Innovation Management: A Web-Based Innovation Assessment Tool for Construction Organisations

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ABSTRACT

It is generally recognised that, compared to other industry sectors, the construction industry is slow in its adoption of technological innovations and new ways of working. This has often been attributed to the conservative nature of the industry, which is arguably due to the fact that, unlike other industry sectors such as the manufacturing, automotive and pharmaceutical industries, the industry has a very weak culture of innovation and research (IR). This problem may well be explained by the industry's lack of recognition and understanding of a number of key determinants of innovation in the industry, such as leadership, management, people, processes, IR investment and technology.

The Latham and Egan Reports call for improvements in the construction project delivery process to improve efficiency, productivity and ensure value for money for the construction industry's clients. The 'Accelerating Change' report calls for improvements to be more rapid and sustainable. These improved business processes cannot be achieved and sustained unless there is an established culture of innovation within the industry.

The research findings indicate that construction companies are not able to deliver on their potential to innovate. Against this background, an innovation assessment model and a prototype application for construction organisations were developed to provide a rapid, online assessment of innovative practices and competencies in construction companies. The objective of the tool is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and to allow construction

companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

The main benefits of the tool are it complements the existing innovation management frameworks and promotes wider uptake of the concept in the construction industry as whole. Industry evaluators have welcomed the concept of an innovation assessment tool and acknowledged the need for the tool in the construction industry.

Hence, this thesis presents the development and evaluation of a web-based prototype application.

KEYWORDS

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CHAPTER 1: INTRODUCTION

1.1 Introduction

The construction industry has been characterised as slow to adopt technological innovation, which has been said contribute to low productivity and poor performance. This has often been attributed to the conservative nature of the industry, which in turn is attributed to a number of features that set it apart from other industries like automotive and pharmaceutical industries, which appear to have stronger, more visible innovation cultures. The UK's construction output is the second largest in the EU and contributes 8.2% of the nation's Gross Value Added (GVA) and employs up to 2.1 million people in a multitude of roles (DTI, 2007). However, the construction industry is perceived as old-fashioned and conservative (Fairclough, 2002). Certain sectors of industry have traditionally invested in Research and Development (R&D) as a means to support innovation and therefore growth - sectors such as automotive and pharmaceutical have strong innovation cultures (Dikmen, 2003). Other sectors, notably including construction, have weak innovation cultures and are accused of being conservative and non-innovative (Larsson, 2003), with a passive approach to research investment.

In his review of the state of Rethinking Construction Innovation and Research, Fairclough (2002) highlighted many issues, which UK construction would have to address in order to deliver on its potential to contribute to the wider economy. *'It is widely recognised that the construction industry must improve its performance and this represents a significant challenge to the entire construction community, its processes and technologies'* (DTI, 2004. page 16).

Construction is a project-based industry and projects are generally carried out by multiple parties, where each party is a separate organisational entity that possesses its own interests and expected end rewards from the project (Dulaimi, et al, 2003). This has created a range of problems and the industry has become highly inefficient compared to others (Winch, 2003).

This research reports an extensive study on innovation in construction and its management. *'Evidence shows that businesses that have the awareness to continually create, evaluate and successfully exploit their new ideas are more likely to survive and prosper in the competitive global economy'* (DTI, 2007). To achieve this, an innovation assessment model and a prototype application for construction organisations, have been developed to provide a rapid online assessment of innovative practices and competencies in construction companies. The objective of the tool is to allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

This chapter describes the research background, defines innovation in the context of this research, discusses innovation policies within the government and the scope of the research in the context of the construction industry.

1.2 Brief Background to the Research

The UK construction industry is a vital part of UK's economy, but it has inherent problems due to its structure and fragmentation. There is widespread agreement that the fragmented nature of the industry is not conducive to efficiency (DTI, 1999; Strategic Forum for Construction, 2002; Sorrell, 2003; Be and CIRIA, 2003). The construction

industry is slow in the adoption of technological innovations and new ways of working

(Winch, 2002). Construction's poor performance has been challenged by its client base

and it has been forced to seek ways to deliver improved performance (Beatham, 2003).

The Latham (1994) and Egan (1998) reports called for improvements in the

construction project delivery process to improve efficiency, productivity and ensure

value for money for the construction industry's clients. They conclude that radical

changes are required to deliver real improvements through the industry (Lenard and

Abbott, 1998). Through these reports the then Construction Task Force set up the

Construction Best Practice Programme (CBPP) and the Movement for Innovation M^{4}I)

to address the issues raised in these reports.

Egan (1998) outlined five key drivers for change, four key integrated project processes

and proposes seven targets for improvement. These have become known as the '5-4-7'

mantra of Rethinking Construction and are shown in Figure 1.1.

Five Key Drivers for Change	Four Project Process Improvements		Seven Targets for Improvement
Committed leadership	Product development	Partnering the supply chain	Capital cost
Focus on the customer			Construction time
			Predictability
Product Team Integration			Defects
Quality driven agenda	Project implementation	Production of components	Accidents
			Productivity
Commitment to people			Turnover & Profits

Figure 1.1 The '5-4-7' diagram to improve construction (based on Egan, 1998, p13)

The changing nature of work, increasing competition and the power of information technology have driven companies to search for ways of monitoring and improving performance (Neely, 1999). Whilst various UK government initiatives (such as those described in section 1.4) have produced several notable developments, questions have been asked in recent years about how construction's performance can be further improved. Against this background, the sponsoring organisation, Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University instigated and supported this research on innovation management in the construction industry, to develop an innovation assessment model and a prototype application for construction organisations, to provide a rapid online assessment of innovative practices and competencies in construction companies. This is further described in detail in section 1.6.

1.3   Definition of Innovation

The Collins English dictionary definition of the word "*innovation*" is a new thing or a new method of doing something (Collins Cobuild English Dictionary, 1995). There is no generally accepted definition of innovation at the present time. However, there has

been a noticeable convergence as to its principal characteristics. In the context of this

thesis, this point can be illustrated by a sample of general definitions.

- *'Innovation consists of all those scientific, technical, commercial and financial*

  steps necessary for successful development and marketing of new or improved

  manufactured products, the commercial use of new or improved processes or

  equipment or the introduction of a new approach to a social service. R&D is

  only one of these steps' (OECD 198. page 15-16).

- *'Innovation is the successful exploitation of new ideas. Ideas may be entirely*

  new to the market or involve the application of existing ideas that are new to

  innovation organisation or often a combination of both. Innovation involves the

  creation of new designs, concepts and ways of doing things, their commercial

  exploitation, and subsequent diffusion through the rest of the economy and

  society' (DTI, 2003, page 19).

- *Innovation is a core process concerned with renewing what the organisation*

  offers (its product and /or services) and the ways in which it generates and

  delivers these (Tidd, Bessant & Pavitt 2003, page 14 1997).

Construction industry sources indicate there exist a variety of definitions for innovation:

- *'The successful exploitation of new ideas, where ideas are new to a particular*

  enterprise, and are more than just technology related - new ideas can relate to

  process, market or management' (CRISP, 1997).

- *'Innovation is successful exploitation of new ideas leading to profitable change'*

  (Fairclough, 2002, page 19).

- *'Innovation is considered to be the generation of a new idea or transfer of an*

  already existing idea followed by effective implementation' (Glass, 2002 p, 8).

These definitions may display specific biases of different sources, studies and organisations, but they appear to have a number of common features: new ideas, performance, and competitiveness. Indeed, Seaden et al (2001) believe that innovation tends to be viewed as "a process that enhances the competitive position of a firm through the implementation of a broad spectrum of new ideas" (Seaden and Manseau, 2001, page186). Innovation is considered to be the generation of new ideas and its implementation, where ideas can relate to product, process or services. Seaden's definition of innovation is therefore adopted in this thesis as this best captures most features of innovation as described previously.

1.4 Innovation policies within UK Government

The innovation challenge has been a clear theme in policy making since 1997. In that time the government has published many White Papers, including: *'Our Competitive Future - Building a Knowledge Driven Economy'* (DTI, 1998) and *'Competing in the global economy: the innovation challenge – Innovation Report'* (DTI, 2003). For example, in the latter report, Prime Minister Tony Blair stated:

> *'Innovation, the exploitation of new ideas, is absolutely essential to safeguard and deliver high-quality jobs, successful businesses, better products and services for our consumers, and new, more environmentally friendly processes.' (DTI, 2003)*

These policies have already produced results, for example, the significant cultural change in the relationship between the universities and business – government is investing in the UK science base and interventions that support and encourage innovative companies to invest in R&D and collaborate with academia to turn ideas into profit (DTI, 2007).

The UK government is therefore keen to see improvements in UK productivity in the face of worldwide competition and the Department of Trade and Industry (DTI), in particular, is prepared to support 'innovation' through a combination of fiscal measures and direct investment in Science and Technology through the research councils (HM Treasury, 2004). Through the Latham (1994) and Egan (1998) reports, UK government has supported major reviews of the way in which the UK construction industry performs, and some ambitious targets were set for performance improvement. Through a number of initiatives the government has also attempted to increase the profile of innovation and research (IR) through research councils (e.g. EPSRC, ESRC, CICE) and a research programme funded by the construction directorate of the DTI (2007). In addition, the government is providing leadership in driving a construction research and development agenda.

1.5 Aims and Objectives

1.5.1 Project aim

This research project aimed to develop an innovation assessment model and a prototype application for construction organisations to provide a rapid, online assessment of innovative practices and competencies in construction companies.

1.5.2 Objectives

In order to achieve the research aim, four key objectives were identified. The four specific objectives of the project include, to:

- investigate the drivers and barriers to the development of a culture of innovation;

- review theoretical and industrial models of innovation in the construction industry; and develop an innovation model for use in the construction industry

- explore methods for assessing innovation capabilities and develop a prototype application for construction organisations; and,

- Evaluate the usability of the innovation assessment tool such that it can be adopted easily into construction organisations.

1.6 Justification and Research Scope

The construction industry has been described as slow in the adoption of technological innovation and new ways of working and it is commonly characterised as a 'backward industry' and in particular, one that fails to innovate in comparison to other sectors (Winch, 2003). There are many reasons pushing firms to innovate (whether or not they are in construction), most of which are known and understood, e.g. to improve competitiveness. Most stakeholders expect innovation to offer benefits in one or more of following areas; capital and operational expenditure, quality, performance, market share, competitiveness, customer service and value etc. (Barrett and Sexton, 1998; Glass, 2002). Tatum (1991) points out that construction firms need to innovate to win projects and to improve the financial results of these projects. Westbury (2004) argued that innovation is best facilitated through a blend of methodologies, work practices, a supportive culture, the right business infrastructure and also business environment. The construction industry needs to innovate more frequently to boost its competitiveness so it can meet the ever increasing client demands of both national and international marketplaces (Larsson, 2003).

This research study focused primarily on exploring methods for assessing innovation capabilities by reviewing theoretical and industrial models of innovation in the construction industry; developing an innovation assessment model and prototype

application for use in the construction industry and evaluate the usability of the model and prototype application.

In his critical review of innovation in UK construction, Fairclough (2002) critically suggested that it is important that a better mechanism be developed for defining the industry's long term research needs. The lack of IR can be explained by the lack of recognition of a number of key determinants of innovation in construction industry, such as; investment, strategic vision, mechanisms for change and research base structure. (Fairclough, 2002).

Taking this in to account, an innovation assessment and prototype application have been developed as part of this research to help construction companies assess and develop their innovation capabilities. The tool is built around the assumption that a company will be better able to manage innovation if it measures and improves itself against leadership, management, people, processes, IR investment and technology, hence the tool is structured around these headings. Lloyd et al (2002) argued that an automated and web-based monitoring system can remove geographic barriers and reduce time in transferring data, in addition, it enables exchange of massive volumes of information at high speed and a relatively low cost (Deng et al, 2001), an automated and web-based innovation assessment tool is proposed to bring together the six aspects/ criteria cited (shown in Figure 6.3) and translate these into an effective tool to assess innovation end-users both SMEs and large construction companies. Such a tool will also help to organise company performance data and can be easily retrieved via intranet/internet and database technology.

1.7 Research Methodology

A research methodology describes the principles and procedures of logical thought processes applied to scientific investigation (Fellows and Liu, 1999). There is no unique or best research method (Yin, 1994); the use of each research method is based on the form of research question, the objective and contextual situation.

The research road map has been included Table 3.5 in Chapter Three; it maps research objectives and associated tasks along with adopted research methods and outputs.

1.8 Research Achievements

The project focused on the development of an innovation assessment model and prototype application to facilitate a rapid online assessment of innovative practices and competencies in construction organisations to improve performance. The main achievements of this research include the following:

a) A review of construction innovation and innovation management literature and analysis of gaps in knowledge of the subject area has been undertaken.

b) A review of assessment models and tools to check their appropriateness for the construction industry

c) An innovation assessment model has been developed for assessing innovative practices and competency for construction organisations

d) The development and evaluation of the innovation assessment tool for construction

e) Implementation of the tool to provide a rapid online assessment of innovative practices and competencies in construction organisations.

1.9 Structure of Thesis

This thesis is organised into six main chapters, which are structured as follows.

Chapter 1 introduces the research project, provides an introduction to the general subject domain and identifies the aim and objectives. It justifies the need for the research and sets it within an industrial context.

Chapter 2 discusses the literature and related work on innovation and establishes some potentially critical success factors for improving innovation within the construction industry. It also reviews the subject of innovation management and presents a number of assessment tools that have been used to measure organisational and project performance. In addition, it highlights how this research builds on the previous work by demonstrating innovation in the application of knowledge with the context of the construction industry.

Chapter 3 describes the development of the innovation assessment model, it discusses the development of innovation assessment model for construction organisations.

Chapter 4 briefly explores the different types of methods available and describes the portfolio of methodologies used in the project. It highlights their weakness and strengths, and explains those adopted for this research. The chapter discusses the main methodological approaches that were used to achieve the research aim and objectives. It provides a research map of the overall research process and justifies the reasons for their selection as appropriate.

Chapter 5 describes the development of the prototype application, including the evaluation results of the prototype application, details the impact and implications of the research in the construction industry. It discusses the development and implementation of the prototype application; a web based innovation assessment tool for construction organisations.

Chapter 6 discusses the key findings of the research it contains the major conclusions to have arisen as a result of this study. It also makes a number of recommendations for the construction industry and for further research. The key limitations to the study are reiterated. Further to the chapters, a number of appendices are included:

Appendices A contain five papers that were published in support of this research study.

Appendices B – G includes other supporting information such as the survey and interview questionnaires, assessment model and prototype tool evaluation questionnaires, internal articles and award.

1.10 Summary

This chapter has presented an introduction to the subject domain and justified the need for the research and explained the context of the study. Next chapter highlights how this research builds on previous work and demonstrates innovation in the application of knowledge with the context of the construction industry.

CHAPTER 2: REVIEW OF CONSTRUCTION INNOVATION

2.1 Introduction

This chapter sets the background to the research undertaken in the context of the subject domain. It summarises the findings of extensive literature review so as to provide a sound theoretical framework for the research. This section therefore examines the general concept of innovation, its management, needs, barriers/drivers, assessment models/tools and the nature of innovation in the construction industry. It then illustrates how the project aim and objectives for this research were derived.

2.2 Innovation in Construction

In any society, the economic contribution of the construction industry is unparallel to any other industries. The construction industry is vital for providing a built environment which is one of the most important in economy (Pearce, 2003). In the UK, like other countries, the creation of the built environment and its associated infrastructure underpin the continuous economic growth of the country. Thus, it is plausible that the higher the levels of innovation in the construction industry, the greater the likelihood that it will increase its contribution to UK economic growth. Unfortunately, it is not perceived as innovative and there have been calls for improvement (e.g. Fairclough et al., 2002; Winch, 2002; Latham, 1994; Egan 1998).

Fairclough (2002) in his review, 'Rethinking Construction Innovation and Research', identified such problems as poor rates of investment in IR, fragmented supply chains, and a lack of coordination between academia and industry in research activities as being

the core of the problem. Fairclough (2002) further highlighted several issues, which the UK construction industry would have to address in order to deliver on its potential to contribute to the wider economy. Other industries, such as aerospace, automotive and pharmaceutical have been described as being generally more innovative than the construction industry (Sturges et al., 1999; Dikmen, 2003, Winch, 2003).

Bowley (1960; 1966) found several barriers that tend to hinder the progress of innovation in construction, which include form of contract, cost of carrying out research, lack of information on cost savings arising from the innovation and restrictions imposed by regulations. Gann (2000) identified other impediments to construction innovation: contractors and consultants are isolated from one another; contractors are often of a small size and fragmented. Most research on the factors necessary for successful innovation appears to have been undertaken by observing examples of innovation in construction projects and within firms (Stewart and Tatum, 1988; Tatum and Funke, 1988; Tatum et al., 1989; Nam et al., 1991).

It is increasingly accepted that construction innovation encompasses a wide range of participants within a product system (Marceau et al, 1999). This broad view incorporates many of the participants shown in Figure 2.1. Figure 2.1 shows a representation of the breadth of participants in the construction industry, and of the need for active networking between them. The main players in the construction innovation systems and research are government funders such as DTI (sponsorship), ODPM (regulators), EPSRC (long-term academic research), independent organisations (IRO's), universities, private firms, clients and users.

Regulatory Framework		
Activities: technical, economic, environmental and social regulation **Actors:** government, firms, industry associations		

Supply Network	Project-based Firms	Projects
Activities: materials, components, equipment manufacture **Actors:** process, mass- and-batch production manufacturing firms	**Activities:** design, engineering, integration, assembly/construction **Actors:** consultant designers/ engineers, project managers, constructors, specialist contractors	**Activities:** Commissioning and using constructed projects **Actors:** clients/owners/users

Technical Support Infrastructure	
Activities: long-term technical development and support	**Actors:** government, education and R&D institutes, industry association

Figure 2.1: Construction systems – activities and actors (Gann and Salter, 2000).

Miozzo and Dewick (2004) also suggest that networks can benefits from inter-organisational cooperation in a fragmented industry such as the construction industry. Their research findings suggest that the strength of inter-organisational cooperation may be responsible for enhanced performance of the construction industry in some of the European countries. This includes:

- The relationship between contractors and subcontractors or suppliers of materials,

- Government, universities, architects or engineers, clients and international collaborations with other contractors.

2.3 Innovation Needs for Construction

The construction industry has been described as slow in the adoption of technological innovation and new ways of working and it is commonly characterised as a 'backward industry' and in particular, one that fails to innovate in comparison to other sectors (Winch, 2003). There are many reasons for construction firms to innovate, most of which are known and understood, among others is the need to improve competitiveness. Most stakeholders expect innovation to offer benefits in one or more of the following areas (Barrett and Sexton, 1998; Glass, 2002);

- Capital and operational expenditure,

- Quality,

- Performance,

- Market share,

- Competitiveness,

- Customer service

- Value

According to Egbu (2004), *'Innovation is seen as a major source to improve competitiveness and is perceived to be a pre-requisite for organisational success and survival'*. It is widely accepted in policy, business and academia that innovation is the main source of economic improvement for industries (OECD, 2000; DTI, 2003, Tidd et al, 2001; Seaden et al, 2001; Jones and Saad, 2003,; Egbu, 2004; Fairclough, 2002). Indeed, experience in OECD countries shows clearly that innovation has a positive impact on profitability at the firm level (Guellec and Pattinson, 2001). Tatum (1991) points out that construction companies need to innovate to win projects and to improve the financial results of these projects.

The construction industry needs to innovate more frequently to boost its competitiveness

so it can meet the ever-increasing client demands of both national and international

marketplaces (Larsson, 2003). However, there are many barriers and limitations to

construction innovations (Dulaimi, et al, 2005) such as managing innovation.

2.4 Innovation Management

According to Tidd et al (2001) innovation management is a learning process towards

effective routines to deal with the challenges of the innovation process. Managing

innovation is complicated, it rarely proceeds in a straight line and it must be organised

(Barker, 2002). Jones et al (2003) argued that the implementation of innovation

management must be linked to the organisation's background and culture in order to

ensure compatibility and success. Over the past five decades several studies of

innovation processes have been carried out (Rothwell, 1992; Langrish, 1972;

Georghiou, 1986; Isenson, 1968; Carter and Williams, 1957; Cooper, 1999; Maidique

and Zirger, 1985; Lilien and Yoon, 1989; Utterback, 1994; Wheelright and Clark,

1992). Table 3.1 presents a chronology of such studies and attempts to focus on how

innovation is managed within one firm.

Table 2.1 An overview of studies on innovation management, based on literature.

