Addressing complexity in the construction industry: A learning approach

By

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Abstract:

Projects in the construction industry have continued to fail at an astonishing rate (Bosch-Rekveldt et al., 2010; Flyvbjerg et al., 2003; Hall, 1981; Morris and Hough, 1987; Thamhain and Wilemon, 1986). Thus, this thesis is intended to provide an insight into the importance of skills, competences and knowledge necessary in handling major and complex projects successfully. The departure point of this research from other studies of this nature, stemmed from a need to move away from defining complexity and instead proposing frameworks to manage complexity as a means to tackle the crux of the issue. Specifically, this study has chosen to investigate the human skills or 'soft skills', which is generally recognised to be an important factor in managing projects (Cooke-Davies, 2002) particularly under increasing complexity (Müller, Geraldi and Turner, 2011). To achieve such a feat, an empirical study has been conducted through interviewing 12 highly influential and experienced professionals in the construction industry. These individuals are employed by the top construction companies in the UK according to The Top 100 Construction Companies 2010 (The Construction Index, 2010). Results have shown that although having had sufficient education and training, there is no substitute for experience gained from managing major and complex projects. Secondly, it appears that what senior managers perceive as complex is related mainly to the context of the project and also the contextual constraints. Finally, setting up the front-end of the project is also considered to be a vital component. Recommendations are also provided for both practitioners and academia to overcome some issues of complexity in construction and help bridge the gap between current circumstances of training and skills, competencies and knowledge necessary for future project managers.

Keywords: Project management; Complexity; Construction; Skills; Competencies; Knowledge; Leadership; Project manager

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Chapter 1

Introduction

1.1. The complex nature of the construction industry:

The construction industry needs to be better understood through the lens of its distinct characteristics. Such an understanding may provide a means to identify challenges (Fernández-Solís, 2007). Koen (2003) attempts to respond by at first explaining that the very nature of engineering falls under the category of heuristic, which involves learning by discovery and problem-solving using reasons and past experience. Each construction project is somehow unique. That is due to the fact that there is always at least one of the following parameters that change: environment, resources and targets. This makes constructing project and its management an even more complex process (Vidal, Marle and Bocquet, 2010). This very nature "*makes a project rich in unforeseen events, deviation from plans and variability, thus affirming the concept of contextuality of a complex system*" (Fernández-Solís, 2007: 1618). Reports by Latham (1994) and Egan (1998) add more layers to the debate in their unflattering descriptions of the problematic nature of the construction industry. They point to inconsistent value generation, low quality, frequent cost and time overrun, harsh working conditions and bad safety practices. Nevertheless, an analysis of the complexity of construction is likely to demonstrate how a myriad of variables are the root cause of complexity, which is why there remains some differences observed between this industry and others.

Complexity can be outlined and described as dynamic and multidimensional dependencies. It has been given more receivable recognition due to its vital role as a key player affecting construction industry. This is a result of factors that built on a number of complexities. As it turns out, types of complexity tend to be: structural which is the most mentioned type of complexity; uncertainty and ambiguity; pace or urgency and criticality of time; dynamic or changes in projects and finally socio-political complexity (Geraldi, Maylor and Williams, 2011).

1.2. Identification of the research problem:

One of the hotly debated areas in the construction industry is the high percentage of project failure, so much so that it has frequently been reported over a long period of time (Bosch-Rekveldt et al., 2010; Flyvbjerg et al., 2003; Hall, 1981; Morris and Hough, 1987; Thamhain and Wilemon, 1986). It is claimed that complexity of these projects is one of the main sources of failure (Williams, 2005). It must be noted that complexity is not the only determinate of a project's success, but it remains a focal point of our discussion (Shenhar, Levy and Dvir, 1997). Therefore, the focus is firmly planted on issues revolving around the complexities of the construction industry and the ways to cope with them.

The industry has shown great difficulty in managing the rising complexity of major projects (Stocks and Male, 1984; Williams, 2005). The role of complexity has been a centre of attention by academia and practitioners (Ives, 2005; Jaafari, 2003). Recent research has concluded that there is a need for moving from concentrating on characterising and modelling complexity to a well concerted effort to address the issue of managing complexity and coping with it (Bosch-

Rekveldt et al., 2010; Maylor, Vidgen, and Carver, 2008). However, very little research has been carried out to explore how better we can be equipped for acting in response to the increase of project complexities (Bosch-Rekveldt et al., 2010; Maylor, Vidgen, and Carver, 2008). The researcher is aware that there are two levels to look at complexity; the project level and organisation level. The former level is what this research seeks to address due to the high failure rate of projects. Despite the fact that previous studies have thoroughly explored what complexity is at the project level, the gap is that they have not been vast enough to incorporate the application approaches.

Indeed, recent findings have revealed that the level of project management education, including bodies of knowledge, universities outcomes and training courses fails to prepare project management students to deal with the increase in complexity (Thomas and Mengelb, 2008; Crawford at el, 2006). Therefore, understanding the day to day activities of the project manager leadership (Müller, Geraldi and Turner, 2011; Malach-Pines, Dvir and Sadeh, 2009) is fundamental for our research (Thomas and Mengelb, 2008).

Nevertheless, I contend that before we can start to develop different educational programmes to equip project managers as proposed by Thomas and Mengelb (2008), there is a need to understand what they need to know and what competencies and skills would be necessary to manage. That is, to look at the skills, competencies and knowledge needed to handle complexity in construction.

1.3. Research questions:

It is noticeable that there is a gap in the literature on the project manager's competencies and skills needed to cope with complexity. The bulk of research on project management tends to focus on complexity, whereas studies on technical methods of handling project complexities, including skills and competencies, have been sparse. Current research in the area has been mainly quantitative (Malach-Pines, Dvir and Sadeh, 2009) or deductive, applying an existing framework of leadership or competencies (Müller, Geraldi and Turner, 2011); others looked at competencies or leadership in general, and not specifically to cope with complexity (Gadaken, 1994; Geoghegan and Dulewicz, 2008; Dulewicz and Higgs, 2005). Thus, there is still a lack of qualitative research or inductive studies aiming to improve our current understanding of the competencies and skills necessary to cope with complex projects. This study will attempt to fill this gap. Specifically, it asks two research questions:

- What are the skills and competencies necessary to handle project complexity?
- How would the current training courses of project management prepare and advance professionals to deal with complexity?

1.4. Research aims and objectives:

This study is a journey of learning, given that it attempts to search for skills to overcome the difficulties and obstacles of dealing with complexity in the construction industry. One will attempt to contribute to the ongoing debate of understanding complexity better by identifying the way in which the construction industry has addressed complexity and coped with its increase. In addition, this research will provide a suitable approach that is applicable for educational institutions to adopt in order to learn more about handling complexity and hence to prepare students to deal with complexity in the construction industry. This research endeavours to improve the performance of constructing projects by increasing the ability to cope with complexity. It explores specifically the skills, competencies and knowledge that project managers need to cope with complexity. Such an understanding could be used to improve project management education and training.

1.5. Research literature:

This research is somewhat unaided. There seems to be little published academic research in the area of project management that investigate how we can be capable of responding to the increase of project complexity that contended in particular with complexity in the construction. The literature appears to be mainly focused on either project management education or on complexity (Thomas and Mengelb, 2008). Little attention has been paid to the challenge of addressing the issue of coping with complexity. Principally, this research tends to formulate its hypotheses from deep interpretation of the theoretical works of both; complexity in construction and skills, competencies, capabilities and knowledge that are recognised to be one way to cope with the rise of complexity.

1.6. Research methodology and data collection:

To answer the research questions, this study aims not only to synthesize the existing theoretical and empirical works in the area of complexity in construction, but also to draw more attention to particular skills, competencies and knowledge to grasp complexity. In order to add further substance to the discussion, qualitative data was collected on how project managers can cope with complexity and what they perceive to be the essential skills and techniques to do so. This collection of data involved two main stages. First, a look at the literature in order to draw a clear image about what has been conducted to date. This review provided an evaluation of the strengths and weaknesses of many of the key arguments, which used as a spring pad to formulate hypotheses and underscored areas that require further research. The Second stage consists of interviews with project managers in firms operating in the construction industry. These interviews were aimed at reflecting the industry standpoints about complexity, as well as the skills and competencies necessary by comparing and contrasting the current training and preparation on construction project management. More succinctly, what

practitioners have identified as important principles and practices to cope with complexity. Through this analysis, it can be easier to assess the adequacy of current project management training courses to equip project management professionals to handle complexity.

1.7. Structure of the research:

The structure of this thesis is represented in a way which borrows from the logic of carrying out such research; starting with presenting the main research questions and its importance and impacts. The research sought information from a literature survey and formulated its hypotheses that were illustrated in chapter 2. In the research methodology's chapter, the second source of information was conducted in which data was collected from the construction industry. Chapter 4 represents the data analysis and a discussion where the answers of the research questions were demonstrated. Highlighting the findings and some recommendations for further studies were displayed in the last chapter.

1.8. The significance of the research:

This study contributes to the current knowledge of project management in two ways. First, it helps project managers to improve their abilities to deal with complexity, by summarising the current principles and practices used by practitioners. Secondly, the study benefits training course providers to develop their curriculum by proposing an appropriate approach, in order to learn more about how to address complexity.

Chapter 2

Literature Review and Research Hypotheses

2.1. Introduction:

A considerable amount of the literature has been published on either complexity or project management education. A modest consideration has been given to the attempt to combine both bodies of research so as to be beneficial to practitioners and academics. An often cited example is a paper written by Fisher (2010), which investigates what practitioners consider to be skills and behaviours of an effective people to be project managers. Some of the findings suggest that some skills and behaviours might be more appropriate for application in certain project environments, for example, the construction industry or the IT industry. Another helpful work was done by Thomas and Mengelb (2008) that considers the role of complexity and the requirements for improving the preparation of successful project managers. An additional example of the genre is a paper by Crawford and others that addressed the challenges of complexity, highlighting gaps between the current theories and practises and also emphasising a myriad of issues including the need for extension of development to include "*technical and general management knowledge and skills*" (2006: 727).

In this chapter, there are two main areas to investigate. The first area will attempt to offer a definition of complexity as well as an overview of the most comprehensive approaches of modelling and characterisation of complexity. The second area is to conduct a review of the general management knowledge along with focusing upon skills, competencies and leadership.

