimating the return on investment' for the **client**?

- ***Job autonomy*** *refers to what extent the project manager is involved in making decisions within the team.*

21. How does **the power you have to make decisions** (job autonomy) impact on 'accurate' prediction of the time for planning, design and construction?
22. How does **the power you have to make decisions** (job autonomy) impact on 'accurate' prediction of the cost for planning, design and construction?
23. How does **the power you have to make decisions** (job autonomy) impact on 'raising the quality issues' of the final output?
24. How does **the power you have to make decisions** (job autonomy) impact on 'comparing the estimated return on investment' for the **client**?

- ***Proactive personality*** *refers to the relatively stable tendency to identify the problems in advance.*

25. How does your **proactive personality** to identify problems impact on 'accurate' prediction of the time for planning, design and construction?

26. How does your **proactive personality** to identify problems impact on ‘accurate’ prediction of the cost for planning, design and construction?
27. How does your **proactive personality** to identify problems impact on ‘raising the quality issues’ of the final output?
28. How does your **proactive personality** to identify problems impact on ‘comparing the estimating return on investment’ for the **client**?

- ***Supportive supervision*** *refers to the enhancement of leader effectiveness in a self-management context.*

29. How does the **development of the team members’ skills** impact on ‘accurate’ prediction of the time for planning, design and construction?
30. How does the **development of the team members’ skills** impact on ‘accurate’ prediction of the cost for planning, design and construction?
31. How does the **development of the team members’ skills** impact on ‘raising the quality issues’ of the final output?
32. How does the **development of the team members’ skills** impact on ‘comparing the estimated return on investment’ for the **client**?

Appendix IV – Literature Review

TEAM COLLABORATION		PROACTIVE BEHAVIOUR	KEY PERFORMANCE INDICATORS	
Antecedents		**Antecedents**	**Antecedents**	
Teams		Flexible role orientation	Time	
	Roles	Co-worker trust		Accurate Time Prediction – Design & Construction
	Relationships	Self-efficacy	Cost	
	Share Awareness/Knowledge	Control appraisal		Accurate Cost Prediction – Design & Construction
	Common ground	Change orientation	Quality	
	Group processes	Job autonomy		Raise quality issues
	Composition	Proactive personality	Business Performance	
Interaction Processes		Supportive supervision		Return on Investment (client).
	Learning			
	Coordination			
	Communication			
	Decision making			
Support				
	Tools			
	Networks			
	Resources			
	Knowledge management			
	Error Management			
Context				
	Organisational structure			