Author	Study name	Key focus
Cooper, 1999	Project NEWPROD	Long-running survey of success and failure in product development
Utterback, 1994	MIT studies	Five major industry-level case
Rothwell, 1992	Project SAPPHO	Success and failure in matched pairs of firms, mainly in chemicals and scientific instruments
Wheelwright and Clarke, 1992	Sources of innovation	Case studies examining different levels of user involvement

Lilien and Yoon, 1989	Innovation success and failure	Literature review of major studies of innovation success/failure
Georghiou, 1986	Post-innovation performance	Looked at these cases 10 years later to see how they had fared
Maidique and Zirger, 1985	Stanford Innovation Project	Case studies of innovations emphasis on learning
Langrish, 1972	Wealth from knowledge	Case studies of successful firms. All were winners of the Queen's Award for Innovation
Isenson, 1968	Project Hindsight TRACES	Main aims were to identify sources of successful innovation and management factors influencing success
Carter and Williams, 1957	Industry and technical progress	Survey of UK firms to identify why some were apparently more innovative than others in the same sector, size range etc. derived a list of managerial factors which comprised technical progressiveness

The studies outlined in Table 2.1 tended to focus on how innovation is managed within one firm, whereas Dulaimi et al. (2002) proposed a theoretical framework of how to manage the implementation of innovation in a project organisation comprised of many players (in their case, based on a typical construction project). In their framework, Dulaimi et al. (2002) proposed several factors that need to be controlled when players are attempting to initiate, implement or support an innovation to ensure that it is properly managed. By considering a number of parties concurrently, it is thus consistent with Gann's recommendation (2000) that for an innovation to be successful, it would be necessary for firms to work together, erode boundaries between professions and for project-based firms to embrace new roles and develop new capabilities (Gann, 2000). In a later study, Dulaimi et al (2003) found some evidence that high-expected goals and

favourable innovation results lead to increased commitment and hence higher organisational motivation. They found that for innovation to be successfully implemented, a champion is needed to lead a task force or working group at the initiation and implementation (Dulaimi et al, 2003).

Trott (2002) also presented an innovation management framework that helps to illustrate innovation as a management process. This framework describes the main factors (such as R&D, Marketing, and Organisation and business strategy), which need to be considered if innovation is to be successfully managed. Dikmen (2003) proposed an innovation management model with four fundamental components- environmental, strategies, organisation and targets. These components cover the external drivers/barriers that effect innovation process, strategies used by the company to increase innovative capability, the organisational characteristics that support/hinder innovation within the organisation, and the major reasons why the organisations innovate.

2.5 Innovation Barriers/Drivers in Construction

In accordance with the problem definition set out in section 1.6, the aim of this research was to develop an innovation assessment model and a prototype application for construction organisations to provide a rapid online assessment of innovative practices and competencies in construction companies, this involves investigating the drivers and barriers to the development of a culture of innovation in construction sector. Innovation barriers and drivers in construction specifically include organisational culture, human and management factors, low investment in R&D, client, manufacturers, conservatism and innovation broakers (Blayles and Manley, 2004). The Blayles and Manley study highlights a range of factors that either push or impede innovation and its progress in

the construction industry. This study provides then a useful framework within which such issues can be examined, so these aspects are elaborated upon in the following sub-sections.

2.5.1 Cultural Factors

Culture is as complex as innovation, and means the personality and behaviour of an organisation. *'It can help to bind people together through a sense of belonging and a sense of common purpose and can also generate an environment conducive to competitiveness through joint learning and innovation'* (Jones and Saad, 2003). Organisational culture can be seen as unity of the characteristics of the organisation together with the norms, values and traditions (Dikmen et al., 2003), whereas innovative behaviour and creative thinking have different components (Tatum, 1987; Egbu, 1999; Girmscheid and Hartmann, 2001). Table 3.2 presents the diversity inherent in various definitions of culture.

Table 2.2 Diverse definitions of culture (Source: Bodely, 1994)

Topical:	Culture consists of everything on a list of topics, or categories, such as social organization, religion, or economy
Historical:	Culture is social heritage, or tradition, that is passed on to future generations
Behavioural:	Culture is shared, learned human behaviour, a way of life
Normative:	Culture is ideals, values, or rules for living
Functional:	Culture is the way humans solve problems of adapting to the environment or living together
Mental:	Culture is a complex of ideas, or learned habits, that inhibit impulses and distinguish people from animals
Structural:	Culture consists of patterned and interrelated ideas, symbols, or behaviours
Symbolic:	Culture is based on arbitrarily assigned meanings that are shared by a society

The existence of a particular culture in construction is cited by several sources (Banwell, 1964; Latham, 1994; Egan et al, 1998) as a major factor in many of the ills faced by the industry (Ankrah and Proverbs, 2004). There is distrust between clients, consultants, contractors, subcontractors and suppliers leading to conflicts of interest and to relationships that are predominantly short term (Luiten et al., 2000). Therefore, understanding that this results in a particular 'construction culture' is likely to be a significant step towards identifying why management of innovation in construction can pose problems. There is of course the view that this culture produces constructive conflict and it would be neither easy nor desirable for it to be managed in practice.

Egbu et al. (1999) examined the management of innovation in construction by surveying a number of companies, which had been identified as 'innovative'. They highlighted certain characteristics shown by all innovative organisations. These are:

- people are open-minded;
- willing to accept change;,
- flexible in lines of communication;
- structure that allows both top-down and bottom-up communication; and,
- risk-tolerant climate where it is accepted that lessons can be learned through mistakes.

Other characteristics or conditions favourable to innovation include:

1. a 'knowledge-friendly culture' where people are not inhibited about sharing knowledge and do not fear that sharing knowledge will cost them 'power and influence' or even their jobs;

2. a climate where people genuinely feel valued and where people feel some sort of 'ownership' or involvement with the innovation; and,

3. a climate where people feel some job security.

Clearly many of these characteristics would be difficult to engender in an industry based on adversarial and entrenched relationships. It may appear that the frequency with which culture is mentioned and in some cases blamed for the ills of the industry has become something of a cliché, but the fact that it continues to be mentioned should be respected. What is missing is a systematic and thorough interpretation of the various elements of culture that could be manipulated to improve the effectiveness of innovation.

2.5.2   Human Factors

The UK construction industry has long experienced difficulties in meeting its skill requirements. *'Factors contributing to the current situation include the competition for workers from more attractive competitor from other industries and insufficient numbers of people coming into the industry'* (Jones and Saad, 2003). Given the right atmosphere or culture, *'innovation will not readily take place without the right people being drawn to it'* (Sturges et al., 1999). The greatest challenge facing the construction industry today is the shortage of skilled labour. Studies reveal a number of factors, which have combined to influence the construction skills shortage (e.g. Dainty, 2004). These include:

- the demographic downturn and resulting reduction in the number of entering the labour market (Druker et al, 1996);

- the poor image of the industry, which adversely affects its popularity as a career choice (Dainty, 2000; Fairclough, 2002);

- the high number of jobs shed during the recession of the early 1990s (Churchill, 1997);

- the introduction of technologies, which have reconstituted the skills required (Agapiou et al., 1995);

- failure to develop multi-skilling as a route to overcome skills shortages (Scott et al., 1997);

- the growth in self-employment and the use of labour-only sub-contractors, which have reduced the commitment and investment in training within the industry (Harvey, 2001); and,

- that people in the construction industry were though to be poorly trained and not given appropriate knowledge and expertise on innovative ideas (Glass, 2002).

All the above factors have led to the skill shortage for the industry (Dainty, 2004). This is not a new phenomenon within the construction industry and has been a recurrent problem in the UK over the past three decades (Department for Education and Employment, 2000).

2.5.3 Management Factors

Management attitude is crucial to technological innovation and can play a part in achieving successful construction innovations and creating competitive advantage (Pries and Janzsen, 1995). A survey of construction industry professionals carried out by Buro Happold and Building Design Magazine established that 88% of the respondents believed that innovation was not managed effectively (Cripps, 2002). Innovation is

extremely complex and involves the effective management of a variety of different activities. To do so, management must believe in innovative practices and need to take key strategic measures aid its adoption. Pries and Janzsen (1995) have emphasised the crucial role of innovation management in achieving successful construction innovation and creating competitive advantage.

2.5.4 Low Investment in R&D

In the UK, R&D in construction has a relatively low profile compared to other industry like aerospace, automotive and pharmaceutical industries. The amount of investment funding available for construction research has been steadily declining in recent years and is estimated less than 0.45% of the construction sector's spending. By comparison aerospace invests 11%, automotive over 9% and pharmaceutical up to 13% of their revenues on research (ICE, 2003). A lack of continuing investment in R&D in the construction industry may be preventing innovation starting and continuing (Glass, 2002). There are many reasons to explain the low level of R&D investment in construction, they include: in accurate or invalid reporting of R&D expenses, small sizes of professional service firms, lack of risk capital, conservative behaviour of clients, unsuitable government policies and many more factors (Seaden and Manseau, 2001).

2.5.5 Clients

Clients are a key factor in terms of driving innovation (Cripps, 2003). It is the client who chooses the process and procurement requirements, which to a great extent decide the boundaries for the rest of the industry (Widen, 2003). Clients are commonly considered to exert enormous influence on firms and individuals involved in

construction, in a way that fosters or hinders innovation (Seaden and Manseau 2001; Barlow, 2000; Gann and Salter, 2000; Nam and Tatum 1997; Dulaimi et al, 2001). Clients are able to enhance innovation in a number of ways. They can identify specific, novel requirements to be supplied by developers, building product suppliers, contractors and operators (Seaden and Manseau, 2001). The more demanding and experienced the client the more likely it is to stimulate innovation in projects it commissions (Barlow, 2000).

2.5.6 Manufacturing Companies

Manufacturing companies are key sources for construction innovation, because they often provide innovative components and building products that are incorporated into buildings (Anderson and Manseau, 1999). The innovations developed by manufacturers are adopted by construction clients, contractors and consultants improving the performance of the industry (Anderson and Manseau, 1999). According to Blayse and Manley (2004) manufacturing companies tend to operate in more stable and more standardised markets than do consultants or contractors in that matter, allowing them to maintain R&D programmes.

2.5.7 Conservatism

The conservative nature of the industry is attributed to many features that set it apart from other industries like pharmaceutical industry etc, which appears to have stronger, more visible innovation cultures. Many stakeholders in the construction are being perceived as conservative: planners, funders, insurers and clients (Construction Product Association, 2001). They adopt tried and tested methods and are risk averse, whereas it may be more appropriate terms to be risk averse to gain best value (Glass, 2002). These risk averse characters may well impede innovation in construction.

2.5.8 Innovation Brokers

Innovation brokers can act as information intermediaries between construction firms and others, helping firms become aware of technologies and competencies that may not otherwise come to their attention (Manseau, 2003). The construction industry, according to Davidson (2001), is one that can benefit greatly from the services of innovation brokers. This is because the practice of 'technology watch' within the industry is either impractical or simply non-existent. Manseau (2003) noted especially the potential for innovation brokers to enhance the innovative capacity of small to medium enterprises.

2.6 Key Determinants of Innovation in the Construction Industry

The need to identify the key determinants of innovation in the construction industry requires an extensive review of methods for assessing innovation capabilities. This will aid the development of a prototype application for construction companies, as stated in Section 1.6. According to Cheung et al, (2004), effective performance assessment depends on well-structured assessment parameters, which in turn are subject to the following questions:

- what kind of data can be used; and,

- how to collect and interpret the data in a way that end-users can understand.

To derive a reliable set of innovation performance parameters, the review covered the work such as Goolsby, (2001); Larkin, (2003); Emmett, (2002); Karlsberg and Adler, 2005 to mention a few. The review indicates processes, people and technology are the three key aspects the need to be considered for successful implementation of technological innovation. Emmett (2002) stated that 'people, processes and technology need a leader' just as 'an orchestra needs a conductor'.

Six key determinants of successful innovation that form the basis of innovation assessment model for the construction organisations are discussed below.

Leadership: The European Foundation for Quality Management EFQM (1999) assigns 10% of its weighting to leadership because most people react best to leaders who connect with them and are not hierarchical in their approach. Leaders also create the psychological environment that fosters sustained innovation at all levels (Karlsberg and Adler, 2005) They are expected to be able to; identify and overcome the basic barriers to innovation; create and deploy proven internal marketing principles to better incubate innovative projects; maintain a culture of continuous play etc. They can articulate their vision of the innovation to the rest of the company (Afuah, 2003). In the proposed tool, leadership issues will be assessed using both question aimed at leaders and subordinates.

Management: Management attitude is crucial to technological innovation and can play a part in achieving successful construction innovations and creating competitive advantage (Pries and Janzsen, 1995). A survey of construction industry professionals carried out by Buro Happold and Building Design Magazine established that 88% of the respondents believed innovation was not managed effectively (Cripps, 2002). Innovation is extremely complex and involves the effective management of a variety of different activities. To do so, management must believe in innovative practices and take such strategic measures sufficient to save its adoption. This must therefore be addressed in the tool. Pries and Janzsen (1995) have emphasised the crucial role of innovation management in achieving successful construction innovation and creating competitive advantage.

People: The UK construction industry has long experienced difficulties in meeting its skill requirements. Given the right atmosphere or culture, 'innovation will not readily take place without the right people being drawn to it' (Sturges et al., 1999). The people factor accounts for the social and cultural aspects related to the people within an organization and are important to its success (Ruikar et al, 2004). Egbu et al. (1999) examined the management of innovation in construction by surveying a number of companies which were identified as 'innovative'. They highlighted certain characteristics shown by all innovative organisations. These are: people are open-minded, willing to accept change, flexible in lines of communication, structure that allow top-down bottom-up and risk tolerant climate where it is accepted that lessons can be learned through mistakes. Clearly many of these characteristics would be difficult to engender in an industry based on adversarial, entrenched relationships (Gesey et al, 2007a), therefore the people factor is important and is a key ingredient to innovation success and can effect overall performance of an organization and need to be addressed in this proposed tool.

Process: According to Sexton and Barrett (2003) the process of innovation means a series of actions and reaction forces which include management support (action), resistance to change from the staff/people (reaction), allocation of capital to purchase needed technology (action) and lack of appropriate work routines to coordinate and channel the innovation activity (reaction). The innovation process is not often an orderly process, but a process that is subject to peaks and troughs as the progress of the innovation competes with the day to day variability of workload and the often acute pressures on finite staff and financial resources. "What is needed is a framework or process that can guide innovation activities from start to finish." (Dundon, 2002).

Process change of any nature carries its rewards and risks but strong links between the different stages of the innovation process are critical to success and need to be addressed.

IR Investment: The amount of investment funding available for construction research has been declining steadily in recent years and is estimated to be less than 0.5% of the construction sector's spending. By comparison aerospace invests 11%, automotive over 9% and pharmaceutical up to 13% of their revenues on research (ICE, 2003). A lack of continuing investment in R&D in the construction industry may be preventing innovation starting and continuing (Glass, 2002). Furthermore, the construction industry itself has clearly struggled with the notion of R&D as a tangible benefit, which may relate to the fact that the industry has traditionally been very slow to exploit innovation. At present, no construction organisations have been placed in the top 250 R&D investors list (Steele and Murray, 2001). Since the publication of the Egan report 'Rethinking Construction'(1998), it has been accepted that for future growth within the construction industry to be sustainable it will become increasingly reliant on its R&D capabilities and it is very important that a better mechanism be developed for defining the industry's long term R&D investment needs (Fairclough, 2002).

Technology: The technology factor covers all aspects relating to information and communication technology (ICT) and its capability of coordinating different activities within and cross organizations and also across industries (Laudon and Laudon, 2002). Kao (1997) explains the role of technology as a catalyst for and multiplier of creativity. Electronic tools for sharing information, including e-mail, intranets and knowledge management systems dramatically enhance people's ability to represent, organize and

apply knowledge and ideas (Kao, 1997). According to Tidd et al, (2001) technological development does have its own internal logic, which helps define where companies will find innovative opportunities. Lloyd et al (2002) argued that an automated and web-based monitoring system can remove geographic barriers and reduce time in transferring data, in addition, it enables exchange of massive volumes of information at high speed and a relatively low cost (Deng et al, 2001), An automated and web-based innovation assessment tool is proposed to bring together the six aspects/ criteria cited (shown in Figure 5.1) and translate these into an effective tool to assess innovation end-users such as SMEs or large construction companies. Such a tool will also help to organise company performance data and can be easily retrieved via intranet/internet and database technology.

2.7 Contribution to Research

Research on innovation is mostly focussed on product development, with little service innovation literature and virtually none on the engineering environment such as the construction industry. There is a lack of agreement on benchmarking and there is no national or international guidance for innovation in the construction industry. As such, the literature does not really provide a clear basis for an innovation assessment tool for the construction industry.

For these reasons, the development of an innovation assessment model and prototype application/tool could help construction companies to assess their innovation capabilities. The prototype application/tool could initiate a business improvement process leading to the effective implementation of a strategy/best practice guidelines and allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies into overall competitive strategies; and benchmark their innovation

performance with peers and within the construction industry. Hence, it would help to address the current problems surrounding implementation of innovation management in the construction industry.

The innovation assessment model described in Chapter 4 is built around the assumption that a company will be better able to manage innovation if it measures and continuously improves itself to become more innovative. The model is thought to be unique in the construction industry (certainly in the UK) and hence there is sufficient novelty in this research. The development of the innovation assessment model and prototype application are covered in detail in subsequent chapters.

2.8 Summary

This chapter has provided an overview of the relevant research that has been conducted within the subject area. It examined the general concept of innovation, its management and the key determinants of innovation in the construction industry. The next chapter will elaborate on the research methodology adopted for this project.

CHAPTER 3: DEVELOPMENT OF INNOVATION ASSESSMENT MODEL FOR CONSTRUCTION ORGANISATIONS

3.1 Types/Models of Innovation

The second objective of the research was to review theoretical and industrial models of innovation in the construction industry, and develop an innovation model for use in the construction industry. This forms an important stage in the research by exploring the evolution of key innovation models, with a view to informing the development of an innovation assessment tool for the construction industry.

3.1.1 Types of Innovation

Many research projects have attempted to characterise technological innovation and explain how it works, for example, by categorising innovations via type (incremental, radical or system innovations) or process (whether the innovation is radical or incremental, is continuous or discontinuous, is sustaining or disruptive). This has produced an array of many competing models, varying in their integrity and applicability Gesey et al, (2005b). Research on innovation in construction has demonstrated that it can take many forms (see. Barrett and Sexton, 1998; Gann et al, 1998; Pries and Janszen, 1995). For example, Slaughter (1998) characterised innovation according to whether it is incremental, architectural, modular, system or radical.

- Incremental innovation is a small change, and is based on existing experience and knowledge.

- Architectural innovation may consist of a small change within a component, but a

major change in the links to components or systems.

- Modular innovation is a significant change in the basic concept within a component only.

- System innovation is identified through the component's integration of multiple entities that must work together to perform new functions or improve the facility performance as a whole.

- Radical innovation is based on a breakthrough in science or technology that often changes the character and nature of an industry.

The types of innovation presented by Slaughter (1998) above describe the relative consequences of an innovation and its characteristics, but do not provide a simple descriptor (Glass, 2002). Instead, Glass (2002) suggested that the construction industry is being driven towards other types of innovation. As can be seen from the Table 3.1, innovation can take place at many different forms/levels, whether it be service, product, communication or technology transfer etc.

Table 3.1 Generic categories for construction innovation (adapted from Glass, 2002)

Categories	Description
Communication	Advances in ICT
Construction methods	Developments in the practical aspects
Design methods	Methods of designing with IT
Information	Ways of capturing expertise or experience
Integration	Approaches to integrating existing systems or processes
Maintenance	Advances in 'building care' aspects
Manufacture	Developments in production/assembly
Materials	Changes and advances in construction materials
People	Approaches to managing people through organisational change
Performance	Life-cycle improvement
Process	Management of manufacture, design, construction and operations
Procurement	Strategies to encourage and manage partnering arrangements etc

Product	Development of construction materials or components
Service	Customer care and/or delivery of product
Technology transfer	Methods of sharing and/or exchanging development

3.1.2   Models of Innovation

The research has identified various models that attempt to explain how the innovation process works mainly from academic literature. It is useful to present the evolution of these various models and their limitations. Rothwell (1992) classified the models into five generations as shown in Table 3.2. Although his fifth-generation models appear complex, they still involve the same basic process framework (Tidd et al., 2001).

Table 3.2 Five generations of innovation models based on Rothwell (1992)

Generation	Time	Model	Key features
First	1950/60s	Technology push	Simple linear sequential process. Emphasis on R&D. The market is a receptacle for the fruits of R&D.
Second	1970s	Market pull	Simple linear sequential process. Emphasis on marketing. The market is the source for directing R&D. R&D has a reactive role.
Third	1980s	Coupling model	Emphasis on integrating R&D and marketing
Fourth	1980/1990s	Interactive model	Combinations of technology push and market pull
Fifth	2000	Network model	Emphasis on external linkages

The five generations of innovation models based on Rothwell are discussed in detail below.