2.2. Complexity in the construction industry.

2.2.1. Defining complexity:

In order to initiate this study, it is important that we reach an agreement of terms; one of which is complexity. Dictionaries have stated that complexity is "*the state or quality of being intricate or complicated, or a factor involved in a complicated process or situation*" (Oxford, 2011). Cambridge (2011) says "*when something has many parts and may be difficult to understand"* or it is "*the features of something which make it difficult to understand or find an answer to*". Most common synonyms for the term complex are; "*complexity, intricate, complicated, involved, tangled and knotty"* (Whitty and Maylor, 2009: 305). What is common between the two definitions is that both have the difficulty attribute. The point of difference, however, is that Cambridge's definition emphasises more on the existence of pluralism in components or divisions.

So how does one reconcile this with the current literature? The several attempts of definition are even less uniform than the dictionaries. It seems that there are not many signs looming on the horizon for an ideal definition to be acknowledged. According to Chu and his colleagues (2003), there is no generally accepted definition of complexity. Others concurred that complexity lacks a generally accepted comprehensive definition (Waldrop, 1992; Lorenz, 1993). The problems of complexity begin with the term itself. The most widely touted definition of complexity involves the edge of chaos (Kauffman, 1995). Not only can

complexity be understood in different ways, in different fields, but also in different connotations within the same field (Morel and Ramanujam, 1999), which makes the job of defining it accurately even more difficult.

We are now faced with a conundrum; such a topic requires concrete terms. Thankfully, in the construction industry, complexity has been seen as a key player influencing construction performance (Winch, 1998). Therefore, this industry does not have the luxury of producing abstract terms. Baccarini (1996: 202) proposed that it can be defined as "*consisting of many varied interrelated parts and can be operationalised in terms of differentiation and interdependency"*. Around "*half of the publications"* consider complexity in projects as a degree of differentiation and interdependence of project elements (Howell, Charlotta and Rainer, 2010: 258). As a result, it can be said that Baccarini's definition of complexity is fairly standardized. Though recent attempts to define complexity have suggested that "*project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system"* (Vidal, Marle and Bocquet, 2010: 02), others argue that "*understanding complexity should be decoupled from the 'natural' engineering desire of a 'predict and control' approach"* (Bosch-Rekveldt et al, 2010: 02). They added that understanding complexity in order to manage projects better is not automatically focused on just reducing complexity. In other words, there are other characteristics of complexity that should be taken into consideration in coping with complexity. To sum up, it seems that what Orstavik and Bygballe (2010: 226) have suggested is a succinct argument and this study shall utilise this definition of a complexity:

> "*The essential aspect of complexity is not the many dependencies in themselves, but the fact that dependencies are dynamic, time-dependent and sporadic in nature, rather than stable, predictable and ubiquitous. Complexity is multidimensional, and the dependencies involved are at the same time technical, economic, logistic and social in nature. Coping with complexity means to handle these multiple dependencies.*"

In the construction industry, complexity is frequently related to the problems and obstacles of carrying out operations and its execution. Consequently, the nature of construction depends on heterogeneous knowledge bases and the coordination and integration of a large number of various operations in space and time (Gidado, 1996). Maylor, Vidgen and Carver went somewhat further and argued that these attempts of defining complexity "*to be inconsistent with the diversity of usage of the term in organizations today and only partially helpful in understanding the associated task of managing these activities"* (2008: 15). Cicmil and Marshall (2005) describe this evolutionary nature of complexity in a construction process, with the processes of social interaction interfacing with the persisting ambiguity in the context of flux and change. Projects are socially constructed (Lundin and Soderholm, 1995) and definitions of complexity should imitate this, by including technical and social dynamics.

Academically, researchers have concentrated upon two trends of work: "*complexity in project"* and "*complexity of project"* (Cicmil et al., 2009). The first is a theoretical approach (Manson, 2001), whereas the second is practitioner-driven, aiming to identify the characteristics of complex project and the responding to it (Geraldi and Adlbrecht, 2003). This research will focus will be on the second trend.

2.2.2. Measuring complexity:

Notwithstanding it is not easy to confine all dimensions and characteristics of complexity in order to measure it, it is significant to try and develop a set of measures that capture and categorise the majority of critical aspects of complexity (Xia and Lee, 2005). However, Whitty and Maylor (2009: 309) raised an interesting question of "*How do you measure complexity in a robust manner, that takes account of structural, dynamic and interaction elements?"*

There has been a five stage evolution of ideas put forward to answer this poignant question. One of the first attempts to answer this question was put forward by Kaimann (1974). Kaimann suggested a measure that the first time user may apply to evaluating his networks. He defined the Coefficient of Network Complexity (CNC) as it is equally applicable to both PERT type networks and to Precedence type networks. Those types of networks are project management tools, techniques or models used to organize, schedule and coordinate tasks within a project. The CNC can also apply to any model of a project as a graph. In the case of PERT networks, the CNC is equal to the quotient of activities squared divided by events. Nevertheless, one of the problems here is that "*such graphs are specific models of the project system, which restrict the view and understanding of project complexity* [and] *applying such measures to these kinds of elementary models of the projects cannot properly account for a measure of project complexity since they are in essence relative to the model"* (Vidal, Marle and Bocquet, 2010: 02).

A few years later, Akileswaran, Hazen and Morin (1983) attempted to gather measures which stand for the computational complexity of some project management issues, such as scheduling matter and the sequencing. However, the limitation here is that it does not really concentrate upon complexity of the project, but rather only on specific matters such as scheduling.

A third attempt was represented by Santana (1990). He classified construction projects according to the scale of complexity. His classification considers three categories: *singular, complex* and *normal. Singular* refers to very unique project with very long period of planning and execution. *Complex* projects share many features of that of the *singular* projects, but they are not unique and the problems involved are better known. Finally, *normal* is where all the other projects are included. Yet, the drawback of this finding is that it does not provide enough details; instead, it gives a broader classification of projects in relation to the scale of complexity.

Haas (2009) has developed more holistic measures. He described project complexity using a complex systems thinking approach to identify several aspects of complexity, such as; cost/duration, performance and team composition or political sensitivity/multiple stakeholders. This approach is particularly adapted to the issue of project selection. Nonetheless, the disadvantage of such measures is that it is not easy to sometimes calculate for non-skilled users (Vidal, Marle and Bocquet, 2010), which makes it even more complex to do and to analyse it.

Last but not least, a recent study by Vidal, Marle and Bocquet (2010) attempted to address the issue of measuring complexity. They acknowledged a number of the previous works done about this matter and built upon them. Their approach is using the Analytic Hierarchy Process (AHP) to assess project complexity. The purpose of such measurement is to rank factors causing complexity according to their levels of the importance of contributing to project complexity. Figure 01 depicts the main four groups of project complexity factors. They are project variety, project size, project interdependencies and project context-dependence. Using a certain ratio, developed from Saaty (1977), and overall criteria and sub-criteria weights, project complexity factors comparison can be done easily.

Nevertheless, it can be noticeable that using the Analytic Hierarchy Process (AHP) has had criticism on the bases of rankings that can vary, especially when adding or subtracting an alternative to the set of alternatives on which the study conducted by Vidal, Marle and Bocquet is performed (Holder, 1990). This raises that with the process and tools of decision-making, caution should be taken into account.

Family	**Organisation Complexity (Org)**	**Technological complexity (Tech)**
Project system size	Number of stakeholders	
Project system variety	Variety of information systems to be combined	
	Geographic location of the stakeholders (and their mutual disaffection)	
	Variety of the interests of the stakeholders	
Project system interdependencies	Dependencies with the environment	Specifications interdependence
	Availability of people, material and of any resources due to sharing	
	Interdependence between sites, departments and companies	
	Interconnectivity and feedback loop in the task and project networks	
	Team cooperation and communication	
	Dependencies between schedules	
	Interdependence of information systems	
	Interdependence of objectives	
	Level of interrelation between phases	
	Processes interdependence	
Project system context-dependence	Cultural configuration and variety	Environment complexity (networked environment)
	Environment complexity (networked environment)	

Fig. 01: Refined project complexity framework (Vidal, Marle and Bocquet, 2010: 06).

It can be observed that all of the above attempts to measure complexity have displayed their limits and drawbacks for several reasons. The main criticism is the reliability of such measures. Other criticisms revolve around the fact that many are non intuitive for the final users and hence represent results that are difficult to actualize (Vidal, Marle and Bocquet, 2010). However, all of the above measures are also tools to promote discussions about project complexity which may lead to a better understanding and visualisation of project complexity (Ibid 2010). Therefore, what can be utilised from these studies to the aid this current expedition is that the way in which complexity is measured and defined varies extensively, even though some measurements are far more adequate than others, they still vary. Thus, when looking at ideas of coping with complexity, it is important to first define what it is meant by complexity. Such an outlook will actualised by focusing not only on the measurement of the dependencies of complexity, but rather a full appreciation of their dynamic and multidimensional nature.

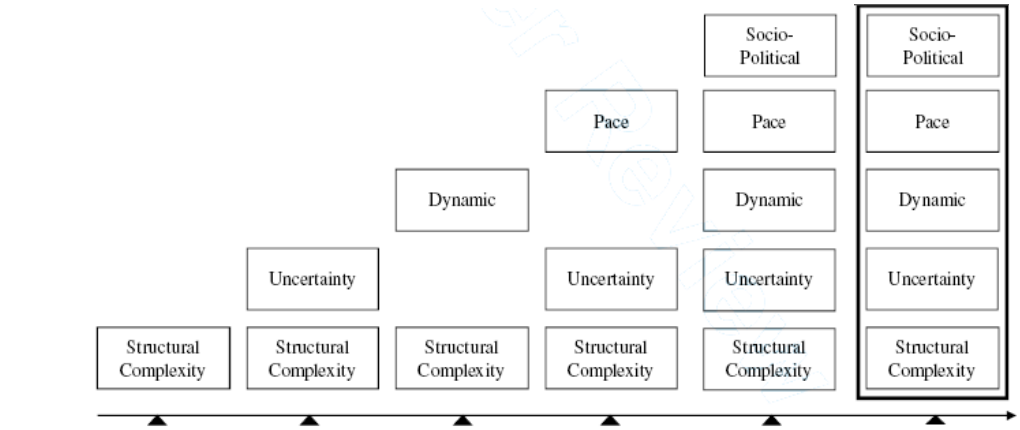
On a more conceptual level, the research revised above supports the implicit assumption of which this study is built upon; namely that complex projects demand far more rigorous competencies and skills than simpler projects. If the assumption that construction projects have become more complex than ever before is proven to be correct (Fernández-Solís, 2007), then it is safe to assume that complex projects demand more 'complex' behaviours, skills, competencies, tools and techniques for projects to be successful, which in turn produces a pressing need to investigate what these competencies and skills are (Hypothesis 01).