First and second generation: technology-push versus market pull model: Rothwell (1992) provided a useful historical perspective on this, suggesting that the nature of innovation and its process has been evolving from a simple linear model (Tidd et al., 2001). The 1950s were a period of post war recovery where demand exceeded production capacity. Economic growth came from new technological sectors. As such the dominant corporate strategy emphasised R&D and manufacturing. During this period, the predominant model of innovation was the technology-push model, also known as the linear model.
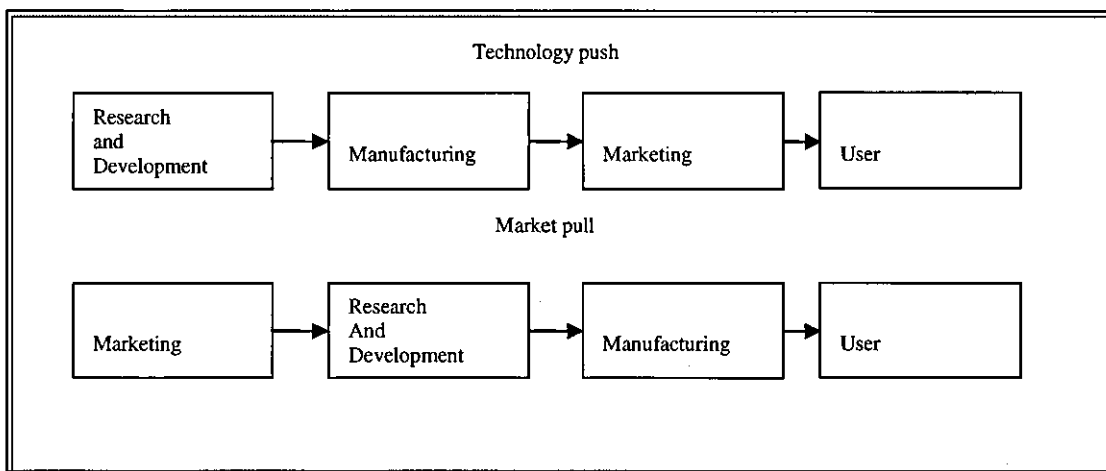
Figure 3.1 Linear models of innovation (based on Trott, 2002)

Rothwell (1992) argues that in the latter part of the 1960s was an era of corporate growth. Companies diversified their product offerings to meet intensifying competition. Customer needs were seen to be driving the innovation process, hence the market-pull model. In the market-pull model, the key input to the innovation process is customer needs. The market was seen as a source of ideas for directing the activities of R&D. Rothwell (1992) and Freeman (1996) reported that R&D plays an important role in

ensuring that innovations are available when required, but it is not the only generator of innovation.

Third generation: coupling model: Hobday (2002) concluded that the first and second generation models of innovation were extreme and atypical examples of industrial innovation. The linear models of innovation concentrated on what is driving downstream efforts, rather than how innovation occurs (Galbraith, 1982). In the 1970s, the explanation of the innovation process shifted towards the coupling model. Drawing on the coupling model, Rothwell and Zegveld (1985) described the innovation process as "a complex net of communication paths, both intra-organisational and extra-organisational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the marketplace". Trott (2002) argued that the linear model is only able to offer an explanation where the initial stimulus for innovation was born. The coupling model shown in Figure 3.2 suggests that it is the result of the simultaneous coupling of the knowledge within the manufacturing, marketing and R&D functions.
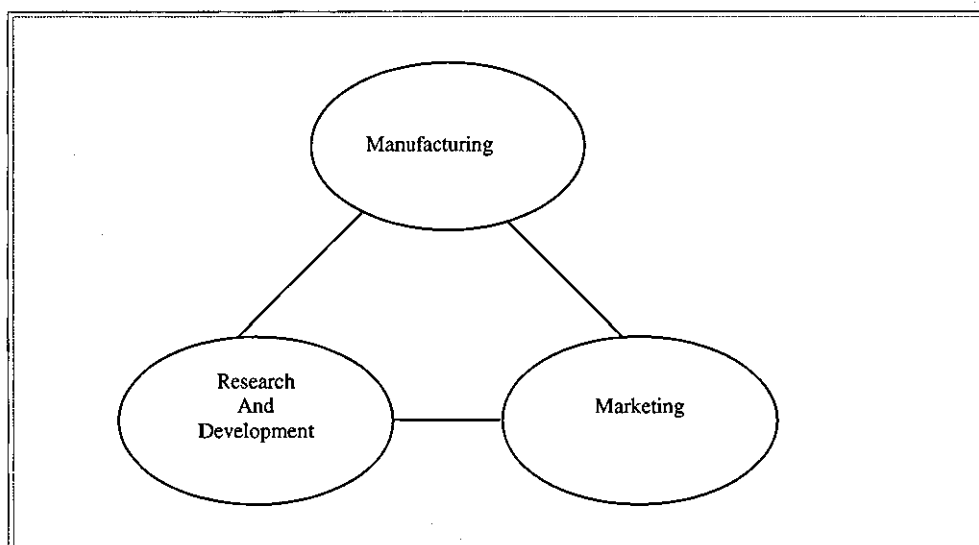
Figure 3.2 The simultaneous coupling model (Source: Trott, 2002)

Fourth generation: integrated model: The previous iterations suggest that the innovation process is complex, non-linear and requires feedback and cannot be seen as being caused by a single factor (Jones and Saad 2003). The importance of understanding the process of innovation has been advanced by work by Rothwell (1992) and Freeman (1996). The interactive model develops and links together the technology push and market pull models (see Figure 3.3): 'it emphasises that innovations occur as the result of the interaction of the market place, the science base and the organisation's capabilities' (Trott, 2002). Similarly, Dosi (1982) argued that innovation is a cumulative process of iteration between technical feasibilities and market possibilities. The interaction is not limited to market and technology, but affects the economic, social and institutional context to determine the best practice pattern for innovation (Freeman and Perez, 1988).
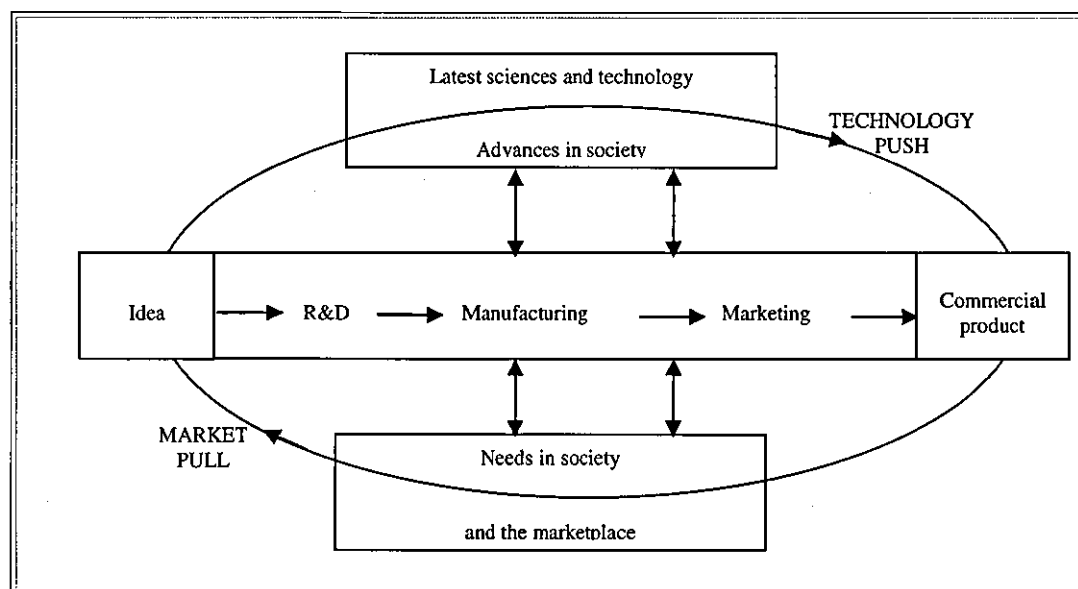
Figure 3.3 Interactive model of innovation (Sourse: Trott, 2002)

Fifth generation: systems integration and networking: Rothwell (1992) called the fifth generation innovation process the systems integration and networking process (SIN).

This is characterised by elements of systems integration and networking. System integration is made possible by the use of Information Technology (IT) to integrate the various functions within a firm. IT enables a firm to be connected to the outside world more effectively, for instance through the Internet, EDI linkages to suppliers, Computer Aided Logistics Support (CALS) and integrated information system for supporting production, procurement and operation. The firm's linkages to external networks and the relations to customers have been shown to be important to innovation activities in firm. (Von Hippel, 1988; and Stevens, 1997). In particular, Stevens (1997) emphasises the importance of networking among firms and the role of competition in advancing innovation. Miozzo and Dewick (2004) also suggest that networks can benefits from inter-organisational cooperation in a fragmented industry such as the construction industry.

Over the past 80 years several studies of conceptual innovation models have also been carried out, they include the work of Schumpeter, 1934; Schmookler, 1954; Mensch, 1979; Mowery and Rosenberg, 1979; C Freeman, 1996; Nelson and Winter, 1977; Dosi, 1982; Freeman and Perez, 1988; Clark and Juma, 1987; Cooke and Morgan, 1993; and Rothwell, 1992. Table 4.3 provides a few examples of the key innovation models in the literature; While innovation is present in all of these, its characteristics and description vary, so there appears to be a lack of consistency, even after such an extended period of development. This is a problem and one that this research seeks to address.

Table 3.3 A review of conceptual innovation models, based on literature

Authors	Models	Key focus
Schumpeter, 1934	Technology - Push	Economic growth is achieved by introduction of a new idea where science and technology are the major sources of innovation
Mensch, 1979	Clusters of innovation	Stalemate creates an accelerator mechanism and induces innovation which comes in clusters
Schmookler, 1954	Need-pull	Innovation is the result of emphasis put on demand factors
Mowery and Rosenberg, 1979	Coupling model	Technology and demand are both determinants of success in innovation
C Freeman, 1996	Long cycles of the world economy	Electronics industries considered to form the basis of the fourth Kondratiev wave with innovation arising in the upswing phase as outcome of both market and technology
Nelson and Winter, 1977	Natural trajectories	Innovation is viewed as an interaction between the firm's natural trajectory and the selection environment
Dosi, 1982	Technological paradigm	Technological paradigm incorporates interrelationships between scientific progress, technical change and economic development and suggests a continuous progress along a defined technological trajectory
Freeman and Perez, 1988	Social and economic paradigm	Innovation is viewed as an economic interaction between the economic, social and institutional spheres
Cooke and Morgan, 1993	Regional network paradigm	Significant links between innovation and regional support and learning
Rothwell, 1992	System integration and network paradigm	Innovation as a multi-factor process depending on intra and inter-organisational relationship
Schumpeter, 1934	Technology - Push	Economic growth is achieved by introduction of a new idea where science and technology are the major sources of innovation

3.2 Assessment Models and Tools

This section reviews existing business improvement models and innovation assessment tools, both from within and outside of the construction industry, with the aim of identifying how innovation management is currently dealt with by businesses, whether or not they are construction-focused.

3.2.1 Review of Business Improvement Models

There are several tools/models that have been used to self-assess organisations' performance and capabilities. These assessment tools or models have different underlying goals and definitions. For example, the Department of Trade and Industry (DTI) in the UK and Construction Excellence have produced Construction Industry Key Performance Indicators (KPIs) that underpin a number business excellence models (CE, 2005). Furthermore, Information Communication Technology (ICT) has driven large and SMEs companies from all sectors to search for ways of monitoring and improving performance (Neely and Hii, 1998). Over recent years there has also been increasing recognition that a more holistic approach to performance is required, such as:

1. the European Foundation of Quality Management Excellence Model (EFQM, 1999);

2. the Balanced Scorecard (Kaplan and Norton, 1996);

3. Key Performance Indicators (KPIs) and benchmarking (CE, 2005); in managing sustainable construction (BRE, 2002), and

4. a guide for managing innovation (CIDEM, 2002).

Table 3.4 Business improvement models and their measures

EFQM Excellence model	The Malcolm Baldrige Model	ISO 9001
▪ Leadership ▪ Policy and strategy ▪ People ▪ Partnerships and resources ▪ Processes ▪ Customer results ▪ People results ▪ Society results ▪ Key performance results	▪ Leadership ▪ Strategic planning ▪ Customer and market focus ▪ Measurement, analysis and KM ▪ Human resources focus ▪ Process management ▪ Business result	▪ Quality management system ▪ Management responsibility ▪ Resource management ▪ Product realisation ▪ Measurement, analysis and improvement
Total Quality Management (TQM)	**Balanced scorecard**	**Key Performance Indicators (KPI)**
● Culture ● Communication ● Commitment ● Planning ● People ● Process ● Performance	● Learning and Growth Perspective ● Business Process Perspective ● Customer Perspective ● Financial Perspective	● Client Satisfaction – Product ● Client Satisfaction – Service ● Defects ● Predictability – Cost ● Predictability – Time ● Profitability ● Productivity ● Safety ● Construction Cost ● Construction Time

These business improvement models and assessment tools (Table 3.4) have been used to self-assess organisations' performance and capabilities and have been developed using principles that underpin a number of business excellence models. The models originated from the manufacturing and service industries and it has been argued that they are not necessarily appropriate for construction (Thompson, 2005). The business improvement models and approaches are useful in themselves, but innovation that appears to be present in them is unclear and in an unstructured manner. Thus there are questions about their relevance to both: a) construction and b) innovation management.

3.2.2 Review of Assessment Models/Tools

To attempt to address the problem of overarching business improvement models not matching the needs of construction and innovation management, several performance assessment models were reviewed to check their appropriateness for the construction

industry in the light of current practices within the industry. See also Table 3.5 which follows a commentary on each of the tools.

ISDT (Innovation Self-assessment Diagnostic Tool)

This diagnostic tool was designed and developed by Department of Trade and Industry (DTI). The tool was designed to help companies identify themselves with some of the better behaviours that promote innovation and identify specific areas of poor performance and look for advice in these areas (www.innovation.gov.uk).

GIS (Go Innovative System)

The 'Go Innovative' system helps organisations to innovate and to develop innovation as a core competency without significantly altering their organisation's current methodologies (www.goinnovate.com).

OAT (Organisational Assessment Tool)

This tool was designed and developed by the Innovation Network. The tool was designed to help companies understand their organisational strengths, and to throw some light on areas in need of improvement (www.innonet.org)

RAT (Readiness Assessment Tool)

This tool was designed and developed at Leeds/Birmingham University. The tool was designed to help senior business managers in identifying area of current organisational weakness etc (Burgess and Shaw, 2004).

SPICE (Standardised Process Improvement for Construction enterprises)

This tool was developed at the University of Salford. The tool was designed to evaluate the construction processes within a construction organisation (SPICE, Questionnaire, 1998).

RACE (Readiness Assessment for Concurrent Engineering)

This tool was developed at West Virginia University in the 90s and is widely used in the software engineering, automotive and electronic industries. The RACE model is conceptualised in terms of organisational processes and technology to support the product development process (CERC Report, 1993; Wognum et al, 1996).

BEACON (Benchmarking and Readiness Assessment for Concurrent Engineering in Construction)

This tool was developed at Loughborough University. It assesses the readiness of construction companies to improve their project delivery processes through the implementation of concurrent engineering (CE), (Khalfan, 2001)

VERDICT (Verify End-user e-Readiness Using a Diagnostic Tool)

This construction specific tool was developed at Loughborough University. It is an Internet based e-readiness application that assesses the overall e-readiness of end-user construction firms for using e-commerce technology (Ruikar, 2005).

Table 3.5 Comparison of business performance and innovation assessment tools

Criteria Tools /Models	Aspect	Status of Model/Tool	Software Availability	Usability	Survey Method	Suitability for Construction
ISDT	Business process	Development ongoing	Yes, web based	Yes, but its very basic	Questionnaire	No
GIS	People, process, structure and technology	Commercial	None	It seems very complicated	Interview	No
OAT	Organizational strengths	Commercial	Yes, web based	Yes, but its very basic	Questionnaire	No
RAT	Business, technical managers	Development ongoing	None	Pencil & paper	Interview	No
SPICE	Project management	Research prototype	None	Yes	Questionnaire	No
RACE	Process & technology	Commercial	Only for specialists	Yes	Questionnaire/ Interview	No
BEACON	People, process, management and project	Research prototype	None	Yes	Questionnaire	Yes, It is designed for CE in construction not for innovation
VERDICT	People, process, management and technology	Research prototype	Yes, web based	Yes	Questionnaire	Yes, but it requires some modification, as it is designed for e-readiness and not for innovation

Of these assessment tools, most conceive organisational improvements in general as supporting innovation, some of them are under development and some are being used on a commercial basis. However, the assessment models that are most relevant to being adapted to address innovation management, after appropriate modification, would be the BEACON model (Khalfan, 2001) and the VERDICT model (Ruikar, 2005). The BEACON model (Benchmarking and Readiness Assessment for Concurrent

Engineering in Construction) assesses the readiness of construction companies to improve their project delivery processes through the implementation of concurrent engineering (CE), it consist of four elements, which are People, Process, Project and Technology. The BEACON model is not useful as it tend to rely on manual data collection and interpretation, and while the VERDICT model (Verify End-user e-Readiness Using a Diagnostic Tool) is an Internet based e-readiness application that assesses the overall e-readiness of end-user construction firms for using e-commerce technology (Ruikar, 2005). The VERDICT model is similar to the BEACON model it comprises a series of statements that fall into four categories, namely; People, Process, Management and Technology. Such approach is good for the modern business environment with the wide applications of internet and database technology. But the tool does not benchmarks each individual construction organisations for each category with peers of similar business types (e.g. clients, consultants), group types in terms of turnover, as well as the industry as a whole. It only benchmarks one IT company called CISCO with their e-readiness. Another drawback is that the tool does not provide guidance to end-user companies that are not e-ready in order to achieve e-readiness.

On their own, VERDICT's four parameters may actually not be sufficient for an assessment whether it is e-readiness or innovation assessment in the construction industry (or indeed for any other industry). This might require the addition of items such as 'leadership' in order to drive policies and strategies and to successfully implement it. Another possible parameter missing from the VERDICT models is 'IR investment', which is one of the key determinants of innovation or technology in any industry. The addition of such parameters could enable the conceptual framework behind both BEACON and VERDICT to be adapted to better suit the practice of innovation

management. This is one of the novel features in iCon model. Furthermore the iCon model and its associated questions/statements has been developed specifically for innovation assessment for the construction industry.

3.2.3 The Development of Innovation Assessment Model (iCon)

This section describes the development of the innovation assessment model iCon. The acronym iCon was derived from the overarching goal of the prototype application (Innovation Assessment Tool for Construction). The Prototype Application is an innovation assessment tool, which aims to provide a rapid online assessment of innovative practices and competencies in construction companies. The following sections present the iCon Model.

The iCon model has been developed for assessing innovative practices and competency for the construction industry. The proposed prototype model named (iCon) is shown in Figure 5.1. A questionnaire was developed for the model, which covers all the components/parameters shown in the model. The proposed model has some similarities with the BEACON and VERDICT models, it combines aspects of these two models and builds on them as discussed in Section 5.2. The iCon model adopt in terms of methodology used, the questionnaire criteria and diagrammatic output used in VERDICT, i.e. the use of radar diagrams. However, the iCon model differs from the VERDICT model in that it focuses on innovation management and its assessment in the construction industry, whereas Verdict model focus on an e-readiness. The key advantage of the iCon model is that it does not only include the four parameters as covered in other models but also introduces two new components, leadership and IR investment. The rationale behind including these two components is that both of them

are as critical as the other parameters as people, process, technology and management and should be distinguished. The development of the iCon model is important for the effective implementation of a strategy/best practice guidelines and benchmarking for innovation performance.

According to Have et al, (2003) benchmarking is the comparison of organisational processes and performances in order to create new standards and or improve processes. There are four basic types:

- Internal - benchmarking within an organisation, e.g. using iCon model, construction companies can benchmark internally by tracking and comparing current performance with past performance

- Competitive – benchmarking operations and performance with direct competitors, e.g the model is comparing performance against the practices of other leading construction organisations for the purpose of improving innovation performance.

- Functional – benchmarking similar processes with the broader range of the industry e.g. the model helps construction organisations to measure and benchmark innovative practices within the construction industry.

- Generic – comparing operations between unrelated industries e.g. the model facilitate a rapid assessment of innovative practices and performance that has been achieved in the recent past by other innovative organisations.

The benefits of the model include: It allows companies to assess their innovative performance and highlight on the areas where improvement is needed; it enables them to integrate innovation-related strategies/best practice guidelines into their business

activities and to benchmark their performance with peers and within the construction industry.

The iCon model comprises of six main categories as depicted in Figure 3.4, which are partly addressed by other mentioned models and translates these into an effective tool to assess innovation end-users such as SMEs or large construction companies. These parameters were derived from assessment models/tools, as discussed in Section 3.2. Innovation auditing models from a number of authors such as Higgins (1995) and Tidds et al (2001, pp 377-381) were used as they provide a detailed method for evaluation of innovation management in an organisation. Similar checklists of output measures were also provided by Kuczmarski (1996; p.182, 2001) and an anonymous list of measures from the International Trade From (2002) see Appendix F.

The iCon model has been developed for use in assessing construction organisations such that the six categories covered in the model would be assessed using these parameters shown in Figure 3.4.
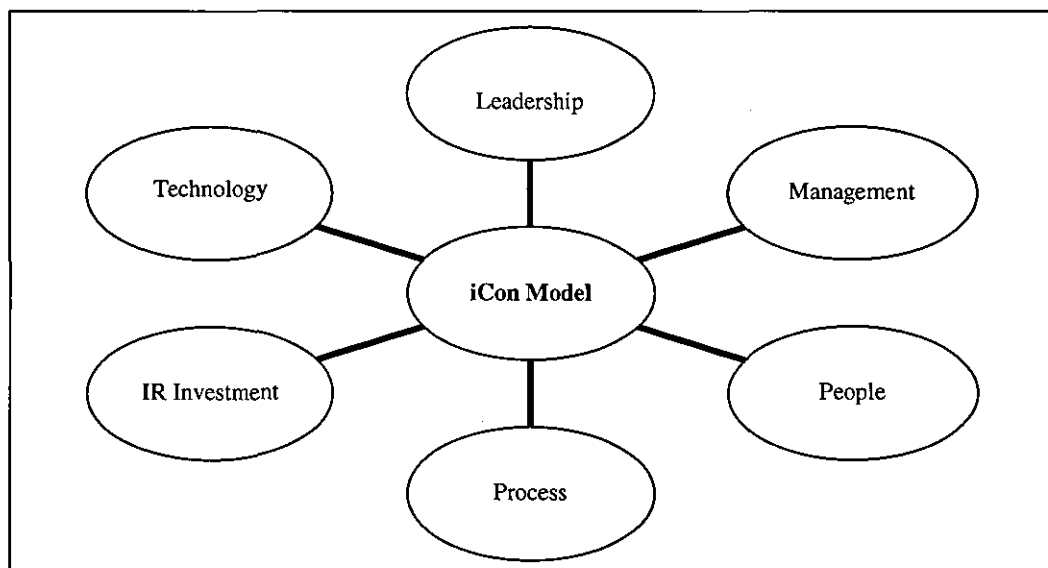
Figure 3.4: Innovation Assessment Model for Construction (iCon)

The iCon system is built around the premise that, in order to be innovative, construction organisations require to excel in the following six categories as discussed in chapter 2 section 2.6 they include;

- Leadership to drive innovation policies and strategies

- Management that believes in innovation

- People who have the adequate skills and who believe that innovation is the successful exploitation of new ideas

- Processes that enable and support innovation

- IR Investment, one of the key determinates of innovation or technology in any industry

- Technology tools and the necessary infrastructure to support business functions

A survey questionnaire and interviews with a range of companies within the construction industry was carried out to validate the model, its parameters and associated statements. These statements were derived from business assessment models/tools, which covers all the components/parameters shown in the model (Assessment model questionnaire in Appendix D).

3.3 Summary

This chapter has provided an overview of the relevant research that has been conducted within the subject area. It was found that innovation is mostly focussed on product development. There is a lack of agreement on benchmarking and there is no national or international guidance for innovation in the construction industry. As such, the literature does not really provide a clear basis for innovation management practices in the construction industry. Hence, a review of existing assessment tools found that the BEACON and VERDICT assessment tools could provide the theoretical basis for the development of an innovation assessment tool to address these problems. The next

chapter will explain the development of the prototype application (iCon), its design,

development and implementation of the tool; a web based innovation assessment tool

for construction organisations.

CHAPTER 4:   RESEARCH METHODOLOGY

4.1   Introduction

This chapter reviews a range of research methodologies and compares the different research methods and approaches, but in particular explains the rationale for techniques adopted in this research project.

A research methodology describes the principles and procedures of logical thought processes applied to scientific investigation (Fellows and Liu, 1999). There is no unique or best research method (Yin, 1994); the use of each research method is based on the form of research question, the objective and contextual situation. The success and validity of any research depends critically on the appropriate selection of research methods (Steele, 2000; Fellow and Lui, 2003). According to Robson (1996) there are a number of research methods that can be adopted including: interviews, questionnaires, one-to-one discussions, observation, and experiments; however a common distinction is made between qualitative, quantitative and triangulation research methods (Johnson and Christensen, 2003). The qualitative, quantitative, and triangulation approaches are briefly described below.

4.2   Research design

The research design is the logical sequence that connects the empirical data produced by research to the initial research objectives of the study, and ultimately to its conclusions (Yin, 1994). For example, Steele (2000) highlights seven strategies of research: experiment, survey, archival analysis, history, case study, action research and modelling, which are shown in Table 4.1.

Table 4.1 Research methods: adapted from (Steele, 2000).

Strategy	Form of research question	Required control over behaviour events	Focus on contemporary events
Experiments	How, why	Yes	Yes
Survey	Who, what, why, where, how many, how much	No	Yes
Archival analysis	Who, what, why, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes
Action Research	Who, what, why, how many, how much	Yes/No	Yes
Modelling	Who, what, how many, how much	No	Yes/No

The choice of research methods has a critical effect on the final outcome of any research because an appropriate choice of research method can lead to failure of the research. Literature review, surveys (interview, focus group and questionnaire) action research, RAD and case study are discussed in detail in Section 4.3 as they have been adopted as part of the methodology for this research.

4.2.1 Qualitative and Quantitative Research

Research methods can be classified in various ways (Robson, 1996), however one of the most common is between qualitative, quantitative research and mixed research approaches known triangulation method. Qualitative research approach was originally developed in the social sciences to enable researchers to study social and natural phenomena, whereas quantitative is developed in the natural science, and it relies on the collection of quantitative data (Straub et al, 2005). For all types of research methods of collecting data will impact upon the analysis, conclusions and validity of the study

(Fellows and Liu, 2003). According to Bryman (2001) the connection between theory and research – quantitative and qualitative research can be taken to form two distinctive cluster of research strategy. These strategies are set out in detail within the next sections.

4.2.2 Qualitative Research

Qualitative research involves the collection of qualitative data, which include observation, survey (interview and questionnaires), documents and participant observation (Seale, 1999) to understand and explain social phenomena (Myers, 2004). It tends to be subjective in nature and consists of detailed descriptions of situations, events, people, interactions and observed behaviour (Patton, 1992). Qualitative methods seek to find out individual beliefs by asking how and why (Beatham, 2003) and when something occurs. According to Hancock (1998) the main methods of collecting qualitative data are individual interviews, focus group, direct observation and case studies. According to Steele, (2000) Qualitative research consists of two conditions; (1) the use of close up, detailed observation of the natural world by the researcher and (2) the attempt to avoid prior commitment to any theoretical. Much qualitative research concerns the generation of concepts through the researcher becoming immersed in the data collected in order to discover any patterns. Therefore, it is essential to be sensitive in order to detect inconsistencies and to be aware of the potential for different views to the expressed and for alternative categorisations and explanations to be valid (Thompson, 2005).

The researcher therefore must be aware of his/her own preconditioning and views and hence potential bias (Fellows and Liu, 1997). Hence, there are advantages as well as

disadvantages involved in using a qualitative research method. Qualitative approaches include richness of data and deeper insight into the phenomena under subject of study (Hancock, 1998). Among various advantages are that it facilitates in-depth study, produces detailed information with a smaller number of people and provides a great understanding of the topic under study. The disadvantages of qualitative approaches relate to the problems of achieving adequate validity and reliability of the data collected due to its subjective nature. The data collected is usually unstructured and analysing it tends to be difficult, often requiring a lot of filtering, sorting and other manipulations (Fellows and Liu, 1997). The comparison of both qualitative and quantitative research epistemology has been tabulated in Table 4.3.

4.2.3 Quantitative Research

Quantitative research is an exploratory study or an operational study based on in-depth analysis of interviewee responses and is objective in nature (Naoum, 1998). Quantitative data can be gathered using a variety of techniques such as experiment, quasi-experiments and surveys (SJI, 1999). Quantitative approaches compare factual data with theory, how many and how much? (Walker, 1997); results can be analysed statistically using mathematical techniques (Carrillo, 2001). The effectiveness of the selected types of quantitative methods depends of the nature of the research (Adetunji, 2006). The most common quantitative techniques are personal, telephone and mail surveys (OWBC, 2001). Table 4.2 highlights some of the key advantages and disadvantages of these survey methods.

Table 4.2 An overview of the advantages and disadvantages of quantitative survey methods, based on literature.

Methods	Advantages	Disadvantages
Personal survey	• Allows high flexibility in the questioning process • Interviewers have control of the interviewing situation • High response rate	• Higher cost than mail questionnaire • Potential interviewers bias due to high flexibility • Time consuming
Telephone survey	• Moderate cost • Fast • High response rate • Increase quality of data	• Difficult to discuss certain topics • Can be expansive • Less chance for supplement information
Mail survey	• Cost is low compared to other methods • High degree of respondents anonymity • Wide geographical reach	• Low rates of response • Require easily understood questions and instructions • Greater respondents bias • High uncompleted questions

According to Brannen (1992), quantitative research is concerned with attitudes and large-scale surveys rather than simply with behaviour and small-scale surveys. The advantages of the quantitative methods are that control is achieved through the sampling, design, and also reliable measurement (Burns, 200). In quantitative research, data is usually analysed statistically, the common tools include the survey technique which is the most widely use method in social science and also the most relevant to this study.

4.2.4 Triangulation

Triangulation is the process of using more than one form of research method, often involving the use of both qualitative and quantitative approaches; it has proven to be more powerful and very effective than a single approach (Lee, 1991; Sherif, 2002). The

triangulation method is used to obtain confirmation of findings through convergence of different perspectives taken from both quantitative and qualitative methodologies. This approach offers researchers a greater deal of flexibility, where theories can be developed qualitatively and be tested quantitatively or vice versa (Ruikar, 2005). Table 4.3 highlights the main characteristics of qualitative and quantitative research methods.

Table 4.3 The main characteristics of qualitative and quantitative research methods (adapted from Key, 1997).

Point of comparisons	Qualitative Research	Quantitative Research
Focus of research	Quality (nature, essence)	Quantity (how much, how many)
Associated phrases	Fieldwork, ethnographic, naturalistic, grounded, subjective	Experimental, empirical, statistical
Design characteristics	Flexible, evolving, emergent	Predetermined, structured
Goal of investigation	Understanding, description, discovery, hypothesis generating	Prediction, control, description, confirmation, hypothesis testing
Sample	Small, non-random, theoretical	Large, randomly, representative
Data collection	Researcher as primary instrument, interviews, observations	Inanimate instruments (tests, questionnaires, surveys, computers)
Data analysis	Inductive by researcher	Deductive (by statistical methods)
Outcome	Comprehensive, holistic, expansive	Precise, narrow, reductionist

A triangulation method involves the use of both qualitative and quantitative approaches. Using this method, theories can be developed qualitatively and tested quantitatively (Khalfan, 2001). Triangulation increases the validity and reliability of the data, since the strengths of one approach can compensate for the weaknesses of another (Ruikar, 2005).

Therefore, triangulation method serves to reduce or eliminate the disadvantages of each individual approach whether qualitative or quantitative, whilst gaining the advantages of each, and of the combination – a multi-dimensional view of the subject, gained through synergy (Fellows & Liu, 1999).

There are conflicting reports on the different number/types of triangulation, but the general consensus including (Mathison, 1988 and Begley, 1996) appears to indicate that five variants exist. These are:

- Data – triangulation of different sources of data across time, space or persons.

- Investigator – triangulation of work amongst several researchers.

- Methodological – triangulation of multiple methods to study a single problem.

- Theory – triangulation of two or more contrasting theoretical positions.

- Analysis – triangulation via use of more than one analysis technique.

4.3 Adopted Research Methodology

This section explains in detail adopted research methodology for this thesis they include: literature review, surveys (interview, focus group and questionnaire), action research, case study and Rapid Application Development (RAD). The adopted research approach was to divide the research into three phases: investigation, synthesis and application adapted from Morse (1994). Each phase was divided into separate stages, as shown in Table 4.4.

Table 4.4 Research phases and stages (based on Morse, 1994).

Phase	Stage
Investigation ■ Involves the review of literature ■ Understanding subject area of the research	■ Preliminary Information Gathering ■ Problem definition
Synthesis ■ Solution System Proposal	■ Secondary Information Gathering
Application ■ Prototype	■ Evaluation

As explained in section 4.3, the selection of the most suitable research method depends largely on the intention of the research objectives and the type of data needed for the research.

The aim and objective of this research as stated in section 1.6 gave a clear perspective about how the project would be approached. Thus it combined different research methods, that involve both qualitative and quantitative methods was adopted. This type of research methodology can also be referred to as the triangulation method. According to Wing et al (1998), established research methods in both quantitative and qualitative approaches are seen as having a contribution to make at various points in the process, depending upon the existing body of knowledge in the specific area under study, the objectives and perspectives of the research and the quality of available data.

With this in mind, Table 4.5 presents the overall research approach and identifies the objectives and associated tasks against the phases of the research methods along with research output. The table identifies the objectives and the work tasks against the stages of the research.

Following the table, the subsequent sections discuss the precise research methods deployed and their research instruments; i.e. literature review, surveys (interview, focus group, questionnaire), action research, case study and Rapid Application Development (RAD).

Table 4.5 Research roadmap of objectives, tasks and methods

Overall Aim	*To develop an innovation assessment model and a prototype application for construction organisations to provide a rapid, online assessment of innovative practices and competencies in construction companies*		
OBJECTIVES	**TASKS**	**PHASE**	**METHOD**
1. To review theoretical and industrial models of innovation in the construction industry	1. A review of extant literature on innovation	*INVESTIGATION*	LR
	2. Review of the drivers, barriers and business case for the development of a culture of innovation in the construction industry.		LR
	3. Prepare a detailed survey questionnaire		S
2. To develop an innovation model for use in the construction industry	4. Identifying the successful innovation models within the UK construction industry.	*SYNTHESIS*	S
	5. Investigate barriers to the development of a culture of innovation in the construction industry		LR
	6. Review of extant literature on innovation, specifically on the generic, theoretical and industry-specific models or frameworks for innovation and the interpretation of such models.		LR
	7. Identify the most influential models, sets out the evolution of these models, their advantages and limitations		S
3. To explore methods for assessing innovation capabilities and develop a prototype application for construction organisations; and,	8. Reviews existing innovation assessment tools and models, from within and outside of the construction industry..	*APPLICATION*	LR
	9. Analyse existing process, methods, procedures and business practices in construction industry.		FG
	10. Develop a web-based innovation assessment tool specifically for construction companies, which addresses innovation management in the construction industry		FG
4. To evaluate the usability of the assessment tool such that it can be adopted easily into construction organisations.	11. Design and develop a prototype innovation assessment tool for construction companies.		RAD
	12. Evaluate a prototype application		S
	13. Develop recommendation for implementation of innovation framework		CS
KEY: Literature Review (LR), Survey (S), Focus Group (FG), Case Study (CS) & Rapid Application Development (RAD)			

4.3.1 Literature Review

It is essential that in the early stage of any research a search is carried out to identify potentially relevant theory and literature. It is often the case that research based on a literature review identifies additional questions that would be fruitful to pursue (Burns, 2000). The literature review helps to stimulate the thinking of the researcher on the previous work that has been carried out in the subject domain (Fink, 1998). A literature review was therefore used to: define the problem; highlight previous research and methodologies that have previously been used; reveal gaps in previous research; and, suggest areas for further research.

There are substantial amount of literature available regarding the issue of innovation in general, but comparatively less exists on innovation and its management in the construction industry. As a result, information was gathered using several possible avenues to acquire all information used herein: Loughborough University Library. Sources were located using inter library loans, databases (e.g. Compendex, Zetoc on engineering journals, periodicals, conference proceedings and text books), plus internet websites such as DTI, ICE, ISTRUCTE, CIOB, CE, CIRIA etc; together with discussion with supervisors and peers with interest in the subject area.

This literature search did not aim to concentrate solely on innovation management in construction. Its aim was to provide the author as a researcher with a detailed understanding of the ways in which the field of innovation and its management had been explored previously in the construction industry and other sectors.

The core literature items for this project included papers from the following academic journals: Building Research and Information; Construction Management and Economics; Journal of Construction Engineering and Management; International Journal of Technology Management; and Engineering, Construction and Architectural Management. In addition, the Proceedings of the International Conferences on Construction Industry development, (CIB) were found to particularly useful.

The effort to collate all the considerable amount of information into a single body of work has helped in providing a better insight and understanding in the major issues concerning innovation and its management in the construction industry.

4.3.2 Survey Instruments

4.3.2.1 Questionnaire Survey (QS)

A questionnaire is a self-administrated measuring instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents (Lui, 1994).

Questionnaire survey was conducted to identify innovation activities and advanced business practices in the construction industry what constitutes innovation, types of innovation whether technologies or advanced business practices, factors that drives or stops innovation within the construction industry. The study reviewed the successful innovation models, best practice and lessons learned within the construction industry.

The survey was distributed by post, to a random of 98 construction companies encompassing various construction disciplines. From the 98 participants a total of 25 usable, but detailed responses were received. This can be considered reasonable for a voluntary postal survey. Saunders et al (2000) suggested that response rates for postal

surveys can be as low as 15 - 20% and Ruikar et al, (2002) carried out a similar survey in the construction industry and the response rate achieved was 22%. Akintoye and Fitzgerald (2000) confirmed that the construction industry response norm is 20 – 30%. It is possible that the low response rate can be explained by the fact that responsibility for innovation within construction companies is not necessarily clearly delineated. The findings presented in this thesis are based on an overall response rate of 25.5%.

4.3.2.1.1 Design of Questionnaire

Brenner *et al*, (1985) suggest that the design of a questionnaire involves a process with several general stages: understanding the areas to be explored; the question wording and sequencing; and the physical design and layout. The advantage of using questionnaire surveys is that: they are cheap; do not require as much effort from the questioner as verbal or telephone surveys; and often have standardised answers that make it simple to compile data. The disadvantage of the questionnaire survey is that standardised answers may confuse or frustrate users (OEBC, 2001).

An important aspect of designing any questionnaire is to ensure the largest possible return, which enables meaningful analysis. A survey was used as the method for collecting data to identify innovation activities in the construction industry. A postal questionnaire was considered appropriate for the investigation in the construction organisations. To improve the response rate, several important steps were taken, they include:

Primary contact of the respondent prior to sending the questionnaire by telephone, restriction of the questionnaire to six pages, accompany the questionnaire with a cover letter explaining the purpose of the survey, enclose a stamped and returned envelope;

and companies that had not responded received written reminders with additional copies of the questionnaire.

The questionnaire essentially included the following information: background information about the respondents; company size and activities; innovation activities; business practices and strategies; and additional information.

4.3.2.1.2 Pilot Study

A pilot study for the survey questionnaire was conducted to ensure that the questions were appropriate and made sense to the target group. It covered innovation rates, types, e.g. whether its technology or advanced business practices, drivers and strategies. The objectives of the pilot study were to insure the length of questionnaire; the clarity, simplicity of the language used, and to insure it is understood by respondents. The pilot questionnaire was then sent to eight industry professionals and prominent academics. It was refined through them on the design and content of the survey. Minor modifications were made as a result of the pilot study which improved the clarity and structure of the survey questions.

4.3.2.1.3 Method of Analysis

Analysis of the data was a descriptive one, which involves the central tendencies, measuring the spread of data and plotting distribution exhibited by the sample. Creswell (1994) highlights that there is no one right way to analyse data and therefore the method that is most suited to the response data has been chosen, for example the results were analysed statistically.

It is usual respondents fail to answer some questions, this can create a problem when analysing data, this research encountered this problem and strategy used was to assign zero score for the missing data.