2.2.3. Complexity frameworks:

Utilising Orstavik and Bygballe definition of complexity and the measurement proposed above, it is time to review what the literature says regarding modelling complexity. A myriad of frameworks have already been proposed and the aim of this part of the research is to outline the latest and most comprehensive frameworks proposed, and therewith to draw a clearer picture of complexity. For that reason, two frameworks will be explored; framework of complexity in general and a more specific one about complexity in construction.

To start with, a framework of complexity in general will be explored. Recent research undertaken by Geraldi, Maylor and Williams (2011) presents complexity in five dimensions; structural, uncertainty, dynamics, pace and socio-political. These types of complexity were identified when considering the publication data of 25 articles conducted in different industries since 1996. Figure 02 demonstrates how the authors identified the conceptualisations progressing towards their five-dimension framework. It can be seen how the development of complexity frameworks proves that types of complexity were not building on previous works deliberately. What is interesting is that there is no further type of complexity proposed in the last two years, 2009 and 2010.

The need for exploring as to whether this framework is applicable or not is one of the main concerns of this study.



	1996	1997/99	2002/04	2005/06	2007/08	2009/10
First appearance	(Baccarini, 1996)	(Dvir & Shenhar, 1998; Shenhar & Dvir, 1996a; Williams, 1997, 1999)	(Ribbers & Schoo, 2002; Xia & Lee, 2005)	(Dvir, et al., 2006; Shenhar & Dvir, 2007; Williams, 2005)	(Geraldi & Adlbrecht, 2007; Remington & Pollack, 2007)	
Later appearance	(Austin, et al., 2002; Clift & Vandenbosch, 1999; A. Jaafari, 2003)	(Little, 2005; Tatikonda & Rosenthal, 2000)	(Benbya & McKelvey, 2006; Maylor, et al., 2008; Xia & Lee, 2004)		(Haas, 2009)	(Howell, Windahl, & Seidel, 2010)

Fig. 02: The historical development of complexity frameworks
(Geraldi, Maylor and Williams, 2011: 11).

In engineering and construction, on the other hand, Bosch-Rekveldt and his colleagues (2010) have outlined the elements of a project that contribute to project complexity and also outlined the way in which they can be included in a framework in order to characterise project complexity in engineering projects. That is, to synthesize the existing theoretical and empirical works in the area of project complexity in construction. Around 50 contributors were identified in three areas: Technical complexity (T), organisational complexity (O) and environmental complexity (E) (See Appendix A for further details). The TOE framework was facilitated to be only in three levels or categories and fourteen subcategories. Figure 03, is a diagram illustrating the framework. The category offers opportunities to be discussed on various levels of parties and stakeholders involved in a project. The aims of this framework are to provide a potential means to better handle the project and also to be used for assessing the complexity of projects in the process of engineering industry. Nonetheless, one of the limitations of this framework is that one could argue that construction in general does not behave as an "*industry*", but rather "*conglomerate*" (Morris and Pinto, 2004: 1350), or an "*industry of industries*"

(Fernández-Solís, 2007: 1599). Therefore, the generality of this framework within the construction industry may or may not be applicable to others.

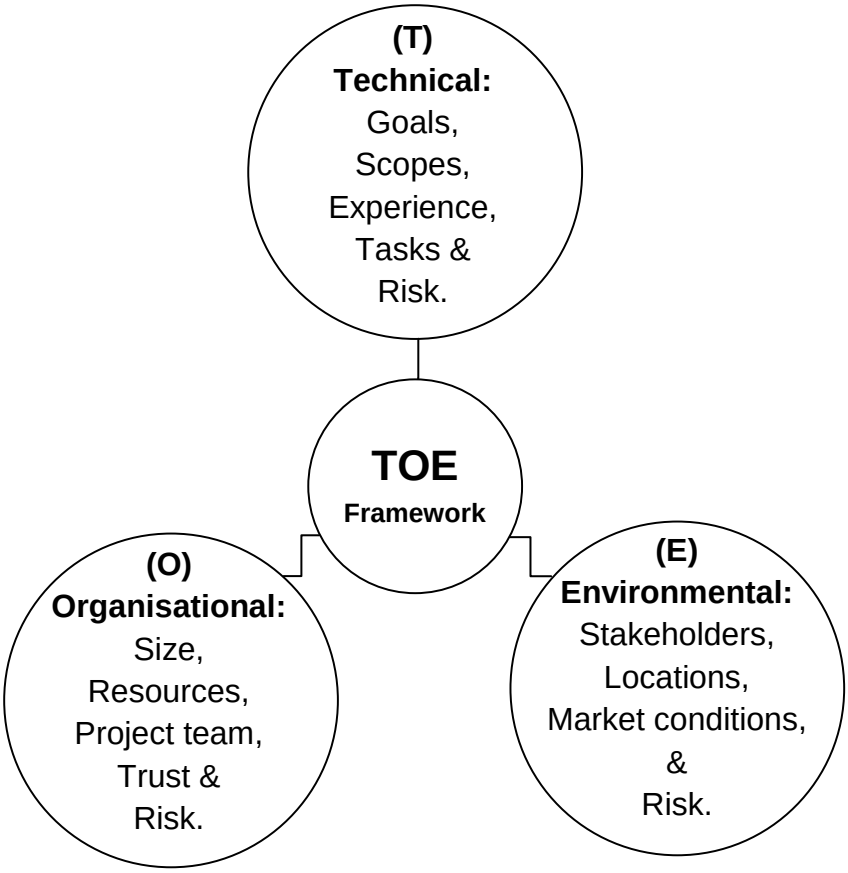


Fig. 03: The TOE framework, adopted from Bosch-Rekveldt, M., et al (2010).

To conclude, it is clear that just as there is a lack of agreement on defining project complexity, there is apparently a limitation of accepting a single framework that supports the characterisation of project complexity. On some level, it is a positive sign since it encourages more research and exploration for tackling the issue of increasing complexity. However, there remains an urgent need to actualise the rise of project complexity, which is one of the key players causing project failure.

On the basis of what has been reviewed, this study will adopt the framework proposed by Bosch-Rekveldt, M. et al. (2010) for two reasons. One of which is due to the fact that it was built upon theoretical as well as empirical findings. Another reason is that it is entirely focused on the construction industry.

2.3. Skills, competencies and knowledge.

Due to the fact that little attention has been given to confront the issue of coping with complexity and the belief that one way to address this is to investigate what is needed, a set of studies on technical methods of handling project complexities will be conducted. Such studies will seek to gather precise information on how project managers can be better prepared to handle the growth of complexity.

2.3.1. Skills, competencies and knowledge: An overview.

Undoubtedly, managing a project requires an appropriate level of knowledge, experience and skills. Much of the knowledge needed is a reflection of scientific and practical understanding of tools and techniques in project management, of which are drawn from areas of expertise such as PMI PMBOK®, ABM BoK and ENAA P2M. Figure 04 shows the generic areas of knowledge which construction project managers are usually expected to acquire by various Accreditation Bodies, which reflect their technical requirements for certification. However, according to the Project Management Institute which articulates that having PMP® does not indicate that a holder of this certificate can be qualified as a project manager, but rather demonstrates a solid foundation of knowledge allowing the holder to practice project management competently (Crawford et al., 2006).

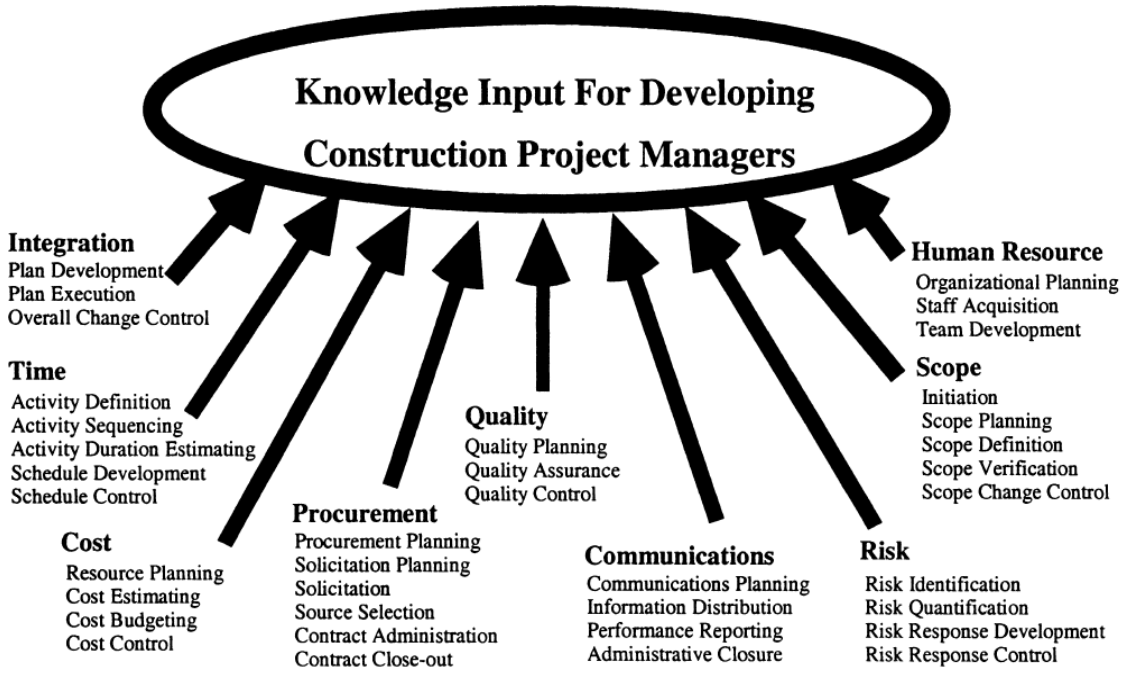


Fig. 04: Areas of knowledge that project managers are expected to acquire by various Accreditation Bodies (Edum-Fotwe and McCaffer, 2000: 113).

Project managers are required to respond effectively to the increasing complexity in projects. This has been identified as an important concern for future project managers who found themselves dealing with other issues and

undertaking additional roles which have traditionally not been part of their responsibilities (Shenhar, Levy and Dvir, 1997). It has been recognised that there is a noticeable shift in the role of project managers. This leads us to pause and think again about what project managers have to be capable of. Russell, Jaselski and Lawrence (1997) suggested that construction project managers have to even supplement their traditional functions with non-engineering knowledge and skills to meet today's professional demands.