4.3.2.1.4 Results and Analysis

This section examines the overall responses to the survey and reports on significant cross-tabulations between survey questions. Of the 25 respondents, almost half 48% were Small to Medium-sized Enterprises (SME). This study has shown that innovation rates in the UK construction industry are comparable, to the those found in the UK Innovation Survey covering the whole of the UK. Findings from the survey indicate 66% of construction companies in the UK were innovative active. The evidence shows the importance of innovation to business success, Innovation leads to customer satisfaction, competitiveness, productivity, profit and efficiency. Although there are obstacles to maximising innovation performance e.g. the lack of recognition of a number of key determinants of innovation in construction industry, such as; investment, strategic vision, mechanisms for change and research base structure. The industry want to improve the innovation performance by adopting procedures to evaluate their innovation capabilities.

In order for construction companies to be effective in adopting procedure to evaluate their innovation capability an innovation self-assessment tool is proposed to provide a rapid online assessment of innovative practices and competencies in construction companies. The objective of the tool is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and to allow construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry. The survey questions is shown in Appendix B.

4.3.2.2 Individual, Expert Interviews (EI)

An interview is a verbal interchange, often face-to-face in which an interviewer tries to elicit information, beliefs or opinions from another person (Burns 2000) and is described as any form of interaction between two or more people. Interviews can be unstructured, semi-structured and structured. In an unstructured interview, the interviewer wants to find out about a specific topic without a preconceived plan, structure or expectation as to how they will deal with the topic (Hancock, 1998). Semi-structured interviews use a series of open ended survey questions whereas structured interviews consist of exactly the same questions in each instance.

4.3.2.2.1 Data Collection by Interview

In this research, interviews were conducted with both senior management staff in the construction industry and academics to determine the content of innovation management, performance measurement of innovation process and outline of the innovation process.

4.3.2.2.2 Interview Question Generation

Interview questions were developed for open and probing questioning (Saunders et al., 2003). This was done to reduce interviewer bias, to elicit interviewee knowledge, to help interviewees to think about their responses and to increase the required depth of response incrementally during the interview.

Semi-structured interviews were used to ensure that personal contact was established. The open ended nature of the answers and the need to be flexible with logic and order of the questioning made a semi-structured interview appropriate (Saunders, 2003). Structured interviews would have been inappropriate in this context because of the need to retain flexibility in the questioning.

The key question was Question 5 (How can innovation be measured?). The other questions were designed to guide interviewees' thinking towards that question. A number of prominent academics and industry professionals were consulted on the design and content of the interview questionnaire. The list of interview questions is shown in Appendix C.

4.3.2.2.3 Selection of Interviewees

Interviews were conducted with Atkins managers and employees to determine the content of an innovation audit, performance measures for an innovation process and outline of innovation process. The interviewees were selected to provide data from different departments in Atkins, fourteen interviewees were selected they include R&D Managers, Business Excellence and Business Improvement Managers (e.g. Junior, Middle & Senior Managers) within Atkins as identified in Table 4.6. The grade profile was generally consistent with that of Atkins overall.

Table 4.6 List of Interviewees

Grade	Respondent No.
7	13
9	10
10	7
12	9
13	14
14	4
14	6
14	5
14	12
14	8
14	11
15	2
15	1
16	3

Responses were organised into broad statements, which were identified with "junior managers", "middle managers" and "senior managers" grades. These were determined from grades 7 to 12, 13 to 14 and 15 to 16 respectively. Cognitive mapping was used to produce relevant outputs from the findings.

4.3.2.2.4 Interview Preparation

Bias and reliability issues were addressed through limiting preparation. It was considered important to find out the interviewees' awareness of innovation and this would not have been achieved if significant notice was given. As most interviewees were manager with engineering background, it was believed that they might try to find "standard" answers. To avoid this, the interviewees were told only that the interview was about innovation and that no preparation on their part was necessary. Generally, interviewees had between 1 and 5 days notice.

4.3.2.2.5 Interview Performance

The interviews were performed in an open, relaxed and informal manner, with all but one in private and one conducted by telephone. Neither of these constraints had a significant impact on the responses. Interviewees appeared to be challenged by the questions, but were normally content to provide answers. Interviews were generally conducted in available offices at known locations.

Recording was performed in most cases using a digital recorder. There were no objections to this and it provided the basis for a preamble discussion, which helped to relax the participants. The recordings were later used to prepare transcripts of interviews.

All interviews lasted approximately 30 minutes, although discussions relating to the subject elongated to 50 minutes at times.

4.3.2.2.6 Data processing

Data was processed in accordance with the stages identified by Radnor (2002, p. 84):

a)   Give each interviewee a simple code (in this case. "respondent ");

b)   Just read all the interviews (more than once);

c)   Read between the lines;

d)   Decide on all the topics ("understanding of innovation");

e)   Organise the topics;

f)   Decide on the categories within the topics (in this case, these were initially guided by the literature search);

g)   Lay out the coding sheet categories;

h)   Read all of the interviews and put a simple code to the data;

i)   Design a coding table for each topic to include all categories;

j)   Collect all of the data codes from all interviews that are particular to a category;

k)   Copy and past actual data into the table;

l)   Include multiple references that interviewees make to the same category.

4.3.2.2.7 Data Analysis and Findings

In general, there was considerable interest in the subject area, although views were mixed. For example, some believed that Atkins is good at innovation, others disagreed. A more common statement with regard to innovation was that parts of Atkins are good, but generally it underperforms.

There was a significant association between innovation and idea generation among all respondents, but limited indication that innovation also had to include a process for turning ideas into useful outcomes. This was stated clearly only one respondent;

> "*Innovation is to do with the generation of new ideas and the process of turning that into a useful outcome.*"

It was clear from other comments, however, that even the respondent placed considerable weight on idea generation as the key constituent of innovation.

4.3.2.3 Focus Groups

Focus groups are a form of group interview that capitalises on communication between research participants in order to generate data (Kitzinger 1995). It involves a group discussion on a predetermined subject, which is instigated by a researcher who usually acts as a moderator or facilitator throughout (Morgan, 1998). This means that instead of the researcher asking each person to respond to a question in turn, people are encouraged to talk to one another: asking questions, exchanging anecdotes and commenting on each others' experiences and points of view (Powell and Single, 1996). Focus groups are an established and accepted research technique for qualitative explorations of attitudes, opinions, perceptions, motivations, constraints, participation, and behaviour. The benefits of a focus group is to gain insight into people's shared understanding of the subject area and the ways in which individuals are influenced by others in a group situation (Gibbs, 1997).

The focus group method was selected to collate data from professionals in construction industry and IT experts for the development of the Innovation Assessment Tool specifically for construction companies, and also as an evaluation strategy for understanding the possible end-user perception on the adoption of the prototype application. Focus Group was therefore adopted as an evaluation strategy for understanding the possible end-user perception on the adoption of an innovation management approach.

The researcher was a member of various focus groups including: Innovation Group tasked to implement innovation issues within the company; Business improvement group tasked to identify areas of improvement and Business excellence group to develop best practice guidelines for the company and the fact that the company traditionally used these types of meetings to investigate and resolve pertinent issues has been a significant help. This is further discussed in Chapter 5.

The focus group technique provided group-depth interviews through the process of interaction as it allowed further querying of responses. Comments made during group discussion can generally be broken into three categories:

1. Things the participants liked about the prototype application

2. Things they did not like about the prototype, and

3. Suggestions for additions or extensions.

The potential participants were carefully screened through face-to-face discussions and telephone conversations. The size of the group was small to allow the discussion to go deeper into the subject. The key objective of the evaluation was identifying the potential level of acceptance for developed prototype.

The implemented prototype was designed as a proof of concept for a selected target. During the participant selection, the potential evaluators were given a brief description of the developed prototype. Successful ones received an information pack providing further details. Further briefing was also provided during the first 20 minutes of actual focus group session. The next step was discussion the agenda for the session and clarifying any issues that were unclear. In order to build a rapport in the group, participants were requested to introduce themselves and provide some information about their work. The evaluators then viewed a walkthrough of the prototype application and completed a brief questionnaire (Appendix D). A group discussion then ensued based on unstructured, open-ended questions that could be answered from a variety of dimensions (Appendix E).

4.3.3   Case Study

The case study approach is used to gain in-depth understanding of the subject, focusing on process rather than outcome, on discovery rather than confirmation (Burns 2000). A case study may combine a variety of data collection methods and research strategies (Fellow and Lui, 2003, Yin, 1994). The researcher conducting a case study attempts to analyse the variables relevant to the subject under study (Key, 1997). A case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context (Yin, 1994). As shown in Table 4.1 case study is particularly suited to answering "how?" and "why?" questions. The main advantages of a case study include richness of data and deeper insight into the phenomena under study (Hancock, 1998). The disadvantage of a case study is that data collection can be time consuming and consequently data is collected from smaller number of people than that would usually be the case for the questionnaire survey (Ruikar, 2005).

The early phase of the project was based on a review of existing literature, but as the project advanced towards developing prototype application, it became necessary to validate the theoretical concepts through the case study methodology. The case study was therefore undertaken to help understand at first hand the issues and barriers for the development of the prototype application and it was also necessary to repeatedly review the scope of the problem to accommodate constraints.

The case study approach was used to collate data from experts in the field of innovation and its management, and the evaluation of the usability of the prototype application developed. The model questionnaire is required to be completed by appropriate company staff who are aware of and supporting innovations in the construction industry. The example selected for this case study is that of a large consultants engineering company with over 16000 employees.

4.3.4 Rapid Application Development (RAD)

The final part of the research programme involved the design and development of a prototype application, which aims to provide a rapid online assessment of innovative practices and competencies in construction companies. There are various different application development methodologies, they include, Rationalised Unified Process, Extensive Programming, Reflective Systems Development (Avison and Fitzgerald 2003). RAD is a concept that facilitates the faster development of application software (Webopedia, 2004): it is performed iteratively through several stages (Ruikar, 2004; Adetunji, 2005), as illustrated in Figure 4.2.

The review of various software development methods and informal discussion with five software developers (three from within the construction industry) and two researchers at

Loughborough University provided a strong case for the selection of rapid application

development (RAD). Due to the short timescale of this research project and the need to

the design and development of a prototype application, it was decided to use the RAD

methodology, because of its speed in: gathering end-user requirements from qualitative

methods such as case studies and focus group; prototyping and early iterative user-

testing of designs; a rigidly paced schedule that defers design improvements to the next

product version; and less formality in reviews and other team communication that runs

in parallel to the software development process (Whatis, 2000). The methodology

adopted in the development of the innovation assessment tool for construction

organisations is presented below. Figure 4.1 illustrates the development of the tool.
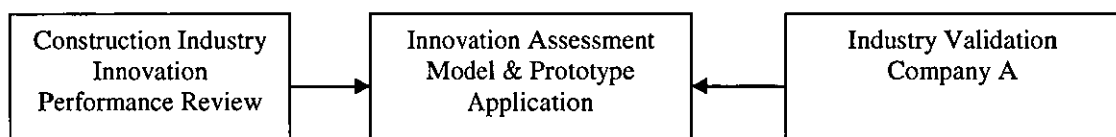
Figure 4.1: Data input for the development of the Innovation Assessment Tool.

The development of the Innovation Assessment Model involved both qualitative and

quantitative methods. This type of research methodology can also be referred to as the

triangulation method. Development of the model was carried out in several stages. The

first stage involved the development of an assessment model for gauging the

construction industry innovation performance. Using a qualitative approach, a review of

existing literature on the subject matter (i.e. innovation assessment models and tools)

was carried out Section 3.2 in chapter 3. The best suited models in the context of this

research study were then adapted to develop a model that assesses the construction

industry innovation performance. Before using the model, a pilot study for both the

model and its associated questionnaire was conducted to validate the model so that the

associated questionnaire were appropriate and obtain feedback for further refinement.

The pilot study was refined through a number of prominent academics and industry

professionals who filled in assessment questionnaire. The results of the pilot study

suggested area for improvement both the model and its associated questionnaire. Some

modifications were made as a result of the pilot study which improved the questionnaire

and the model. The outcome of this led to the development of a set of questions that

assess the overall innovation performances for construction organisations.

The second stage involved development and evaluation of a prototype application. The

development of the application was an iterative process based on Rapid Application

Development (RAD) methodology of software development (Maner, 1997). RAD is a

concept that facilitates the faster development of application software. It is performed

iteratively through several stages as illustrated in Figure 4.2.
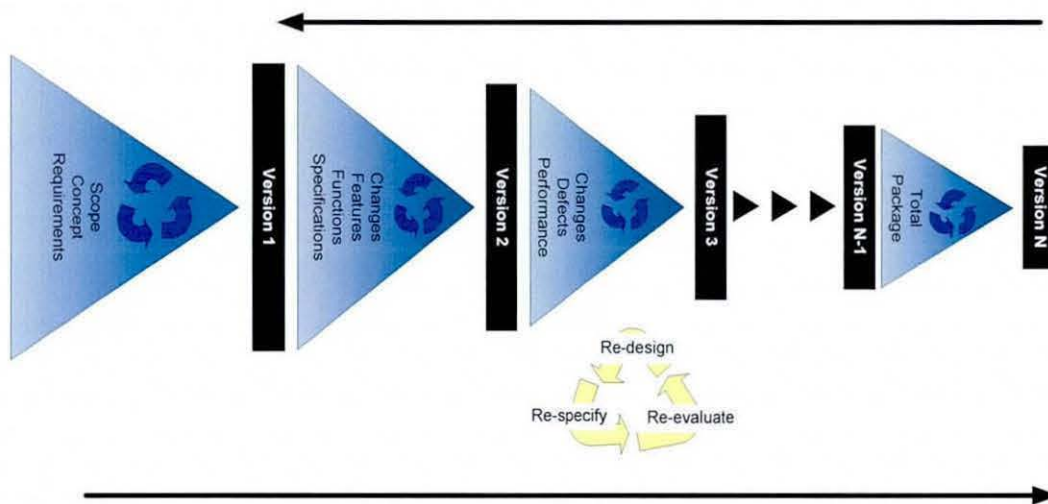
Figure 4.2. Rapid Application Development using iterative prototyping

The prototype application was evaluated using a number of methods including self-

evaluation and peer reviews during the development phase and then through industry

validation of the final prototype application. Evaluation was based on the functionality

of the prototype application, its user-friendliness, errors, and its relevance to its target audience i.e. construction companies. The evaluators were given a standard evaluation questionnaire shown in Appendix E. Evaluators were also encouraged to include and additional suggestions for further enhancing the prototype application. The result is discussed in section 5.1.2.

4.4 Summary

This chapter has discussed the main methodological approaches that were used to achieve the research aim and objectives. It provided a research map of the overall research process and justified the reasons for their selection as appropriate. The next chapter discusses the development of innovation assessment model for construction.

CHAPTER 5: DEVELOPMENT OF THE PROTOTYPE APPLICATION AN INNOVATION ASSESSMENT TOOL FOR CONSTRUCTION (ICON)

5.1 Introduction

The Prototype Application is an innovation assessment tool, which aims to provide a rapid online assessment of innovative practices and competencies in construction companies.

The development of the application was an iterative process based on the Rapid Application Development (RAD) methodology of software development (Maner, 1997). The prototype was evaluated using a number of methods including self-evaluation and peer reviews during the development phase and then through industry validation of the final prototype application. Evaluation was based on the functionality of the prototype application, its user-friendliness, errors, and its relevance to its target audience i.e. construction companies.

The Tool provides a rapid online assessment of innovative practices and competencies in construction companies. It allows construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

5.1.1 Prototype Application iCon

The iCon Application comprises a series of statements with which respondents may or may not agree to varying degrees. Statement indicators are words and sentences that describe a state of behaviour or practice, which are employed to measure practices of a particular process (Sherif, 2002). The iCon tool contains 60 statements, the purpose of which is to establish the existence or non-existence of a good innovation process.

iCon relies on the judgement of the respondent as to whether or not they agree with the statement(s) in the context of their organisation, department or business unit(s). The respondent(s) need to ensure that their responses are consistent with their assumptions e.g. if the responses are in the context of the department and not the organisation, then that assumption must be consistently reflected throughout. Individual who is aware of and supporting innovations within their business unit(s) (e.g. innovation manager, business development manager, business improvement manager, R&D manager, and technology manager etc.) must complete the assessment. The rating scales are as follows: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5, and a "don't know" option is also included, where this equates to a zero score.

Interpretation of results is based on the overall mean score of each of the six categories of the assessment (leadership, management, people, process, IR investment and technology), which involves four levels: e.g. poor, average, good, and excellent. The scores are averaged, and depending on the average score, the respondents are presented with colour key indicators (i.e. red = poor, amber = average, yellow = good and green = excellent), to visually indicate their innovation performance in each category.

- An average score greater than or equal to 1 and less than 2.4 is red. Red indicates that several aspects (within a category) need urgent attention to improve innovation practices (Poor);

- An average score greater than or equal to 2.5 and less than 3.4 is amber. Amber indicates that certain aspects (within a category) need attention to needs to address innovation issues (Average);

- An average score greater than or equal to 3.5 and less than 4.4 is yellow. Yellow indicates that certain aspects (within a category) need attention to needs to address innovation issues (Good); and

- An average score greater than or equal to 4.5 is Green. This indicates that the end-user organisation has high innovation capability and maturity (Excellent).

Users rate their organisation performance on each statement on a five-point Likert scale. The statement is graded on a scale of 1 to 5 where an average score is calculated for each category, the higher the average score the more likely it is that the end-user organisation has high innovation capability and maturity.

5.1.1.1 System Requirements

The iCon system requires a web-based tool, which collects, stores, retrieves and analyses data to generate a report for the user. This involves interaction between the web server and web database. A web-based tool enables exchange of massive volumes of information at high speed and a relatively low cost (Deng et al, 2001). Therefore iCon can be accessible to everyone who has an internet access nowadays every company has an internet access for daily day to day works. According to Roberts (1995) 'if you cannot measure it, you cannot manage it'. So the tool easily helps companies benchmark their innovation performance with peers and within the

construction industry as a whole. Figure 5.1 illustrates the functional decomposition of the iCon Application.
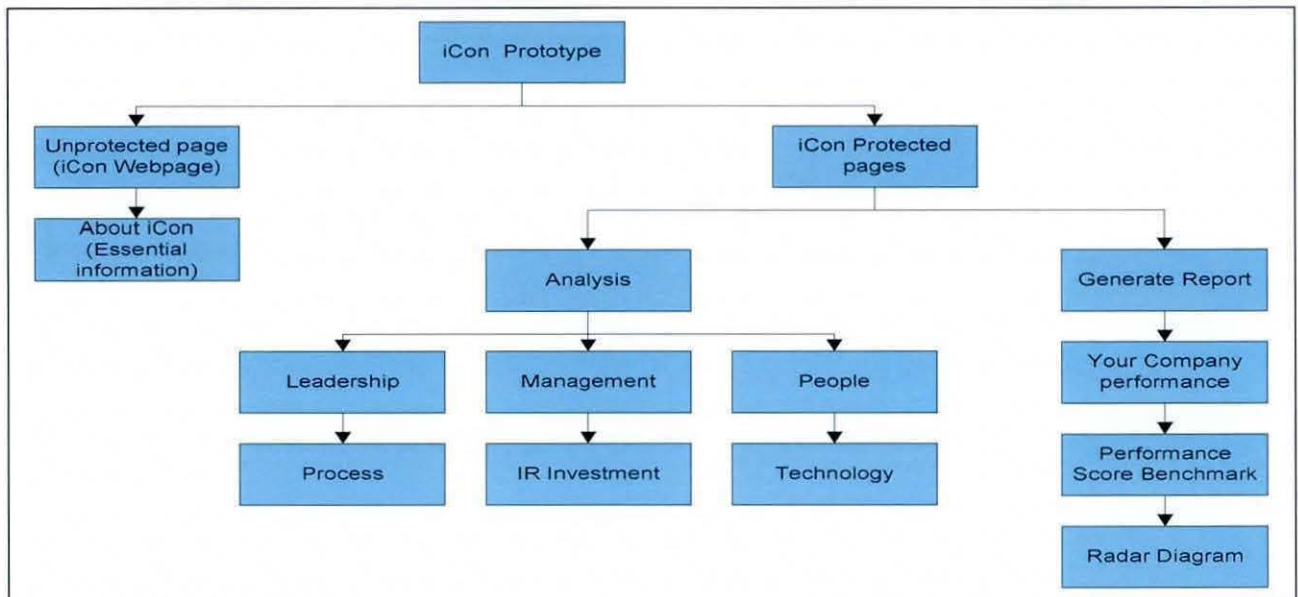
Figure 5.1: Functional Decomposition Diagram

Functional decomposition is the term used in IT to break down a process into non-redundant operations. it provides a hierarchical breakdown of the program into the individual operations, or routines, that are required.

The development of iCon requires both hardware and software specifications, which are necessary for creating dynamic web pages and system database design. Table 5.1 summarises the system requirements for the iCon Application.

Table 5.1: Summary of System Requirements

Functional requirement	Purpose
• Information	Provide information on the aim, expected outcome, benefits, how to use the tool, registration and login page.
• Registration	Collect users data (e.g. email address), Facilitate access to the protected pages
• Login	Check all questions are completed, if not state the uncompleted questions and instruct users to complete the missing questions, if yes, generate statistical and graphical report and provide text and colour coded numerical output for the users.
• Assessment questionnaire	
• Report	
Functional interface design	
Usability issues and web design guidelines (for related literature see Norman et al, 2001 and Schober, 2003)	**Basic Web guidelines:** Standardise the interface colours Use standard interface controls appropriately. Provide information on confidentiality and privacy. Provide easy access to help e.g. an email address, phone, etc. Use short and concise sentences and paragraphs. Use well-designed headings to guide the users **Navigation:** Streamline forward movement through the questionnaire while allowing backtracking to view or change answers. Reduce the branching instructions to a minimum to reduce reading time, confusion, and perceived difficulty of the questionnaire. Label links clearly and make it easy to correct mistakes. Layout: Put important information at the top and/or left-hand side of the page and make it visible at all times. Limit the use of graphics and animation. Eliminate horizontal scrolling and minimise vertical scrolling. Data Entry: Use appropriate data entry tools Label each data entry field clearly. Implement data entry validation check to ensure consistency and data integrity.
Non-functional requirement	
Scalability, compatibility and concurrent access	The system must be flexible and portable so that it can be used in any common version of web browsers. The speed of processing user requests should be within an acceptable time range. Different users in different locations can assess the system at the same time without collisions.
Software requirement	
Microsoft Windows 2000 or above	Operating system.
Web server	Server-side technology for creating dynamic web pages.
PHP	System database design.
Database server	For graphics
MySQL	For graphs/charts
	Security and data integrity (registration and log in forms)

5.1.1.2 System Architecture and Operation

The iCon System Architecture was created around a three-tier application as depicted in Figure 5.2, which shows the IProNET system. The first tier is the presentation tier, which involves the client browser software. The tool is compatible with all standard web browsers. The second level is the middle tier that contains the application logic. The web server, the scripting engine and scripts reside in this tier. The web server is a piece of software that manages forward and backward data communication between the client and database tiers. The third tier consists of a Database Management System (DBMS) for managing and storing created, modified data and retrieved data for the end user.
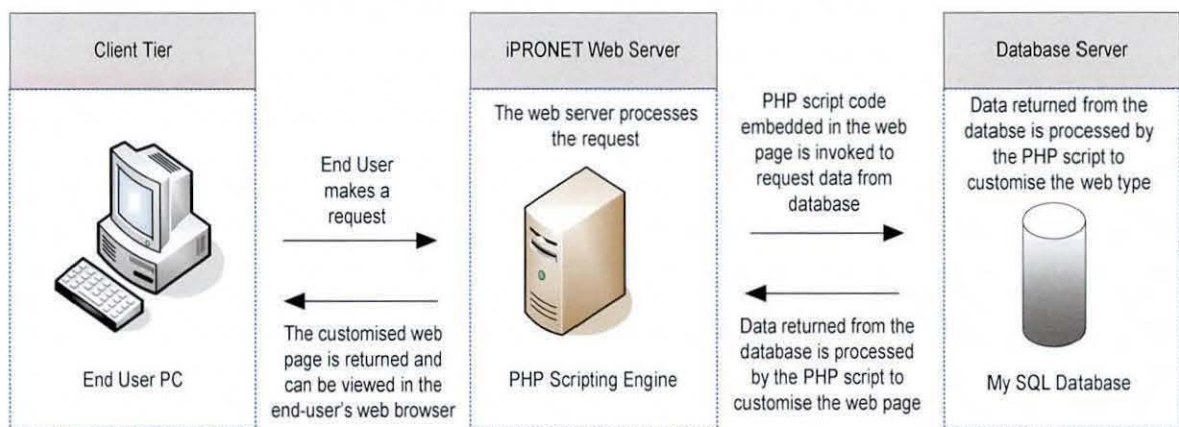
Figure 5.2: IPronet Architecture and Operation – to be adopted within the iCon prototype (Source: Williams and Lane, 2002)

iCon has been developed using Hypertext Pre-processor (PHP) as the scripting language because it is open sources. The front-end of the iCon prototype is designed using iProNET. iProNET is collaborative internet based Project Network System. It allows 'virtual team members' to collaborate on projects in a protected environment, sharing folders and files, tracking activity and creating websites. iProNET management has supported this study in the from of hosting iCon on the iProNET collaboration system, and offered guidance as appropriate.

The application mainly consists of a series of web-based questionnaire forms that can be accessed by the end-user(s) using standard web browsers such as Microsoft Internet Explorer. Any information that is added to these forms is stored in the MySQL database. The iCon system resides on the iProNET server with which the end-user communicates; this forms the core of the middle tier. The iCon prototype design conformed to the functional decomposition depicted in Figure 5.1 and summary of the system requirements in Table 5.1.

5.1.1.3 iCon Prototype Features and user experience

The iCon prototype consists of protected and unprotected pages as depicted in the functional composition diagrams (Figures 5.3, 5.4). The unprotected page forms the iCon home pages shown in Figure 5.3. It provides essential information on the aim, expected outcomes, benefits and how to use the tool. Users are expected to read the front page before using the tool.
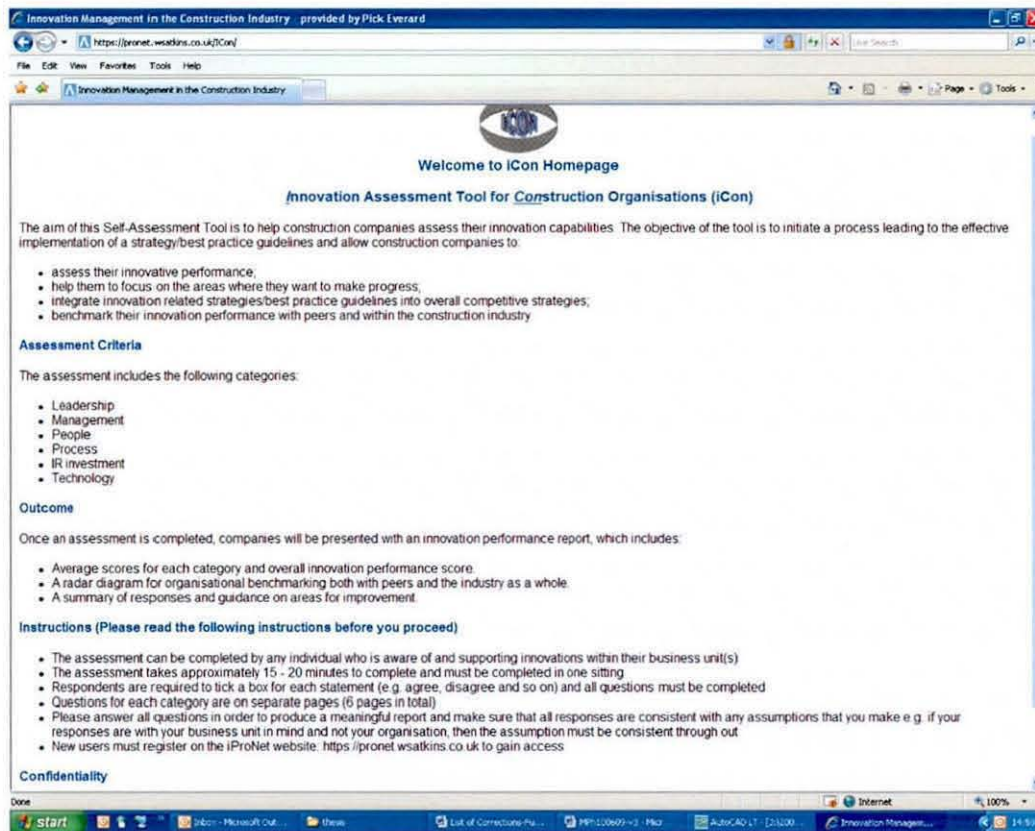
Figure 5.3: iCon Home Page: Front Page

To start the assessment, new users must register on the iProNet website: https://pronet.wsatkins.co.uk to gain access. Figure 5.4. shows the Login Page.
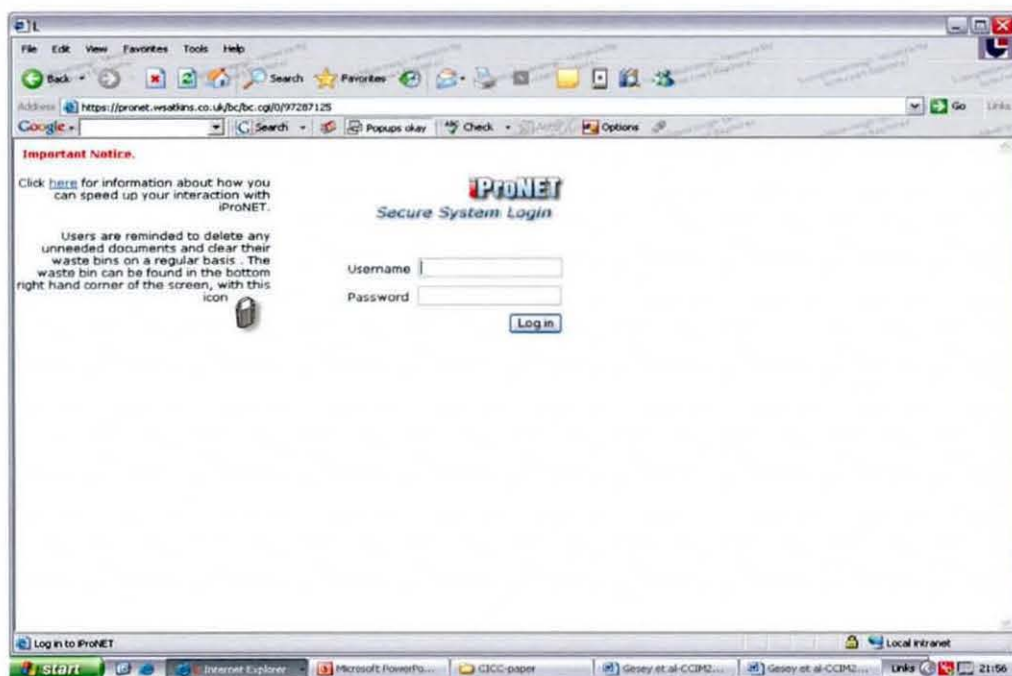
Figure 5.4: The iCon Login Page

The Login page provides access to protected pages (e.g. assessment questionnaire and report). The first page collects employee information as depicted in Figure 5.5.
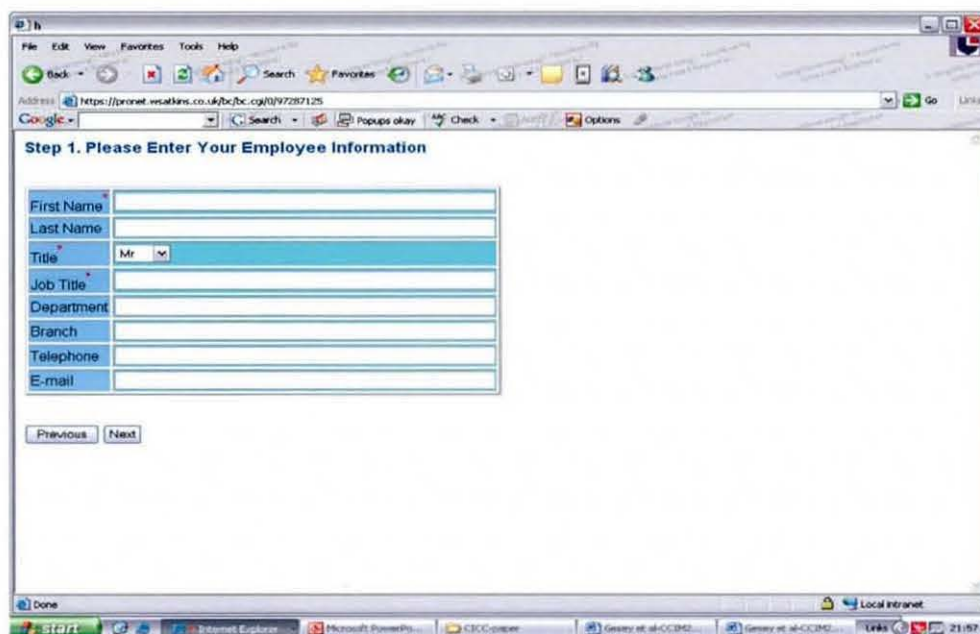
Figure 5.5: iCon Employee Information Form

The questionnaire assessment pages are password protected and on successful login, the system checks the database and populates the assessment questionnaire pages with the user's previous data. The system facilitates creating, storing, modifying and retrieving data; hence the assessment can be completed in one sitting. Also, the system allows forward and backward navigation within the assessment pages to view and change answers. In all, the assessment consists of five steps, which are background information, employee and company information, assessment questionnaire, summary of responses and performance score matrix. The second page collects company information as depicted in Figure 5.6.

Figure 5.6: Company Background Information Form

Types of business, annual turnover and number of employees are implemented for the company information form in Figure 5.6 based on the user's selected option from the drop down boxes (e.g. type of business and annual turnover). A typical questionnaire page as shown in (Figure 5.7) consists of a series of statements relevant to each critical factor and the corresponding category. The users rate their organisation performance on each statement on a five-point Likert scale.

Figure 5.7: Typical Assessment Questions in iCon

Even though the system allows users the freedom to navigate forward and backward after completing all the questions on each page, it does ensure that all questions are completed before the report can be generated. Therefore, on clicking the 'Get Report'

link, the system checks the database and generates the total of the number of questions for each category. Once completion of the assessment the system calculates the mean score of each category and users are automatically presented with a report of their performance and interpretation of their results.

5.1.1.4 Summary of Mean Score

The final part of the report summarises individual organisations mean score on each critical factor and highlights each mean score (red, amber, yellow or green) depending on performance. This establishes areas of improvement and enables organisations to focus on specific critical factors for improvement.
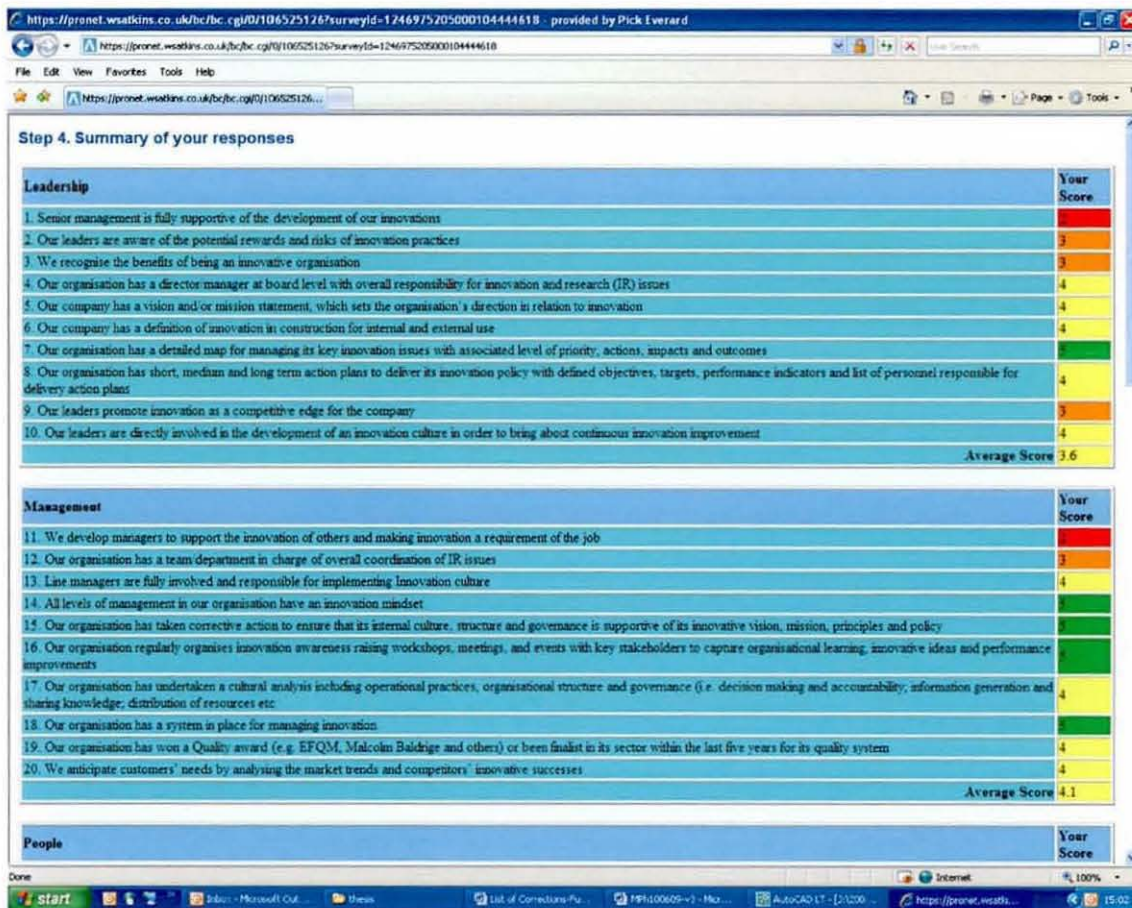
Figure 5.8: Output from iCon: Summary of Mean Scores

5.1.1.5 Mean Scores of each Category with Colour Coding

This part of the report collates the mean scores for the user on each category (i.e. leadership, management, people, process, IR investment and technology) and the total mean score, with interpretation of scores as illustrated in Figure 5.9. It benchmarks each mean scores of individual organisations for each category with peers of similar business types (e.g. clients), group types in terms of turnover, as well as the industry as a whole. In this way, the user or their firm can obtain a view of their relative innovation performance.

Your performance matrix score

Category Name	Mean Score		
	Your Company	Peers	Construction Industry
Leadership	2.5	2.8	3.2
Management	2.3	2.9	3.2
People	2.0	2.9	3.2
Process	2.5	2.9	3.2
IR Investment	2.5	2.9	3.3
Technology	2.1	2.9	3.2

Figure 5.9: Benchmarking of performance with peers and industry as a whole

5.1.1.6 Radar Diagram of Performance Benchmarking

This part presents the graphical illustration of the benchmarking. The mean scores are plotted on a Radar diagram as depicted in Figure 5.10. (i.e. leadership, management, people, process, IR investment and technology). It benchmarks each mean scores of individual organisations for each category with peers of similar business types (e.g. clients, consultants), group types in terms of turnover. The Radar diagram gives the respondents a visual representation of their overall innovation performance (shown in blue), in comparison with peers (shown in red) and the construction industry as a whole (shown in green). In this way, the user or their organisation can obtain a view of their relative innovation performance.
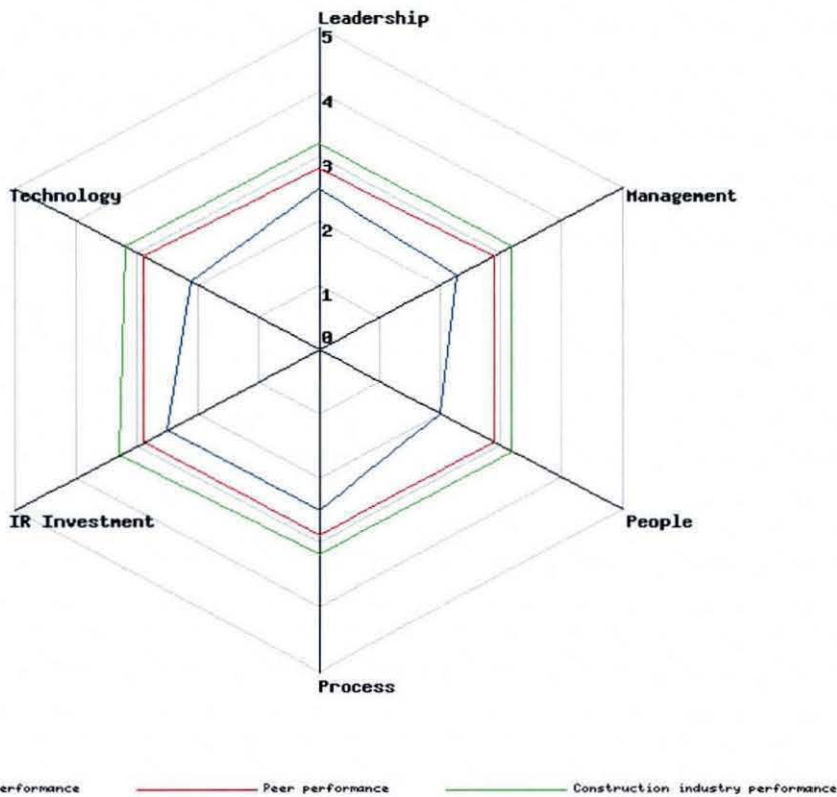
Figure 5.10: Radar Diagram of Performance Benchmark

5.1.2 iCon Evaluation Study

The innovation assessment model and the prototype application were evaluated using an independent panel of reviewers including academic researchers and industry practitioners who are aware of and supporting innovations in the construction industry. The bases of evaluation and validation were effectiveness, usefulness, applicability, its relevance to its target audience i.e. construction industry and also suggestions for improvement. This was involved a presentation of iCon model and completion of a structured evaluation and validation questionnaire using a five-point scale and open questions for comments on area for improvement and were encouraged to make any additional suggestions in each category. A total of 25 samples evaluated the iCon model, these include 20 managerial staff from different construction companies and five academic researchers. The outcome of the evaluation is depicted in Figure 5.11. The evaluation questions includes (i) the effectiveness of the questions in capturing the overall innovation issues; (ii) the formulation and easy to understand each aspect of the questions; (iii) the extent to which the different categories capture overall essence of innovation issue; and (iv) the usefulness of the model to aid organisation innovation implementation process within the construction Industry. iCon Model Evaluation and Validation Questionnaire is shown in Appendix E.

iCon Prototype Evaluation Responses

Percentage of Respondents

Legend:
- Excellence
- Very good
- Good
- Average
- Poor

Questions

1- effectiveness of the questions in capturing the overall innovation issues
2- formulation and easy to understand each aspect of the questions
3- extant to which the different categories capture overall of innovation issues
4- usefulness of the model to aid organisation implementation process with the construction industry
5- a good assessment tool
6- easy to use
7- easy to navigate
8- error free
9- overall assessment of iCon prototype application

Figure 5.11: iCon Model Evaluation Responses

The open-ended questions of the evaluation explored how the model could be improved. Among various comments are as follows.