A simple definition of competence would point out capability and capacity to perform an action or series of actions successfully. In 2000, Edum-Fotwe and McCaffer published a paper in which they argued that:

> "*Professional competency in project management is attained by the combination of knowledge acquired during training and skills developed through experience and the application of the acquired knowledge" (112).*

The new focus on competence at both levels; organisational and personal, is a significant way in which the organisational context of managing projects has changed (Morris, 1999). Moreover, detailed examination of competency by Gale (2004) explained competencies at two levels; organisational and personal. He suggests that "*competence could be defined as knowledge, skills and qualities of effective managers*. *It is a normative concept rather than a descriptive one*. *Competence certainly includes the possession of particular knowledge and skills*" (1089). Cheetham and Chivers (1998) approached the Professional Competency with what can be named "*tacit knowledge*". They argued that professional workers are capable of drawing a set of answers that fit properly to the needs in a particular situation. They also emphasised the significance of competency in acquiring a range of skills including critical analysis, communication and problem solving. The focus in this research will be given at the personal level due to the thesis's aims and objectives.

What can be observed from all of these definitions and characterisations regarding professional competency in construction is that not only is there a demand for general knowledge as well as management knowledge, but also a need for skills that extend beyond the technical aspects of traditional engineering. The nature of complexity leads to the realization that the knowledge, skills and competencies of professionals would be different from that of non-complex projects. This is an example of what the focus of project managers should be upon; a focus on 'human skills' rather than just 'technical skills'.

It can be stated that skills, competencies and knowledge can be renewed and maintained by the acquired through practical experience over a decent period of time and those are particularly important to address complexity. It can be argued that grounded experience is a key for managing complex projects, if it is coupled with other components such as the necessary skills and competencies. For instance, tacit knowledge can rarely be taught. Consequently, it is not easy to convey to people and thus project managers

have to take into consideration that it usually comes with experience over a long period of time (Hypothesis 02).

A lot of research has been conducted in outlining a set of skills and competencies. Six competence elements were a result of research done by Gadaken (1994) on top performing project managers in the UK and US military acquisition commands. The six are: strategic influence, sense of ownership/mission, interpersonal assessment, relationship development, political awareness and action orientation. Further, Edum-Fotwe and McCaffer (2000) listed a range of skills and knowledge such as technical skills, managerial skills, financial skills, legal skills, communication skills, IT skills and general skills such as public relations and understanding of organisation (See Appendix B for further skills). General skills offer a solid platform for strengthening some of the management skills. Leading, which will be explored further in next, is recongised to be essential for project managers. What can be drawn from this point is that there is a variety of skills and competencies that can be described as being important to be learnt and even imitated. However, some skills are described as a natural gift. The literature did not offer definite evidence of what specific skills that project managers can utilise to overcome the problem of increasing complexity in the construction industry. Fisher (2010: 03) explains that "*real people behave differently in the real and socially constructed world (practice) as compared to a world that only exists within people's imagination (theory)*". Fisher's point suggests that the prime questions of this research are relevant and important, but that further insights were required to answer these questions.

2.3.2. Leadership:

Why is leadership essential? Handy (1999) suggested that there is a need for someone able to develop and communicate a vision that indicates meaning to the work of others, this, he argues, is the work of a leader. Leaders are necessary at all levels and in all situations. In the context of projects, the role of leadership is exercised by the project managers (Müller and Turner, 2007). Project managers acting as leaders have been recognised as one of the important soft-success factors (Müller, Geraldi and Turner, 2011). The distinction between leaders and managers has been described as crucial, since the latter are doing things right, whereas the former are doing the right things (Bennis and Nanus, 1985).

There are a number of schools of thought about leadership. Figure 05 summarises several studies which have been conducted in addressing the concept of leadership.

Schools	Thoughts	Authors
Trait	Successful leaders are borne leaders and share common traits.	(Kirkpatrick and Locke, 1991).
Behavioural	Some aspects of leadership can be developed	(Hersey and Blanchard, 1988).
Contingency	There are different types of leadership suitable to different contexts.	(House, 1971).
Relational	Believes in the leader's relationships with other members of the organisation.	(Graen and Bien, 1995).
Visionary/ Charismatic	Distinguishing between transactional and transformational leadership style in organisational change.	(Bass, 1990).
Emotional intelligence	Distinguishing between personal competences and social competences.	(Goleman, 1995).
Competency	Clustering all the previous leadership theories under EQ, MQ, IQ competences.	(Dulewicz and Higgs, 2005).

Fig. 05: Schools of thought about leadership, adopted from Müller, Geraldi and Turner (2011).

The question to be asked now is; how is this relevant to the project complexity in construction? Based on the previous research on leadership styles, a certain style of leadership quality is more suitable when dealing with particular type of project which leads to a successful outcome. This was proven theoretically and practically by Müller and Turner (2007). According to them, 'conscientiousness' is fundamentally important with engineering projects. They say that "*on engineering projects more transactional styles are appropriate*" (31). What might be of particular interest is that Keegan and Den Hartog (2004) reached to the same conclusion that of Müller and Turner (2007) regarding what the appropriate competencies related to complex projects. Precisely, for medium complexity projects, communication and emotional resilience are key. By contrast, sensitivity is essential on high complexity projects. Moreover, these competencies are "*associated more with transformational leadership than transactional leadership*" (Ibid, 2007:31). Goal Oriented, Involving and Engaging are three identified styles of leadership by Dulewicz and Higgs (2004). They believe that on high complexity projects, engaging leaders are best, whereas involving leaders best on medium complexity projects. However, on low complexity projects, goal oriented leaders are best. What can be observed is the fact that directors and senior managers responsible to appoint project managers have the responsibility to address the issue of choosing the appropriate one to do the job, given that skills and competencies vary from managers to other.

Chapter 3

Research Methodology

3.1. The research approach:

To answer the research questions, a deductive research strategy was chosen. A combination of two methods were conducted respectively; theoretical review and empirical investigation. In an attempt to close the gap in the literature, this study will present some practical insights from a sample of senior project managers' interviews. The formulated hypotheses are then tested using the empirical data collected from the construction industry.

However, analysing the qualitative interview data using a comparative assessment was conducted shortly after each interview in order to avoid losing the gist of the findings. All of the interviews were recorded with explicit permission from the interviewees. Subsequently, the relevant notes and the transcribed texts were used for data analysis.

3.2. Object and level of Analysis:

Exploring the skills, competencies and knowledge are the prime objectives of this study. This investigation will be on the personal level of the research sample, due to the specific aims of the study. Though, there are other levels that should be also investigated such as organisation, project and personality.

3.3. Sample:

The rational behind the research was to interview competent project managers, with experience in complex projects. The rational is that these people would be in a good position to provide a reflected and reasonable account of the skills, competencies and experiences required to manage complex projects. As a result, senior project managers were carefully selected on the basis of their connection with very large and successful construction organisations in the United Kingdom. These companies were within the top 100 construction companies' league table which ranks the UK's 100 biggest construction companies in terms of the turnover and profit. Every September, the table is compiled (The Construction Index, 2010). (See Appendix C for further details). Undoubtedly, those companies have become very experienced and have great abilities to deliver successful projects with high performance in terms of Time, Budget, Quality and Clint's Satisfaction.

The project managers were chosen deliberately for their abilities to manage complexity particularly in major and complex construction projects. The focus was on senior level management as it was expected that to obtain the most relevant information from such innovative and competent people. The size of the sample in this study is considered to be reliable, since the number of people interviewed does matter when providing a stronger base for testing and building theories (Yin, 1994). Therefore, to enable more comparisons that help to clarify whether an emergent finding is rather unusual or just consistently replicated (Eisenhardt, 1991). On the other hand, the size of sample does help to limit bias. That is through using numerous and highly

knowledgeable informants, who have a wider view or view the focal phenomena from diverse perspectives (Eisenhardt and Graebner, 2007).

In total, more than 50 major construction companies based in the UK were contacted via email, telephone or correspondence. (Appendix E demonstrates a sample of the invitation). Figure 06 illustrates a summary of the respondents in percentages. In total, 12 professionals have agreed to be interviewed. However, around 29 companies have expressed a willingness to participate, but many factors, mainly time constraints, prevented them from arranging a suitable time. The main reason for this was that this research was carried out during the summer period, in which the majority of project directors and senior managers are on vacation. Moreover, 8 companies have not responded for unknown reasons.

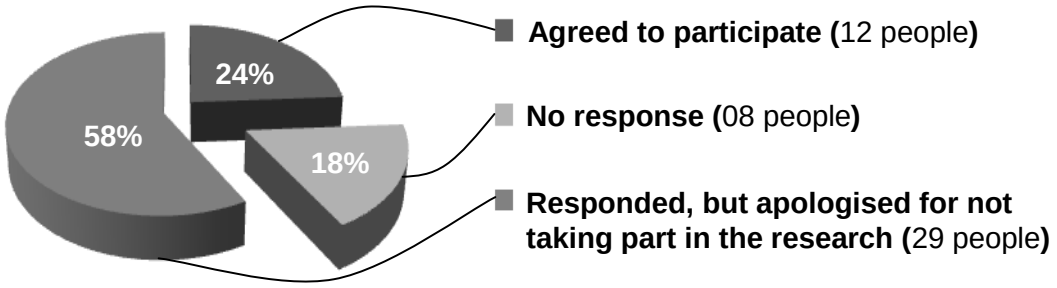


Fig. 06: A pie graph representing the respond to the invitations to participate in this research.

To begin with, the general background of the interviewees will be represented. The following diagrams are a summary of the participants in terms of their ages, qualifications, years of experience and also which organisations they represent. Not surprisingly, Figure 07 shows that the majority of managers were categorised in either middle age or mature.