- *Teams here have a lot of discretionary power: If teams have discretionary power wont that affect the 'effectiveness' of the leader?*

- *Management: Our organisation regularly organises innovation awareness raising workshops, meetings, and events with key stakeholders to capture organisational learning, innovative ideas and performance improvements. How do an organisation's innovation awareness programmes ensure that the management is innovation ready? Might need to rephrase the question.*

- *Our company has fully implemented an accredited Total Quality Management (TQM) system e.g. ISO 9000, EFQM or similar for its operation. Having an ISO or similar accreditation does not necessarily ensure quality is achieved, but merely a tick on the 'right' box.*

- *Questions 3 and 32 are almost identical. This can have implications on the final 'readiness score.*

The results of the iCon evaluation suggested for improvement within the iCon statements, some of the evaluators suggested to reduce the statements and to rephrase some of the statements for the model they though this can have implications on the final score for each category if they are not rephrased.

Such suggestions have been taken on board and the current iCon model reflects this, e.g. some of the statements were rephrased and reduced to 60 instead of 90 statements. This will reduce the time it takes to use the model. The overall evaluation results indicate that the model is an effective and useful tool, which provides a means for construction companies to assess their innovation practices and competences.

For the prototype, evaluators were also asked to make comments how the prototype application could be improved. Evaluation was based on the functionality of the prototype application, its user-friendliness, presence of any errors in content or links, and its overall relevance to construction industry. They were impressed with the prototype application, the feedback from evaluators has been positive to quote some of the reviewers' various comments are as follows.

- *'A novel way to review innovation in organisations and to stimulate improvements. Could also be a benchmark process e.g. do again in 6 months and check for (hopefully positive) changes'.*
- *'It helps companies pinpoint the areas where they can improve innovation'.*
- *'Fast, effective and easy to use'.*

- *'Not time consuming... results are informative and reflects/highlights differences'.*

- *'Gives you an idea of how good your company is for innovation'.*

In general, the evaluation findings highlighted that the model addresses aspects that construction organisations need to become an innovative organisation and to stimulate improvement.

5.1.3 iCon in-Company Testing Evaluation

Besides the useability evaluation, an industrial evaluation was conducted by managerial staff, (e.g. business development, improvement & innovation managers, and also business analysts) from one of the largest and leading UK construction companies (e.g. UK owned consultants, technical staff and turnover), identified herein as Company 'A'. Company A is one of the world's leading providers of professional, technologically-based consultancy and support services. Company delivers total solutions for public and private sector clients in the following key markets worldwide: rail, highways and transportation, telecoms, nuclear, aviation, defence, water, power, oil and gas, health, education, and manufacturing. With over 16,000 employees worldwide - 12,500 of whom work in the UK. With a turnover of £1.4bn, the company is:

1. the largest engineering consultancy in the UK

2. the largest multidisciplinary consultancy in Europe, and

3. the 3rd largest design firm in the world.

The company can offer public and private sector clients worldwide a broad portfolio of skills embracing engineering consultancy, design, planning, management

consultancy, IT, asset management, environmental services, expert services, project finance, project and cost management, programme management, and property agency services (Source: Company website, 2007).

A total of eight departments from Company A were approached to use the prototype application to assess their innovation capabilities. Table 5.2 presents the findings on innovation capabilities of Company A's different departments, the findings also include the average scores of each department in the categories of leadership, management, people, process, IR investment and technology.

Table 5.2: Average scores achieved in Company 'A'

Company A: Department Numbers	Average scores for each category					
	Leadership	Management	People	Process	IR investment	Technology
1	2.80	2.27	3.33	2.87	2.53	2.87
2	3.87	3.07	3.00	3.00	3.60	3.13
3	3.67	3.80	3.87	3.33	3.87	3.53
4	4.33	4.13	4.13	4.33	4.27	4.87
5	3.60	3.87	4.00	3.60	3.80	3.00
6	4.20	3.67	4.27	4.07	3.53	3.87
7	2.67	2.53	3.33	1.27	2.67	1.00
8	3.07	2.60	2.40	2.80	3.27	3.13
Average Scores	**3.53**	**3.24**	**3.54**	**3.16**	**3.44**	**3.18**

It can be seen from Table 5.2, on average in all the departments, process is the lowest score followed by technology compared to the other categories. Department Seven has the weakest level both in terms of process and technology. This indicates that certain aspects within those categories need urgent attention to improve innovation practices and issues. Most departments are innovative active in the leadership and people categories. However, they need to address certain aspects to improve innovation.

Overall, Company A is probably good at innovation, but this is not easy to recognise and confirm. There is a lack of understanding of innovation and there are clear areas of improvement for some of the departments and the company as a whole, particularly with regard to creation of a strategy, process and climate for innovation. Individual department and the company as a whole need to be addressed for innovation to progress.

5.1.4 iCon's Subsequent Adoption within Company A

Company A showed an interest for further development of iCon in terms of its wider use and benefit for the company itself and the construction industry. An article about the tool (iCon) was published in the company's internal magazine (see Appendix G and the iCon tool itself was also short-listed for the company's business excellence innovation award for last year 2007 (see Appendix G)

5.2 Summary

This chapter has explained the development of the iCon assessment model, the design, development and implementation of iCon prototype application; a web based self-assessment tool for construction companies. In so doing, a number of findings can be made and some specific conclusions drawn, which are covered in the next chapter, Chapter Six.

CHAPTER 6:   SUMMARY AND CONCLUSIONS

6.1   Introduction

This chapter presents the research undertaken to meet the aim and objectives of this research project (which were given in Chapter One) and it also highlights the main findings of the research. The research was undertaken using the methodological approaches described in Chapter Four and it has been divided into three parts as stated in Table 4.5. It provides critical evaluation of the research, recommendations and further work. Finally, the chapter presents the overall conclusions of the research.

The project's aim was achieved through the development of an Innovation Assessment Model and Prototype Application for construction companies. A working Innovation Assessment Tool (iCon) can be found at: https://pronet.wsatkins.co.uk/ICon/.

The specific objectives of the project were to:

- investigate the drivers and barriers to the development of a culture of innovation;

- review theoretical and industrial models of innovation in the construction industry; and develop an innovation model for use in the construction industry

- explore methods for assessing innovation capabilities and develop a prototype application/tool for construction organisations; and,

- Evaluate the usability of the tool such that it can be adopted easily into construction organisations.

The project's objectives are discussed in the next sub-sections.

6.2 Investigate the Drivers and Barriers to the Development of a Culture of Innovation

This involved the preliminary phase of the research where an initial literature review was undertaken to investigate the drivers and barriers to the development of a culture of innovation both in construction and other industry sectors. This was achieved through an extensive and critical review of literature on innovation, the attendance of seminars and workshops, and through the expert focus group. These resulted in a better understanding of the development of innovative strategies for enhancing the construction industry's competitiveness through the implementation of innovation culture; they facilitated a means through which the existing culture of innovation could be analysed and identified appropriate methods to devise and implement improvements.

It has been well documented that current construction industry culture is adversarial: professions are fragmented (Egan, 1998; Lottaz et al., 2000) and information insensitive (Gajendren, et al., 2004; Thomas et al., 2001; Tam, 1999), creating divisions in background, culture, learning styles and goals. The R&D base is fragmented, patchy in quality and in size, and because of these above reasons, the industry will find it difficult to attract and retain talented people in the future (Fairclough, 2002). To improve the situation the development of a culture of innovation is of utmost importance if a business is to become universally proactive, and remain successful (Steele and Murray, 2001). It is clear from the literature that investment (both human and financial) in a knowledge-based innovation management method that facilitates both top-down and bottom-up approaches could be an appropriate option for construction companies (Gesey et al., 2005a). UK Construction Industry needs to understand Culture, Skills and

R&D investment and its relationship within innovation if they want to be successful. Figure 6.1 below represents the overall skills, culture and R&D investment and its relationship within innovation in the construction industry.
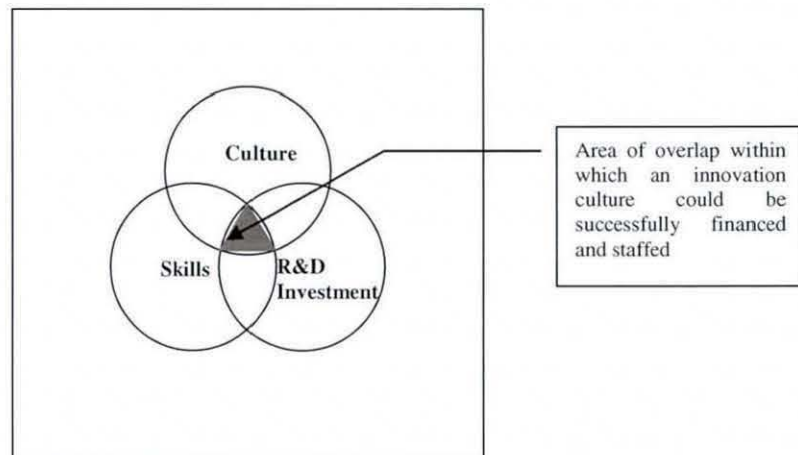
Figure 6.1 A proposed model in search of 'innovation Chemistry' (after Nicolini)

Areas where all three elements overlap represent the opportunities where innovation can be exploited. A good understanding of the relationship between culture, skills and R&D investment is fundamental to practical application of innovation in the construction industry. The successful innovation culture can arguably be financed and staffed at this overlap, i.e. the successful formula or chemistry (Nicolini, 2002).

Specific areas within innovation in the construction industry reviewed (Gesey et al, 2005a), reporting on key literature on culture, R&D investment and skills requirements as they relate to innovation. The construction culture is a major factor in many of the ills faced by the industry; the mismatch of skills supply and demand could prove to be serious for the construction industry and the amount of investment funding available for construction research has also been steadily declining in recent years (Gesey et al, 2005a).

Chapters Two provides extensive coverage of the literature. In summary its findings were innovation is mostly focussed on product development. There is a lack of agreement on benchmarking and there is no national or international guidance for innovation in the construction industry. As such, the literature does not really provide a clear basis for innovation management practices in the construction industry. Hence, a review of existing assessment tools found that the BEACON and VERDICT readiness assessment tools could provide the theoretical basis for the development of an innovation assessment model (iCon) to address these problems.

6.3 Review Theoretical and Industrial Models of innovation in the Construction Industry

It was pertinent to review theoretical and industrial models of innovation in the construction industry so that a better understanding could be achieved. Numerous research projects have attempted to characterise technological innovation and explain how it works. Various techniques were used to capture and analyse data, these included a literature review, focus group and survey questionnaires and interviews. These helped to identify the most influential models, sets out the evolution of these models, their advantages and limitations.

There are various models that attempt to explain how the innovation process works in practice and it is useful to present the evolution of these various models and their limitations. These models are discussed in detail in chapter 3 and Gesey et al, (2005b).

6.3.1 Innovation activities within the construction companies

Survey was conducted to explore innovation activities within the construction industry. The evidence shows the importance of innovation to business success, innovation leads to customer satisfaction, competitiveness, productivity, profit and efficiency. Although there are obstacles to maximising innovation performance e.g. the lack of recognition of a number of key determinants of innovation in construction industry, such as; investment, strategic vision, mechanisms for change and research base structure (Fairclough, 2002).

This study has shown that innovation rates in the UK construction industry are comparable, to those found in the UK Innovation Survey covering the whole of the UK. Findings from the survey indicate 66% of construction companies in the UK were innovative active. The industry wants to improve the innovation performance by adopting procedures to evaluate their innovation capabilities.

In order for construction companies to be effective in adopting procedure to evaluate their innovation capability an innovation assessment model/tool was developed to provide a rapid online assessment of innovative practices and competencies in construction companies. Innovation activities and levels are measured based on technological and advanced business practices presented in the survey questionnaire (Appendix B).

6.4 Explore methods for assessing innovation capabilities and develop a prototype application for construction organisations

This was achieved through a detailed literature review, and semi-structured interviews, focus group, including web-based search and review of academic literature. A pilot study was carried out with a number of prominent academics and industry professionals as mentioned in Section 4.3.2 The results of the pilot study suggested areas for improvement with the model and its questionnaire, e.g. it was suggested a four level assessment scale, namely: poor, average, good and excellent, should be included in the assessment. The development of innovation assessment model for construction companies is presented in chapter 3.

6.5 Evaluate the Usability of the Innovation Assessment Tool

Evaluation is an integral part of the development process, it is therefore, imperative that a clear plan for the evaluation is established at the onset and factored into each step of the development process (Whitten and Bentley, 1998). In this case, evaluation was based on the functionality of the prototype application, its user-friendliness, presence of any errors in content or links, and its overall relevance to construction industry. Evaluators were given a standard evaluation questionnaire and were encouraged to make any additional suggestions in each category.

A two basic stages approach were adopted for evaluating the iCon model and prototype application. The first stage involved development and evaluation of the model. The second stage was an industrial evaluation. The findings are discussed in the next sub-sections. The research findings are discussed in detail in section 6.6.

6.6 Summary of Research Findings

There is evidence that the industry is attempting to move away from its adversarial and fragmented nature but it is a slow process with many traditional attitudes currently remaining. The culture within the construction industry is a major factor in many of the ills faced by the industry. Therefore, understanding this culture is likely to be a significant step towards identifying why management of innovation in construction has so many problems.

Having defined innovation as a core process concerned with renewing what the organisation offers (its product and /or services) and the ways in which it generates and delivers these (Tidd et al, 2001). It is apparent from the definitions that innovation can be given different meanings in different contexts, mainly in product and process innovations. Product innovation refers to the new or improved product or service that is successfully exploited on the market. On the other hand process innovation involves the adoption of new idea leading to profitable change.

The literature review also describes factors that either push or impede innovation and its progress in the construction industry such as: organisational culture, human and management factors, low investment in R&D, client, manufacturers, conservatism, and innovation brokers. In order that the construction industry becomes innovative it should recognise value of embedded knowledge within its own workforce to realise more effective buy in and take up of innovation.

The level of understanding of innovation has improved significantly over the past five decades and during that time a variety of models of innovation have emerged. For example, by categorising innovations in construction via type (e.g. incremental, radical or system innovations) or process (e.g. whether the innovation is radical or incremental).

The literature review also identifies various different models that attempt to explain how the innovation process works. Rothwell (1992) classified the models into five generations. For example, first generation: technology push; second generation: market pull; third generation: coupling model; fourth generation: integrated model; and, fifth generation: network model. The strengths and weaknesses of these models were examined and a conceptual framework was presented in this thesis that stressed the linkages between these models.

This project investigated the drivers and barriers to the development of a culture of innovation in the construction. To achieve this, the research reviewed specific areas within innovation in the construction industry, reporting on key literature on culture, R&D investment and Skills requirements as they relate to innovation. Literature review revealed that the industry is attempting to move away from its adversarial and fragmented nature but it is a slow process with many traditional attitudes currently remaining. The culture within the construction industry is a major factor in many of the ills faced by the industry Gesey, M et al (2007a). The survey found that innovation rates in the UK construction industry are comparable, to those found in the UK Innovation Survey (2005) covering the whole of the UK. Findings from the survey indicate 67% of construction companies in the UK were innovative active.

The evidence shows the importance of innovation to business success, e.g. innovation leads to customer satisfaction, competitiveness, productivity, profit and efficiency.

Although there are obstacles to maximising innovation performance e.g. the lack of recognition of a number of key determinants of innovation in construction industry, such as investment, strategic vision, mechanisms for change and research base structure.

Of the surveyed organisations it can be seen that the main factors that drive innovation was improving performance (84%). Cost reduction, responding to client demands and improving quality were the second most important drivers, each nominated by 72% respondents. On the other hand, the most common barrier to adopting innovation was insufficient benefits/difficult to justify/unclear business cases, nominated by 68% of respondents. Cost of initiate, lack of R&D investment, conservative stakeholders/clients were the second most typical innovation barriers, nominated by 60%, and 40% respondents respectively.

The findings indicate that the most important components are to improve client relations and company culture, followed by profitability and higher turnover. Therefore, understanding the culture is likely to be a significant step towards identifying why management of innovation in construction has so many problems. The industry wants to improve the innovation performance by adopting procedures to evaluate their innovation capabilities. In order for construction companies to be effective in adopting procedure to measure their innovation capabilities an innovation assessment tool was developed to provide a rapid online assessment of innovative practices and competencies in construction companies.

6.7 Recommendations and Further Work

Innovation is complicated, it rarely proceeds in a straight line and it needs to be organised. The focus of this research was to explore ways of promoting culture of

innovation in the construction industry. Managing innovation is more to do with cultural change, new ways of working and it needs to be treated as a continuous improvement initiative. It is necessary to develop closer links with government (DTI), universities (e.g. engineering departments), construction organisations and other industry participants for innovation. This need to be done as part of a wider move to establish innovation and its management as industry concern. Without this, the risks associated with innovation will tend to prevail in construction and it will continue to be an individual activity. This appears to be daunting task, but the Centres such CICE can take a lead by facilitating the creation of an integrated leading environment and bringing construction industry, academia and the government in particular the DTI with the provision of innovation workshops and seminars to create an innovation culture for the construction industry. Furthermore Construction organisations need to establish an R&D community with the industry. Government also should increase R&D investment and encourage construction companies to collaborate with each other and with academia.

This research has successfully demonstrated the potential of the iCon Prototype Application to construction organisations. Based on the research findings and the limitation of the research, the following section makes recommendations for further research and proposes further improvements for the existing tool iCon.

- Due to the many statements of the assessment, there is a need to develop a weighting factors so that each companies could select the most appropriate statements for their organisation.

- Further research could investigate whether companies' innovation performance has improved in relation to their competitiveness since adopting the iCon model and using the prototype application.

- The iCon prototype application base data for end-users to benchmark against is small, as it stands, further research is required to collate base data from other construction companies.

- The iCon prototype application highlights areas that need consideration for improvement. There is a need to develop innovation framework that provide steps and guidance to address these issues.

- The identification, development and integration of a knowledge-based, expert system into iCon prototype application to provide expert advice on innovation best practice (or conversely, the integration of Icon into an existing knowledge management system).

- If iCon is to be used as innovation assessment tool for construction, there is a need to better understand how companies decide on which categories (e.g. people, technology etc) to benchmark against.

- The iCon has been developed as an innovation assessment tool, so there is a need to review the effectiveness of such tool in actually delivering 'innovativeness' for construction organisations.