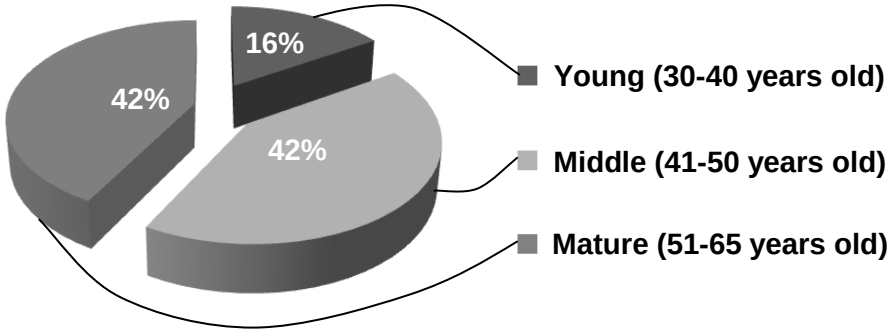


Fig. 07: A pie graph demonstrating participants' age categories.

In addition to the latter observation, figure 08 gives an indication of the experience of the sample ranges between 6 and 35 years as a project manager. A significant proportion of the respondents have between 6 to 25 years of experience in construction. Unsurprisingly, directors tend to be very experienced and usually have 30-year experience. It can only be inferred that

generally, this indicates that to attain the position of a manager in construction, people have to accumulate a number of years of experience.

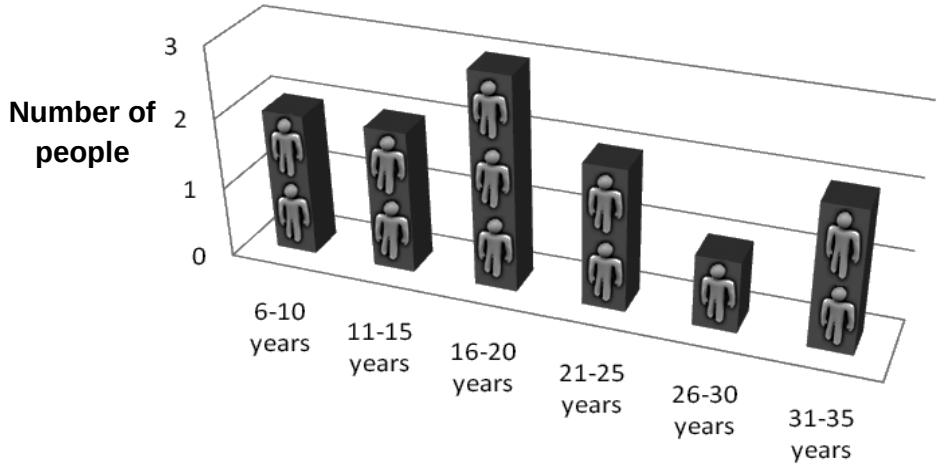


Fig. 08: A bar chart indicating participants' years of experience as project manager.

Figure 09 represents that 9 out of 12 managers in the research sample hold an academic degree mainly in Construction Management, Civil Engineering, Building Management, Architecture Engineering or Quantity Surveying. By contrast, a small proportion has either no formal qualifications or has only obtained diploma level qualifications specifically in Design Engineering and Manufacturing Management. Therefore, it would be safe to assume that large organisations are focusing in attracting more qualified managers from different educational background within the built environment and technical professions.

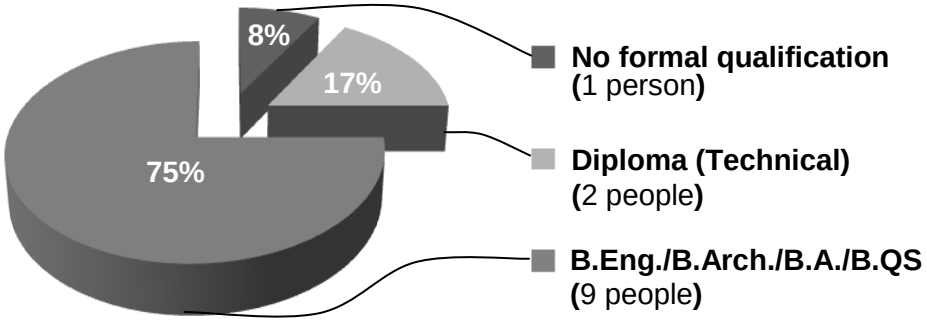


Fig. 09: A pie graph signifying participants' qualifications.

Figure 10 illustrates the types of project managers that represent different organisations. It can be seen that there were two types of manager; one who represents the Client and one who works for the Contractor (Construction Company), to manage delivering the project. The majority of the directors and managers interviewed worked for construction companies, whereas very few interviewees represented clients. Here, one could argue that this may represent two different views that should be taken into account. However, it

could also be argued that they may give slightly different responses and thus reflect different standings. Thus if we were to look at the way in which the interview questions were designed, they are more open-ended and are able to accommodate both views and their standpoints. More importantly, both groups had almost the same position since those who represent clients have worked for contractors before.

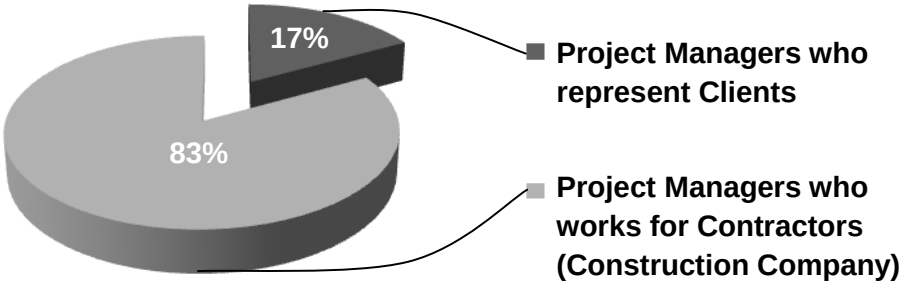


Fig. 10: A pie graph displays the types of project manager involved in the research.

3.4. Data collecting methods:

The key tool employed in collecting the data is semi-structured interviews with senior level project managers in firms operating in the UK construction industry. This method is one of the common ways of obtaining a realistic picture especially in an area that has not been explored in depth (Sharp, Peters and Howard, 2002).

The interviews are developed by employing a range of criteria identified from the literature. (Appendix D shows the interview questions). The nature of the questions was constructed to help answer the main research question. Open-ended questions were designed for the purpose of leaving the interviewees with much room for elaboration and interpretation. Principally, open-ended questions ensure having the chance for project managers to share their experiences and thoughts which at the end serve the research aims and objectives.

It must be declared that some of the interviewees did not want the interview recorded, even though an offer had been made to transcribe the whole interview. This will not be a sensitive problem, since it happened in just 4 cases representing 33% of the sample firstly, and secondly, notes were taken carefully during those interviews to mitigate the limitations this may cause. Moreover, the findings should be representative and largely reliable to a certain degree.

Nevertheless, taken that the literature still did not provide an empirically grounded framework, open questions and a semi-structured interview was important to delve into new aspects of competencies, skills and knowledge needed to manage complex projects, but not yet identified in the current literature.

3.5. Validity and Reliability:

In relation to the reliability of the work, a comparison was undertaken between the final framework proposed for the skills, competencies and knowledge necessary to cope with complex projects in construction and the result of the qualitative study through interviewing a dozen highly competent directors and senior managers for the purpose of identifying overlapping results. Principally, similar findings from both investigations were considered to be validated results.

With reference to the reliability of this research, the method chosen a series of semi-structured interviews. Although this way of collecting data has advantages, there ware disadvantages too. One of which is bias. To overcome this issue, a self-completed questionnaire would help to eliminate bias. However, the drawback of the quantitative study is that it consumes much more time than the qualitative approach that was used in this thesis.

3.6. Generality and Limitations:

George Box believes that all models are wrong, but they are useful. This work proposes a model, and hopes it will be useful, but yet there are limitations in it. One of which is limiting the sampling to just interviewing directors and senior managers. While interviewing other people such as one of the team members within the same organisation would add more layers to this analysis and outcomes in terms of exploring required skills and competencies to cope with complexity, since it is clear that senior managers do not manage complexity in a vacuum.

Chapter 4

Data Analysis

In the beginning, general matters related to complexity in construction were first discussed in each interview with the candidates. Raising the questions of defining complexity and the way to measure it were introduced at the initial stage of the interview. The aim was to encourage the interviewees to brainstorm. What is most interesting is that within the literature, the size of the project - in terms of project duration engineering hours, method of deliveries, budget or capital expenditure and number of locations - is seen as the main dominant and contributors to structural complexity (Williams, 2002; Geraldi and Adlbrecht, 2007; Maylor, Vidgen and Carver, 2008; Müller and Turner, 2007). The most mentioned type of complexity in the literature is structural complexity (Williams, 1999). However, the interviews reveal that few directors and managers pointed out the size issue. Instead, issues such as technical, organisational, logistical and environmental matters were often mentioned. The latter issue was consistent throughout the interviews. One could deduct that it weighed heavily in major planning applications or planning submissions, particularly in relation to statutory issues such as new legislations and regulations with very different agenda locally (Boroughs or Councils) and nationally (Government). In other words, the general contexts of environmental compliances or sustainability required more layers of analysis, fuelled complaints about major schemes and increased the number of stakeholders, which subsequently increases the complexity of projects. Another set of widely discussed issues were the way in which projects were funded and also the rapid development of technology, which is in fact faster than the design and building process.

In terms of measuring complexity in construction, practitioners have rather different approaches. What may be of particular interest is that most contractors measure complexity of projects by measuring performance, either internally within the company or externally. Measurement is usually done by the Key Performance Indicators (KPIs) or by the Project Performance Indicators (PPIs). These are definitive tools to accurately assess performance by it logging against a detailed programme, measuring how waste is dealt with, measuring health and safety information, logging against budget or energy performance. To sum up, most construction companies log all lessons learnt and keep records of such things to be looked at and used in the future for the purpose of mitigating risks and thus complexity in projects.

The crux of issue was integral to the second part of the interview; namely, investigating the skills, competencies and knowledge needed to handle different types of complexity. According to the framework adopted, there are three types; technical, organisational and environmental complexity in construction. The main idea was to introduce each type and then question the interviewees the way in which they handle such complexities. The task was to recognise what skills and competencies more often referred to and why. It was not an easy job to identify trends, since each manager has a different approach. Figure 11 is a proposed framework contains a set of skills and competencies required to counteract all different kinds of complexity and a reflection of the current practice of managing complex projects in construction. How often each skill and competency was mentioned is also taken in to account, chiefly, to demonstrate the importance of such skills. The framework

was developed through analysing and scrutinizing key observations, in order to categorise important skills and competencies.

It can be seen that the key factor to manage technical and environmental complexity was simply a grounded level of experience in coping with issues with a similar nature of complexity. Robust experience here would be built through a myriad of elements. One of which, as suggested, is passing though the hierarchy of staff before becoming a manager. Namely, to experience stages that most senior managers went through. First, a supervisor on-site to know a variety of technical details and the principles of construction and then engineer and next senior engineer followed by the post of assistant manager and becoming a manager is the last before being a senior manager or director. This would allow a range of experiences and knowledge to be gained. However, missing any stage may ultimately lead to a lack of sensitive competencies, skills and knowledge necessary at some stage during project execution. Obviously, there were other important skills to be also learnt such as planning, scheduling, controlling the speed of time, budget monitoring and so on. In fact, according to the managers interviewed, they believe that all these skills can only be dramatically improved through practise over a period of time. In addition, doing related roles in certain departments (in office or on-site) is recognised to be beneficial in developing other weaker skills and competencies. Therefore, this confirms (Hypothesis 2), given that the empirical results declared that *"skills, competencies and knowledge can be renewed and maintained by the acquired experience over the time spent in practicing"*.

Organisational complexity, on the other hand, tends to be handled by developing effective lines of communication, which is seen as a fundamental skill. Managing emotions, building trust among teams and other skills are also cases in point. It must be said that managing the front-end of projects in general and in complex projects in particular was highly emphasised by project managers. Not surprisingly, given that the indicators to why projects fail demonstrated that the top two reasons were down to procurement selection and project definition, *"29% and 16.5%"* respectively (Dalton, Winch and Maytorena 2008: 23). In the front-end, spending sufficient time to develop a robust project definition and the right selection to procure a project is reflected in Aristotle's famous quote, "*defining the question is half the answer*". Much of competencies and skills required at the front-end are specific to the functional expertise necessary in creating the improvement offering – technical, legal, financial etc. Managing the front-end activities offers the best value possible for projects and hence mitigates risks that might occur during the execution. Since risk is linked with uncertainty, which is believed to be a relevant type of complexity, project managers have to address the front-end effectively and professionally.

Types of complexity	Skills and competencies	Times mentioned
Technical	Grounded experience in dealing with project with similar issues of complexity; …….	12 times
	Ability to plan and to schedule accurately; …….	12 times
	Understanding of the client's goals and objectives clearly; ……..……	11 times
	Understanding of the scope of project and its size (Being very clear to all parties involved); …	11 times
	Basic technical knowledge (Procurement, understanding drawings & design activities); ….	10 times
	Awareness of technology and its influence; ……	10 times
	Having a bird-eye view upon the project (wider vision to avoid getting lost in the details) and ….	08 times
	Ability to prioritise; ……...	08 times
	Understanding legal issues (Type of contract and new legislations and regulations) ……...…	08 times
Organisational	Good and clear communication (From the top-down and vice versa); ……..……	12 times
	A decent experience of managing people (Managing emotions); ……..……	12 times
	Managerial skills (leadership, delegation, negotiation, time management, decision making, managing conflicts, open mind, motivation and above all managing the front-end); ……..	10 times
	Trust and openness; ……..	08 times
	Ability to control resources, their availability and mobilise them if necessary; ……..…….	06 times
	Awareness of culture; ……..……	06 times
	Awareness of health and safety issues; ……..	06 times
	Awareness of security issues and ……..…..	06 times
	Understanding organisation …….	04 times
Environmental	Good level of experience to deal with stakeholders (Effective communication, building relationship and ability to remove barriers and unifying different perspectives); …..…….	12 times
	Awareness of environmental issues (Sustainability, weather conditions and difficulties of the project site or location); ……...	12 times
	Understanding the market conditions of the industry (Its stability and also the level of competition) and ……..……	08 times
	Addressing issues like political influence and local agendas ……..……..	05 times

Fig. 11: A proposed set of skills and competencies necessary to manage complexity.

In terms of dealing with risk, given that risk is associated with uncertainty and hence complexity, the managers interviewed have shown the same attitude towards such challenges facing them in construction. Managers share the importance of having the ability to foresee early warning matters in the Risk Register, giving an early warning by notifying other parties involved – such as contractor, consultant and client – attending Risk Reduction Meetings regularly, revising the Risk Register to record decision made and finally issuing the revised Risk Register to all parties mentioned.

As for the current set of tools and techniques such as PERT, CPM, Gantt chart and WBS or as some refer to 'hard skills', the vast majority of managers interviewed support the research's claim in (Hypothesis 1), which exhibits the need for balancing the emphasise upon 'soft skills' as well as upon 'hard skills'. If we where to compare between the emphasis on 'hard skills' and 'soft skills' in the bodies of knowledge, such PMI PMBOK®, then surly we would not find a balance of stressing both skills equally as they should be.

There are some various points that are recognised as being vital by project managers: Steve Skelton says “Complexity, in my mind, is a tangle of string and what you have to do is you have to unstitch it. It is common parts, it is differences, it is dynamics etc and by breaking it down in a systematic way you can then apply your various organisational, technical and commercial issues thus creating a framework for yourself consists of manageable components that can be moved forward”. “To avoid experience to be narrow, project managers have to experience different things throughout their careers through working in different environments and circumstances. This will increase the manager's envelope of knowledge dramatically. It gives managers a range of experience that the business will be benefited from as well as individuals. Therefore, allowing more people to be able to be left completely in charge of a project and also limited the dependence on only certain people who can deliver successfully” (Ian White). “The skills that managers really need are to communicate top-down, bottom-up of the organisation and encourage this for the whole staff. 'Never let problems 'fester'. If there is a problem, you must recognise it, discuss it with your team and solve it immediately” (Steven Regan). “We are all learning from each other, but there is a limit to our credibility when we do what we learn. We work in an industry where vocational further education is something that is necessary to be able to succeed in the industry. There are other industries where you could succeed with a generic further education. The reason is because those skills and qualifications that learnt are immediately transferable. I am still to be convinced that vocational project management qualifications necessarily deliver the best project managers” (Stuart Edwards). “Senior managers cannot cover all the details in major projects, because there is so much of it. So what you have to do is be able to be confident that you have the strategies and the processes in place, and from experience you would know typically where the points of failure are going to be. So it is bird's eye view, but also be able to

look out side the box, dive into the details and zoom to areas of risk, complexity, challenge or gap to test and tease out any problem. Some people cannot operate on those two levels" (Mike Joshua). "Good managers do not just act as a 'post box'" (Derek Guy). "The qualities of good manager are drive, focus, experience, team builder and intellectual ability" (Leonard Quy). "One of the main jobs of the project manager is to reduce risk. Risk increase with lack of knowledge, decreasing supervision, decreasing competent and decreasing understanding" (John McGinley). "When forming the ream, project manager has to look at the various complexities of the project and organise the team according to their appropriate skills to address those complex issues" (Graham Pepperdine). "Your job as a project manager is knowing who is good at what" (Ian Jones). "What is in the hart of leadership is that you are there for your people; to enable them to perform and to create the suitable environment for them to succeed" (Andy Smith). "Most successful project directors or project managers tend to lead from the front, 'leading by example'. If somebody else of their teams is struggling, they will put themselves into that position in order to help that person and pull him along" (Edward Hartwell).

Chapter 5

Conclusion and Recommendations

We have reached our destination and approached the last stop in our journey. Amidst this trip we encountered two posed research questions. In a practical sense, figure 11 is an attempt to answer the first research question. It can be summarised that there is no substitute to experience in managing major and complex projects. It appears that what senior managers perceive as complex is related mainly to context of the project and also the contextual constraints. Setting up the front-end of the project is also considered to be one the keys of success which can unlock complex projects. In short, the value that this study has added is that it contributes to a better understanding of how complex construction projects can be delivered successfully. It is a combination of having a good period of exposure and training and also grounded experience.

To answer the second research question, which was regarding the concern about preparing and advancing professionals to deal with complexity, there are three sets of beneficial recommendations to research, education and practitioners. In regards to education:

- Preparing and advancing students, education and training providers should be more flexible to accommodate more time for students to be engaged with the reality of profession each according to his or her interest. Especially given the fact that we have come to know that hands-on experience is as important as learning at classrooms. Bringing back longer training schemes are also well recommended.

- As for the bodies of knowledge, such as PMI PMBOK®, ABM BoK and ENAA P2M, highlighting the human skills or "soft skills" ought to be as clearly stressed as that of tools and techniques or "hard skills". For example, this must be illustrated at least at the PMI standard of *Project Manager Competency Development Framework*, which is specialised in such matters.

In relation to academia:

- A call for more empirical research into the area of exploring skills and competencies to conduct the views of professionals in the lower spectrums of the construction industry, since this study was chiefly concerned with the standpoint of senior level management.

- A look at small and medium-size organisations would be helpful to draw a meaningful picture about the industry, given that the majority of research has concentrated largely on major companies, which in fact represents only third of industry.

- This study has focused on exploring complexity in construction and the skills and competencies necessary on the project level. Perhaps, another study should be conducted on the organisational level for the reason that there are totally different aspects to deal with.

Given the fact that interviewing a number of project directors and senior managers has helped to produce valuable conclusions, the suggestions for practitioners or construction companies would include:

- Construction companies or contractors should consider the fact of improving staff competencies by developing their skills and expanding their knowledge through further on-the-job training or even short educational courses, although recently the turbulent economic situation has not been that helpful in undertaking such steps. However, it is widely believed to be beneficial for individuals as well as for organisations in the long run. Anne Lytle says *"Life-long learning is about adapting to a changing world. No matter how much education you have had, there is always the need for more education. Think of it as continuously updating knowledge and skills in a changing world"* (Pant and Baroudi, 2008: 126).

- It is known that tacit knowledge, such as good management skills which can rarely be taught, is not easy to convey to people. For this reason, project managers have to bear in mind that it usually comes with experience over a long period of time.

- A small-size project can be as complex as a large project. In other words, all projects are broadly simple unless managers unwittingly make them complex. Managers entirely agree that once projects are broken down to manageable tasks and the adequate resources are allocated, coupled with an experienced and qualified team then surely complex projects are no longer complex.

To conclude, Carbone and Gholston (2004: 16) contend that:

> *"To become a maestro takes more than learning to read notes. It takes a tremendous amount of training and discipline to coordinate the efforts of all the individuals who make beautiful music. We would not expect untrained ear to lead a symphony".*

In our case, we should not expect project managers to cope with the complexity of projects unless they have a combination of decent level of experience and a set of developed skills, soft skills and hard skills.

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Appendices:

Appendix A: The TOE Frameworks (Bosch-Rekveldt, M., et al., 2010).

Explanation	Elements defined	Source L/E/B1	ID	Sub-ordering	TOE
What is the number of strategic project goals?	Number of goals	L	TG1	Goals	T
Are the project goals aligned?	Goal alignment	B	TG2	Goals	T
Are the project goals clear amongst the project team?	Clarity of goals	B	TG3	Goals	T
What is the largeness of the scope, e.g. the number of official deliverables	Scope largeness	B	TS1	Scope	T
involved in the project?					
Are there uncertainties in the scope?	Uncertainties in scope	B	TS2	Scope	T
Are there strict quality requirements regarding the project deliverables?	Quality requirements	E	TS3	Scope	T
What is the number of tasks involved?	Number of tasks	B	TT1	Tasks	T
Does the project have a variety of tasks (e.g. different types of tasks)?	Variety of tasks	B	TT2	Tasks	T
What is the number and nature of dependencies between the tasks?	Dependencies between tasks	B	TT3	Tasks	T
Are there uncertainties in the technical methods to be applied?	Uncertainty in methods	B	TT4	Tasks	T
To what extent do technical processes in this project have interrelations	Interrelations between technical	B	TT5	Tasks	T
with existing processes?	Processes				
Are there conflicting design standards and country specific norms	Conflicting norms and standards	B	TT6	Tasks	T
involved in the project?					
Did the project make use of new technology, e.g. non-proven technology	Newness of technology (world-wide)	B	TE1	Experience	T
(technology which is new in the world, not only new to the company!)?					
Do the involved parties have experience with the technology involved?	Experience with technology	B	TE2	Experience	T
Do you consider the project being high risk (number, probability and/or	Technical risks	B	TR1	Risk	T
impact of) in terms of technical risks?					
What is the planned duration of the project?	Project duration	L	OS1	Size	O
Do you expect compatibility issues regarding project management	Compatibility of different project	B	OS2	Size	O
methodology or project management tools?	management methods and tools				
What is the estimated CAPEX of the project?	Size in CAPEX	B	OS3	Size	O
What is the (expected) amount of engineering hours in the project?	Size in Engineering hours	B	OS4	Size	O
How many persons are within the project team?	Size of project team	B	OS5	Size	O
What is the size of the site area in	Size of site area	E	OS6	Size	O

square meters?					
How many site locations are involved in the project, including contractor sites?	Number of locations	B	OS7	Size	O
Project drive Is there strong project drive (cost, quality, schedule)?	B		ORE1	Resources	O
Are the resources (materials, personnel) and skills required	Resource and skills availability	B	ORE2	Resources	O
in the project, available?					
Do you have experience with the parties involved in the project	Experience with parties involved	B	ORE3	Resources	O
(JV partner, contractor, supplier, etc.)?					
Are involved parties aware of health, safety, security and environment	HSSE awareness	E	ORE4	Resources	O
(HSSE) importance?					
Are there interfaces between different disciplines involved in the project	Interfaces between different disciplines	B	ORE5	Resources	O
(mechanical, electrical, chemical, civil, finance, legal, communication,					
accounting, etc.) that could lead to interface problems?					
How many financial resources does the project have	Number of financial resources	B	ORE6	Resources	O
(e.g. own investment, bank investment, JV-parties, subsidies, etc.)?					
Are there different main contract types involved?	Contract types	B	ORE7	Resources	O
What is the number of different nationalities involved in the project team?	Number of different nationalities	B	OP1	Project team	O
How many different languages were used in the project for	Number of different languages	B	OP2	Project team	O
work or work related communication?					
Do you cooperate with a JV partner in the project?	Cooperation JV partner	B	OP3	Project team	O
How many overlapping office hours does the project have because	Overlapping office hours	B	OP4	Project team	O
of different time zones involved?					
Do you trust the project team members (incl JV partner if applicable)	Trust in project team	B	OT1	Trust	O
Do you trust the contractor(s)?	Trust in contractor	B	OT2	Trust	O
Do you consider the project being high risk (number, probability a	Organizational risks	B	OR1	Risk	O
nd/or impact of) in terms of organizational risks?					
What is the number of stakeholders (all parties (internal and external) around	Number of stakeholders	B	ES1	Stakeholders	E
the table, pm=1, project team=1, NGOs, suppliers, contractors, governments)?					
Do different stakeholders have different perspectives?	Variety of stakeholders' perspectives	B	ES2	Stakeholders	E
What is the number and nature of dependencies on other stakeholders?	Dependencies on other stakeholders	B	ES3	Stakeholders	E
Does the political situation influence the project?	Political influence	B	ES4	Stakeholders	E

Is there internal support (management support) for the project?	Company internal support	B	ES5	Stakeholders	E
What is the required local content?	Required local content	B	ES6	Stakeholders	E
Do you expect interference with the current site or the current use of the	Interference with existing site	E	EL1	Location	E
(foreseen) project location?					
Do you expect unstable and/or extreme weather conditions; could they	Weather conditions	E	EL2	Location	E
potentially influence the project progress?					
How remote is the location?	Remoteness of location	E	EL3	Location	E
Do the involved parties have experience in that country?	Experience in the country	E	EL4	Location	E
Is there internal strategic pressure from the business?	Internal strategic pressure	E	EM1	Market conditions	E
Is the project environment stable (e.g. exchange rates, raw material pricing)?	Stability project environment	B	EM2	Market conditions	E
What is the level of competition (e.g. related to market conditions)?	Level of competition	B	EM3	Market conditions	E
Do you consider the project being high risk (number, probability	Risks from environment	B	ER1	Risk	E
and/or impact of) in terms of risk from the environment?					
1L = based on literature data, E = based on empirical data, B = based on both literature and empirical data.					

Appendix B: Skills and knowledge elements (adopted from Edum-Fotwe and McCaffer, 2000).

Edum-Fotwe and McCaffer listed a range of skills and knowledge into two elements; Primary and Secondary. This category, as the authors claimed, is according to the importance of the skills.

Type of skills	Primary Skills	Secondary Skills
Technical skills	• Planning & scheduling. • Construction management activities. • Basic technical knowledge in own field. • Productivity & cost control.	• Forecasting techniques. • Quality control. • Estimating & tendering. • Material procurement. • Reading & understanding drawings. • Design activities & background. • Site layout & mobilisation.
Managerial skills	• Leadership. • Delegation. • Negotiation. • Decision making. • Motivation & promotion. • Team working. • Time management. • Top management relations.	• Human behaviour. • Strategic planning.
Financial skills	• Establishing budgets. • Reporting systems.	• Project finance arrangement. • Establishing cash flows.
Legal skills	• Drafting contracts.	• Health & safety issues. • Industrial relations. • Preparation of claims & litigation.
Communication skills	• Presentation. • General & business correspondence. • Report writing.	• Public speaking.
IT skills		• Project management software. • Spreadsheet & CAD.
General skills	• Chairing meetings. • Understanding of organisation.	• Marketing & sales. • Public relations.

Appendix C: The Top 100 construction companies (The Construction Index, 2010).

2010 Rank by turnover	2010 Rank by profit	Company	Latest turnover (£m)	Previous turnover (£m)	Latest pre-tax profit (£m)	Previous pre-tax profit (£m)	Latest margin (%)	Previous margin (%)
1	1	Balfour Beatty	10,339	9,486	267	270	2.6	2.8
2	▲2	Carillion	5,427	5,206	148	116	2.7	2.2
3	▼9	Laing O'Rourke	3,070	3,603	50.0	81.2	1.6	2.3
4	▲10	Morgan Sindall	2,214	2,548	44.7	62.3	2.0	2.4
5	▼21	Kier	2,146	2,374	24.8	63.4	1.2	2.7
▲6	▲6	Interserve	1,907	1,800	89.2	79.9	4.7	4.4
▲7	▲3	Babcock	1,902	1,556	107	84.6	5.6	5.4
▲8	▲5	Mitie	1,720	1,522	91.7	78.4	5.3	5.2
▼9	▲8	Newarthill / Sir Robert McAlpine	1,631	1,817	60.9	33.0	3.7	1.8
▲10	▲13	Skanska	1,542	1,481	38.9	-31.5	2.5	-2.1
11	▲4	Amey UK	1,531	1,483	106	78.3	6.9	5.3
▼12	▼98	Galliford Try	1,461	1,832	-26.9	60.3	-1.8	3.3
▲13	▲48	Bovis Lend Lease	1,278	1,343	8.6	2.2	0.7	0.2
▼14	▼35	Vinci	1,163	1,018	15.4	16.2	1.3	1.6
▼15	▼25	BAM Construct	1,134	1,059	19.6	45.3	1.7	4.3
▲16	▼30	Costain	1,061	996	18.1	23.1	1.7	2.3
17	99	Enterprise	1,060	1,090	-30.6	-61.5	-2.9	-5.6
18	▼41	ISG	1,046	1,090	11.8	12.6	1.1	1.2
▼19	▼7	Keller	1,038	1,197	74.7	113	7.2	9.5
▲20	▼29	Willmott Dixon	999	839	18.2	20.0	1.8	2.4
▼21	▲14	Wates	945	1,019	38.9	47.1	4.1	4.6
▲22	▼18	Bowmer & Kirkland	874	895	28.8	43.2	3.3	4.8
▼23	100	Miller	783	1,047	-72.4	(170)	-9.2	-16.2
▲24	▲16	Eaga plc	739	639	37.7	28.4	5.1	4.4
▲25	▲26	Mace	726	654	19.3	14.9	2.7	2.3
▼26	▲31	Rok	715	1,011	17.0	5.9	2.4	0.6
▼27	▼36	Volker Wessels UK	701	585	15.3	1.2	2.2	0.2
▼28	▼90	Shepherd	701	718	-1.5	22.9	-0.2	3.2
▲29	▲19	Connaught	660	553	26.7	21.7	4.0	3.9
▼30	▼22	BAM Nuttall	644	650	24.1	28.2	3.7	4.3
▼31	▲12	Keepmoat	570	558	43.8	61.7	7.7	11.1
▼32	▼97	Homeserve	517	555	-21.7	71.8	-4.2	12.9
▲33	▲27	May Gurney	483	437	18.4	17.0	3.8	3.9
▼34	▼38	Morrison Utility Services	480	474	15.1	9.2	3.1	1.9
▲35	▲28	Mears	470	420	18.4	16.6	3.9	4.0
▼36	▲24	NG Bailey	464	600	19.9	-10.8	4.3	-1.8
37	▲15	Southern Electric Contracting	460	482	38.1	40.5	8.3	8.4
38	73	Ringway	450	465	2.0	-7.5	0.4	-1.6
▼39	20	J Murphy	408	445	24.9	34.7	6.1	7.8
▲40	▼58	Imtech	363	318	5.6	3.2	1.5	1.0
▼41	▲11	Severfield Rowen	349	394	44.1	42.5	12.6	10.8
▲42	▲40	J B Leadbitter	337	323	11.9	9.9	3.5	3.1
43	49	Colas	336	309	8.6	2.2	2.6	0.7
▲44	▲44	Byrne Group	326	317	11.0	9.5	3.4	3.0
45	37	Lagan	321	282	15.3	23.0	4.8	8.2
46	▼43	Emcor	321	357	11.2	10.8	3.5	3.0
▲47	▼34	Apollo	319	261	16.3	17.4	5.1	6.7

▼48	▼78	Renew Holdings	317	391	1.2	6.7	0.4	1.7
▲49	▲67	Geoffrey Osborne	311	333	2.8	2.5	0.9	0.8
▼50	▼32	Spice plc	311	280	16.7	25.4	5.4	9.1
▼51	▲64	Spie Matthew Hall	287	312	4.0	-3.0	1.4	-1.0
▼52	▼46	Morrison Facilities Services	267	323	9.0	13.1	3.4	4.1
▲53	▲69	John Graham (Dromore)	266	218	2.4	2.9	0.9	1.3
▲54	▲50	Seddon	256	249	8.1	1.3	3.2	0.5
55	33	Northstone NI	245	269	16.6	20.3	6.8	7.5
▲56	▼96	GSH Group	239	200	-14.6	10.3	-6.1	5.2
▼57	▲59	Barr Holdings	232	294	5.6	0.0	2.4	0.0
▲58	▲80	Higgins	225	218	1.0	0.6	0.4	0.3
▲59	▲45	William Hare	214	182	10.7	9.9	5.0	5.4
▼60	▲66	Canary Wharf Contractors	210	276	3.3	4.3	1.6	1.6
▼61	▲23	Bouygues	210	116	20.0	10.2	9.5	8.8
▼62	▼61	Malcolm Group	208	225	5.4	8.2	2.6	3.6
▼63	▼70	Ogilvie Group	206	258	2.4	5.7	1.2	2.2
▼64	▼93	Clancy	201	234	-3.0	3.2	-1.5	1.4
▲65	▼52	Rotary	200	212	7.5	10.1	3.8	4.8
▼66	▼60	RG Carter	199	279	5.5	9.5	2.8	3.4
▼67	▼94	Carey Group	198	213	-9.5	9.1	-4.8	4.3
▲68	▲65	Thomas Vale	196	214	3.6	3.2	1.8	1.5
▲69	▲82	GB Building Solutions	193	207	0.5	0.7	0.3	0.3
▲70	▲55	Bullock Construction	191	181	6.7	6.5	3.5	3.6
▲71	95	Brett Group	191	195	-14.3	-1.5	-7.5	-0.8
▲72	▲75	Patton Group	185	184	1.7	0.6	0.9	0.3
▲73	▲53	Integral UK	184	180	7.3	5.5	4.0	3.1
▼74	▲56	Lorne Stewart	183	224	6.3	6.1	3.4	2.7
▼75	▼39	United House	182	161	15.1	6.8	8.3	4.2
▲76	▼79	McNicholas Construction	182	168	1.1	4.2	0.6	2.5
77	71	Teighmore	180	40	2.4	0.6	1.3	1.5
78	72	City Building Glasgow	179	175	2.2	0.7	1.2	0.4
▲79	▲88	Durkan	179	103	-0.8	-1.1	-0.4	-0.8
▼80	▲51	Brookfield	178	197	8.1	-0.4	4.6	-0.2
▼81	▼54	T Clarke	177	220	6.8	13.4	3.8	6.1
82	86	SGN Contracting	174	178	0.2	2.8	0.1	1.6
▼83	▼74	Ardmore	173	300	2.0	5.3	1.2	1.8
▼84	▼42	PC Harrington	171	202	11.7	12.7	6.8	6.3
▼85	▼87	Midas	168	243	0.2	0.6	0.1	0.2
86	▲17	Mabey	162	153	33.0	18.0	20.4	11.8
▼87	▼57	Bechtel	161	301	5.7	119.0	3.5	39.5
▼88	▲76	Sisk	161	226	1.6	2.6	1.0	1.2
▲89	▼92	Robertson Group	158	165	-2.0	5.7	-1.3	3.5
▼90	▲68	RG Group	157	208	2.5	3.2	1.6	1.5
▼91	▼62	McLaughlin & Harvey	149	197	5.1	1.0	3.4	0.5
▼92	▼47	Rydon Group	148	176	8.7	15.2	5.9	8.6
93	▼89	Headcrown	147	162	-1.3	4.9	-0.9	3.0
▼94	▲63	Eric Wright Group	146	117	4.4	-1.6	3.0	-1.4
▼95	▲77	North Midland Construction	144	202	1.6	2.9	1.1	1.4

▼96	▼81	Daniel Contractors	142	181	1.0	3.4	0.7	1.9
▼97	▲91	Styles & Wood	139	243	-1.8	-0.9	-1.3	-0.4
▼98	▼83	Staveley Engineering Services	138	166	0.3	2.3	0.2	1.4
▼99	▼84	Simons Group	136	188	0.3	9.1	0.2	4.8
▼100	▼85	ESH Holdings	134	157	0.3	-6.4	0.2	-4.1

Appendix D: Interview Questions.

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The Main Research Questions: (Not to be answered by the interviewee).

- What are the skills, competencies and knowledge necessary to handle project complexity?
- How would the current training courses of project management prepare & advance professionals to deal with complexity?

The Interview Questions:

General information:

Name (optional):		Company:		
Age and Sex	Qualification (Q.)	Current position	Years of Experience	Years of Experience accumulated to becoming a PM
30-40:	B.Sc./B.Arch.			
41-50:	M.Sc./M.Arch.			
51-63:	Diploma (Technical)			
Male: Female:	No formal Q.			

1st Category: General matters:

Q1) How would you define complexity in construction?
A)
Q2) How do you measure complexity in a robust manner?
A)
Q3) What causes complexity to increase in the construction industry? Is it a true? Why now?
A)

2nd Category: Skills and Competencies:

In my study, I have adopted a framework proposed recently by Bosch-Rekveldt and others (2010) which represents elements contribute to complexity in construction projects. These contributors were categorised in 3 main groups:
- **Technical contributors**: such as experience, goal, scope, tasks & risk.
- **Organisational contributors**: for instance size, resources, project team, trust & risk.
- **Environmental contributors**: for example stakeholders, location, market condition & risk.

Q4) First of all, would you agree upon such a framework? If not why not? Add more contributors when possible and is it possible to control what you have added?
A)
Q5) What are the appropriate skills & competencies necessary to be used in handling the technical contributors of complexity?
A)

Q6) What are the appropriate skills & competencies necessary to be used in managing the organisational contributors of complexity?
A)
Q7) What are the appropriate skills & competencies necessary to be used in dealing with the environmental contributors of complexity?
A)
Q8) What are the differences, if there are any, between competencies to deal with usual projects & complex projects?
A)
In my research, I am focusing on competency on the personal level. It is known that competency is attained by the combination of knowledge acquired during training, and skills developed through experience. My question to you is
Q9) How better can we be equipped for acting in response to the increase of project complexities in terms of competency?
A)
Q10) From your experience, what are the skills that you consider as essential to managers?
A)

3rd Category: Leadership:

Q11) What distinctive qualities distinguish the good project managers who appear to be able to handle complexity?
A)
Q12) Are these qualities imitable?
A)

4th Category: Project Management Education and Training Courses:

Q13) Resent research has revealed that the level and outcomes of the education and training courses are not as good as they should be. Do you agree on this?
A)
Q14) What suggestions can you offer to improve the preparation of students?
A)
Q15) What suggestions can you recommend to advance the training of professionals?
A)

5th Category: Tools and Techniques:

Q16) The increase in complexity is often one the major concerns in the construction industry. Do you think that such scenario requires complex **tools and techniques**[1]? Bearing in mind that some argue that thinking about "soft skills" such as common sense, ability to deal with people and a positive flexible attitude which may make the difference?
A)
Final Q17) Can you give some examples of complex and major projects that you were involved in and what were the main skills that were necessary to control the projects?
A)

1. **Gantt chart:** Bar chart shows relation between tasks & times.
   PERT chart: The programme Evaluation and Review Techniques.
   CPM: Critical Bath Method.
   WBS: Working Breakdown Structure.

Appendix E: The invitation sample.

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An Invitation

To
Take part in a research project
To
Whom It May Concern

Title of Project: **Addressing complexity in the construction industry: A learning approach.**

Investigator Details: Naif Alghamdi
Programme of Study: M.Sc. in Project and Enterprise Management,
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Dear Sir or Madam,

I would like to invite you to participate in a research which investigates the competencies of project managers to manage complex projects. The research is focused on major UK contractors.

One of the reasons for the high failure rates in construction projects are its complexity or an underestimation of it. Surprisingly though, very little research has been conducted on how to cope with complexity. I am interested in exploring particular skills, competencies and knowledge that project managers need in order to deal with complexity and that is by addressing the following questions:

- *What are the skills and competencies necessary to handle project complexity?*
- *What are the skills and competencies necessary to handle the increasing of project complexity?*

Your organisation has been chosen due to a number of reasons. It has been recognised as one of the top 100 construction companies in the UK. Your reputation for having done a number of major construction projects successfully is another reason. Therefore, such a large and successful organisation would tend to attract competent project managers and hence project manager competence is likely to influence project success. That is why I am looking forward to arranging an interview with one of your senior project managers. With the mindset that the interview will only last 30 minutes, you will probably only be asked 4-8 questions after small talk. I would be delighted if we could arrange it within the next 10 days, due to time limitation for submitting the thesis.

If you are happy to take part in my study, then please do contact me immediately by phone or email mentioned above.

I will provide all participants with an executive summary of the research, showing key findings across large major contractors in the UK.

Thank you very much for your help and look forward to hearing from you very soon.

Yours sincerely,

Naif Alghamdi

Friday, July, 08, 2011

CD:

The CD–ROM includes a (PDF) and (DOC) documents of the thesis.