6.8 Critical Evaluation of the Research

The quality of research findings relate to the subjectivity of the research methodology, and the relatively small sample size that is inherent in this type of data collection. The general correlation with the literature underlines the value of this research, therefore the phenomenological paradigm that was used was subjective, with views being elicited, rather than hard data captured (Collis and Hussey, 2003). The researcher interacts with

the research, which is value laden, and biased as discussed in chapter one. The main limitations of this research project pertain to the enormity of the given subject 'Innovation', considering that the research was spread over three years. Some of the main research limitations are summarised as follows:

- The applicability of the iCon prototype application has been evaluated and tested on just one company. Although the company can be said to reasonably represent certain aspects of the construction industry, by no means is it wholly representative – particularly in respect of company size, this research may not necessarily meet the needs of SMEs.

- The iCon prototype application highlights areas that need consideration for improvement. However it does not provides information on the steps that need to be taken within a company to address these issues. This could be addressed by providing guidance for improvements. Indeed, an innovation framework should be developed outlining innovation strategy and methods for implementing innovation.

6.9 Summary

This chapter summarised the findings of this research project and discussed its impact on the industrial sponsor and its implications for the wider construction industry including the evaluation results of the prototype application. This thesis together with supporting evidence in the appendices provides the achievement of the research aim and objectives.

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APPENDIX A: PAPERS PRODUCED DURING THE COURSE

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Gesey, M., Glass, J., Bouchlaghem, N.M., and Murray, M (2005b). Innovation models and the construction industry , published in: Sariyildiz, S. and Tuncer, B. (eds.) Proceedings of the 3rd International Conference on Innovation in Architecture, Engineering and Construction, Rotterdam, The Netherlands, 15-17 June 2005, published by Delft University of Technology, The Netherlands, pp. 449-457 (Volume I). ISBN: 90-8559-057-4.

Gesey, M., Glass, J., and Bouchlaghem,N.M.(2006) Developing an Innovation Assessment Tool for Construction Companies, published in: Dulaimi, M.(ed.) Proceedings of the Joint International Conference on Construction Culture, Innovation and Management (CCIM), 26-29 November 2006, published by The British University in Dubai (BUiD),United Arab Emirates, pp. 32-42. ISBN: 0-947974 53 9

.**Gesey, M.**, Glass, J., Bouchlaghem, N.M. (2007a) *"Identifying the successful innovation and advanced business practises in the construction industry"* Proceedings of the 3rd conference for Postgraduate Research of the Built and Natural Environment, (PRoBE), Glasgow, UK 20th-22nd November 2007 pp 159 -168. ISBN: -13 978-1-905866-17-5

Gesey, M., Glass, J., Bouchlaghem, N.M. (2007b) "iCon: A web-based innovation assessment tool for construction organisations" Proceedings of the 3rd conference for Postgraduate Research of the Built and Natural Environment, (PRoBE), Glasgow, UK. 20th-22nd November 2007 pp 159 -168. ISBN: -13 978-1-905866-17-5

SUPPORTING DOCUMENTS

APPENDIX B: INNOVATION SURVEY

QUESTIONNAIRE

Dear Mr/Ms

Re: Reviewing theoretical and industrial models of innovation within the construction industry

The Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University in conjunction with the EMCBE is undertaking research to develop an innovation assessment model and a prototype application for construction organisations to provide a rapid, online assessment of innovative practices and competencies in construction companies.

.

To help establish current theoretical and industrial models of innovation we would be grateful if you could spare just 10 - 15 minutes of your time to complete the enclosed questionnaire and return it using the reply paid envelope. The survey will provide useful insights into innovation practices within the construction industry and assist with the identification of frameworks, best practice, lessons learned, enablers and barriers to innovation. The results of the survey will be used to develop strategies to enhance the construction industry's competitiveness and promote innovation in the industry.

Please note that responses will be dealt with in the strictest confidence and findings and analysis will be provided to all who respond.

If you feel that you are not best placed to complete this questionnaire, please feel free to forward it on within your organisation.

If you require any further information, please do not hesitate to contact me. Otherwise I look forward to receiving your response.

Yours sincerely,

Maxmood Gesey
Centre for Innovative and Collaborative Engineering (CICE)
Department of Civil & Building Engineering
Loughborough University
Loughborough
Leics LE11 3TU

Innovation Survey Questionnaire   **CICE**

INNOVATION MANAGEMENT IN THE CONSTRUCTION INDUSTRY

The Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University is undertaking research on innovation in construction to review theoretical and industrial models of innovation in the construction industry.

The survey will provide insights into successful innovation models within the construction industry. It should take about 10 – 15 minutes to complete. Your response to this questionnaire is highly valued and will be treated with the strictest confidence and it will be used for academic purposes only. Your details will not be passed to any other organisation. Thank you

It should take about 10 – 15 minutes to complete. Your response to this questionnaire is highly valued and will be treated with the strictest confidence and it will be used for academic purposes only. Your details will not be passed to any other organisation. Thank you.

   I.   *Please note: IF a small box appears on your screen called Exit Design Mode, please click the blue triangle before trying to fill out the form.*
   II. *The free text boxes are not limited – you may write as much or as little as you wish.*

BACKGROUND INFORMATION

Contact Name [   ]   Tel [   ]

Position/role [   ]   Email [   ]

Organisation [   ]

Total number of employees [   ]   Annual turnover (Approx) £ [   ]

SECTION 1. COMPANY SIZE AND ACTIVITIES

1.1 How would you describe the size of your company?

☐ Small (0 – 10 employees)   ☐ Medium(11 – 500 employees)   ☐ Large (> 500 employees)

1.2 What is/are the geographical area(s) of operation for your company?

☐ Scotland   ☐ North East   ☐ West Midlands   ☐ London

☐ Northern Ireland   ☐ Yorkshire & Humber   ☐ East of England   ☐ South East

☐ North West   ☐ East Midlands   ☐ Wales   ☐ South West

☐ Other (please state below)

[   ]

1.3 Which of the following describes your company's main business?

☐ Architect   ☐ Client   ☐ Consultant   ☐ Construction Manager

☐ Contractor   ☐ Main Contractor   ☐ Project Manager   ☐ Specialist Contractor

☐ Supplier   ☐ M&E Engineer   ☐ Civil Engineer   ☐ Structural Engineer

1.3 Which of the following describes your company's main business?

☐ Architect ☐ Client ☐ Consultant ☐ Construction Manager

☐ Contractor ☐ Main Contractor ☐ Project Manager ☐ Specialist Contractor

☐ Supplier ☐ M&E Engineer ☐ Civil Engineer ☐ Structural Engineer

☐ QS ☐ Planning ☐ Other

If other, please describe the nature of your company's business:

1.4 Does your organisation have in-house resources dedicated to innovation and research or R&D?

☐ Yes ☐ No ☐ N/A

If yes, please describe briefly

1.5 What mechanisms do you use for investing in R&D? (e.g. top slice of profits; R&D tax credits) Please state below

1.6 How much approximately as a (%) of turnover was invested on R&D in:

2000 [ ] 2002 [ ] 2004 [ ]

1.7 Does your organisation have, or has it ever had any links with higher educational institution(s) within the East Midlands ?

☐ Yes ☐ No ☐ N/A

If yes, which one(s) and in what capacity (i.e. sponsor, collaboration)?

1.8 Has your organisation successfully implemented any research output from academic institutions/research companies/

☐ Yes ☐ No ☐ N/A

If yes, please describe briefly what the implementation was and the organisations involved

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CICE

SECTION 2. INNOVATION ACTIVITIES

2.1 What in your opinion constitutes innovation? Please describe in your own words

2.2 Please indicate which of the following key types of innovation have contributed most in your organisation. Please tick any that apply.

☐ Technologies (e.g. introducing new technologies, ICT, Computerised project management)

☐ Advanced business practices (e.g. Written strategic plan, long term collaboration with other business)

☐ Other please state below

2.3 What key strategies and/or best practice models are/have been used to enhance your company's competitiveness through the implementation of technological or advanced business practices? Please describe briefly

2.4 What strategy is/was adopted to ensure innovation added maximum value to your business? Please tick any that apply

☐ Formal evaluation programme   ☐ Staff related strategies

☐ Continuing development programme   ☐ Customer/user feedback

☐ No formal strategy   ☐ Other (please state below)

2.5 In essence do you consider your organisation to be innovative ?

☐ Yes   ☐ No

If yes, why? Please describe in your own words:

If not, why not? Please describe in your own words:

2.6 To what extent has innovation impacted on your business over the past 3-5 years? Please tick any that apply

☐ Profitability

☐ Higher turnover

☐ Reduced staffing levels

☐ improved client relations

☐ improved company culture

☐ Other, please give details below _____

|

2.7 What factors typically drive innovation in your organisation, in your view? Please tick any that apply:

☐ Improving efficiency   ☐ Improving performance

☐ Cost reduction   ☐ Responding to client demands

☐ Improving productivity   ☐ Reducing time

☐ Improving quality   ☐ Professional pride/company esteem

☐ Other, please state below _____

|

2.8 What are the typical barriers to adopting innovations within your organisation? Please tick any that apply:

☐ Cost of initiative

☐ Lack of skilled staff

☐ Lack of R&D investment

☐ Conservative stakeholders/clients

☐ Ownership/knowledge sharing

☐ Insufficient benefits/difficult to justify/unclear business cases

☐ Staff attitude/culture

☐ Other, please state below: _____

|

SECTION 3. BUSINESS PRACTICES AND STRATEGIES

3.1 Which of the following are the key sources of ideas/information about new technologies or advanced practices for your business? Please tick any that apply:

☐ In-house staff	☐ Technical support providers
☐ Previous projects	☐ Research Institutions
☐ Professional or trade associations	☐ Journals/magazines
☐ Conferences/workshops	☐ Consultants
☐ Clients/customers	☐ Overseas sources
☐ General contractors	☐ Trade contractors
☐ Competitors	☐ Internet/intranet/extranet
☐ Government	☐ Regional bodies

☐ Others please state below:

3.2 Which of the following does your business currently use? Please tick any that apply.

☐ Long-term collaboration arrangements with other businesses

☐ Staff training budget

☐ Written evaluation of new ideas in order to develop options for your business

☐ Written strategic plan

☐ Computerised project management

☐ Computerised asset analysis

3.3 Which of the following business strategies do you consider are highly important to the success of your business?   Please tick any that apply

☐ Providing a broader range of services to clients

☐ Attracting new clients

☐ Building relationships with existing clients

☐ Increasing your market share

☐ Delivering products/services which reduce clients' costs

☐ Protecting your business's intellectual property

☐ Investment in research and development (R&D)

☐ Introducing new technologies

☐ Enhancing your business's technical capabilities

☐ Actively encouraging your employees to seek out improvements and share ideas

☐ Recruiting experienced employees

3.4 Which of the statements below apply to your business? Please tick any that apply

☐ We have a formal system to encourage staff to share ideas.

☐ We reward staff for maintaining networking linkages with strategically useful industry participants.

☐ When we make changes, we measure how well the changes have worked.

☐ We have a formal system for transferring project learning into our continuous business processes.

☐ We actively monitor advances in related industries that might be applicable to our business.

☐ We actively monitor international best practice in our field.

☐ We have robust relationships with key organisations in the industry.

SECTION 4. ADDITIONAL INFORMATION

4.1 Please use the box below to make any additional comments on the subject of innovation management, theoretical and industrial models of Innovation and Research (IR), or raise queries that you wish the researchers to address in the project.

4.2 Please indicate if you would like to receive a copy of a PDF summary of the findings by email once the survey has been completed.

☐ Yes

☐ No

If yes, please insert your contact email in the box below:

If you have any queries please contact:

Maxmood Gesey
Research Engineer
Centre for Innovative Collaborative Engineering (CICE)
Department of Civil & Building Engineering
Loughborough University
Loughborough
Leics LE11 3TU

------------------Thank you for your contribution and time --------------

Dear

Re: Reviewing theoretical and industrial models of innovation within the construction industry

Two weeks ago a questionnaire was sent to you, asking your opinions on theoretical and industrial models of innovation within the construction industry. If you have already completed and returned the questionnaire, please accept our thanks. If not, then please can you fill out the questionnaire and return it to us as soon as you are able.

We are grateful for your help, as your response will help us to establish current theoretical and industrial models of innovation in the construction industry. The survey will provide useful insights into innovation practices within the construction industry and assist with the identification of frameworks, best practice, lessons learned, enablers and barriers to innovation.

If you have not received a questionnaire or if it has been misplaced, then please let us know. Otherwise we look forward very much to receiving your response.

If you have any queries, please do not hesitate to contact us.

Yours sincerely,

Maxmood Gesey
Centre for Innovative and Collaborative Engineering (CICE)
Department of Civil & Building Engineering
Loughborough University
Loughborough
Leics LE11 3TU

APPENDIX C: INTERVIEW QUESTIONS

4. What is your understanding of the term "innovation"?

This question is designed as an opening gambit to ease the interviewee into the interview process and to get a general appreciation of the divergence (or convergence) of views on the meaning of the subject area. The desired answer will be something like "a process that takes ideas through to value added implementation". It is anticipated that there will be a number of views, however, ranging from ideas about process, such as "making new things" and "having an idea" through to "new products", indicating that innovation is an output.

Supplementary questions depend on response, but will be geared to get the interviewee to think about their experience of innovation (or lack of it), such as;

4. What is your experience of innovation?

5. How good is Atkins at innovation?

5. What part does innovation play in Atkins' business?

This question is designed to identify in general terms what the interviewee knows about the relationship between innovation and Atkins' business. The expected answers should fall into two camps. Firstly, it is expected that some will identify that the business needs to be innovative in order to offer customers new solutions to new problems. Secondly, there is a need to be innovative with internal systems and processes in order to keep costs down. Some interviewees might identify that innovation could be developed as a core competence and offered as a service to customers.

It might also be possible that interviewees will identify the different types of innovation (product, process, service).

If interviewees struggle to answer this question, then a helpful prompt may be to ask the following supplementary questions;

- Which part of Atkins is most innovative? Why?

- Who is innovative in Atkins?

6. What should Atkins do to manage innovation?

It is important to identify whether the interviewee regards innovation as an environmental phenomenon, an output or a process to be managed. The question also seeks to identify what changes in general terms the interviewee would make to Atkins in order to improve the management of innovation if they believe that it is feasible.

7. What are the key determinants of Innovation in Atkins?

This is a general question that should be an indicator of some of the difficulties that individuals perceive in innovation in Atkins. It is hoped and that some of the iCon model will be identified in some form or other, to a greater or lesser degree.

Can innovation be measured, if so, what could be used as an indicator of how innovative Atkins is?

It is likely that this question may be difficult for all interviewees to answer. It is expected that there will show a diversity of responses, which will highlight the difficulties and the ignorance that surrounds the subject. This is also the basic question that underlines this case study, since the researcher is looking for a mechanism that provides the basis for an audit. It is hoped that input indicators can be identified. If not, some prompting may be necessary to determine their influence with the following supplementary questions;

1. What systems, processes and tools could be used to support innovation? Are any of them present in Atkins? (Process, Assessment Tools, Evaluation)

2. What style of management is most appropriate to support innovation? Is it present in Atkins? If not, what could be done to change? (Leadership)

3. What sort of staff are needed to support innovation? Does Atkins have the right staff? What is needed to motivate staff with regard to innovation? (People, Resources)

APPENDIX D: ASSESSMENT MODEL

QUESTIONNAIRE

The main aim of this survey questionnaire is to develop an innovation assessment model and a prototype application for construction organisations to provide a rapid, online assessment of innovative practices and competencies in construction companies.

The objective of the tool is allow construction companies to:

- assess their innovative performance;
- help them to focus on the areas where they want to make progress;
- integrate innovation related strategies/best practice guidelines into overall competitive strategies;
- benchmark their innovation performance with peers and within the construction industry.

The survey will provide useful insights into innovation practices within the construction industry and assist with the development of a self assessment tool. In this context, these sets of questions are designed to be completed by people with overall responsibility for innovation in construction in their organisation. The questions are divided into six sections as follows:
- Leadership
- Management
- People
- Process
- IR investment
- Technology

We believe that you have the relevant experience and knowledge to assist us in this respect. We would be grateful if you could supply us with information by answering the attached questionnaire. Please answer all questions and tick only one box for each statement (e.g. agree, disagree and so on). If there is any statement, which is not appropriate/applicable, then please state it the space provided. It should take about 20-30 minutes to complete. Your response to this questionnaire is highly valued and will be treated with the strictest confidence and it will be used for academic purposes only. Your details will not be passed to any   other   organisation.

Thank you for your kind assistance in participating in this assessment.

Yours sincerely,

Maxmood Gesey
Centre for Innovative and Collaborative Engineering (CICE)
Department of Civil & Building Engineering
Loughborough University
Loughborough
Leics LE11 3TU

(Self – Assessment Tool)

UK construction companies have been found to be unable to deliver on their potential to innovate. Against this background a self-assessment tool is proposed as part of a research project at CICE, funded by Loughborough University and EPSRC.

Goal

The aim of this Self-Assessment Tool is to help construction companies assess their innovation capabilities. The objective of the tool is to initiate a process leading to the effective implementation of a strategy/best practice guidelines and allow construction companies to:

- assess their innovative performance;
- help them to focus on the areas where they want to make progress;
- integrate innovation related strategies/best practice guidelines into overall competitive strategies;
- benchmark their innovation performance with peers and within the construction industry

Assessment Criteria

The assessment may include the following categories:

- Leadership
- Management
- People
- Process
- IR investment
- Technology

Outcome

Once an assessment is completed, companies will be presented with an innovation performance report, which includes:

- Average scores for each category and overall innovation performance score.
- A radar diagram for organisational benchmarking both with peers and the industry as a whole.
- A summary of responses and guidance on areas for improvement.

Instructions

The assessment must be completed by individual who 'should' be aware of and supporting innovations in their business areas.

The assessment takes roughly 30 minutes to complete and can be completed in more than one sitting Respondents are required to tick a box on a scale of 0 to 5 and all questions must be completed

Confidentiality

Please note that the information will be treated as strictly confidential

Please complete the following background information

Company Information

Company Name	
Address	
Town	
County	
Post Code	
Web Address	
Type of Business	
Annual Turnover	
No of Employees	

Employee Information

First Name	
Last Name	
Title	
Job Title	
Department	
Branch	
Telephone	
E-mail	

iCon QUESTIONS TO ALL SECTIONS

Leadership

Please tick the appropriate box to indicate your response	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
1. Senior management is fully supportive of the development of our innovations	1	2	3	4	5	N/A
2. Our leaders are aware of the potential rewards and risks of innovation practices	1	2	3	4	5	N/A
3. We recognise the benefits of being an innovative organisation.	1	2	3	4	5	N/A
4. Our organisation has a director/manager at board level with overall responsibility for innovation and research (IR) issues	1	2	3	4	5	N/A
5. Our company has a vision and/or mission statement, which sets the organisation's direction in relation to innovation	1	2	3	4	5	N/A
6. Our company has a definition of innovation in construction for internal and external use	1	2	3	4	5	N/A
7. Our organisation has a detailed map for	1	2	3	4	5	N/A

managing its key innovation issues with associated level of priority, actions, impacts and outcomes						
8. Our organisation has short, medium and long term action plans to deliver its innovation policy with defined objectives, targets, performance indicators and list of personnel responsible for delivery action plans	1	2	3	4	5	N/A
9. our leaders promote innovation as a competitive edge for the company	1	2	3	4	5	N/A
10. Our leaders are directly involved in the development of an innovation culture in order to bring about continuous innovation improvement	1	2	3	4	5	N/A

Comments:

Management						
Please tick the appropriate box to indicate your response	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
1. We develop managers to support the innovation of others and making innovation a requirement of the job	1	2	3	4	5	N/A
2. Our organisation has a team/department in charge of overall coordination of IR issues	1	2	3	4	5	N/A
3. Line managers are fully involved and responsible for implementing Innovation culture	1	2	3	4	5	N/A
4. All levels of management in our organisation have an innovation mindset	1	2	3	4	5	N/A
5. Our organisation has taken corrective action to ensure that its internal culture, structure and governance is supportive of its innovative vision, mission, principles and policy	1	2	3	4	5	N/A
6. Our organisation regularly organises innovation awareness raising workshops, meetings, and events with key stakeholders to capture organisational learning, innovative ideas and performance improvements	1	2	3	4	5	N/A
7. Our organisation has undertaken a cultural analysis including operational practices, organisational structure and governance (i.e. decision making and accountability; information generation and sharing knowledge; distribution of resources etc	1	2	3	4	5	N/A
8. Our organisation has a system in place for managing innovation	1	2	3	4	5	N/A
9. Our organisation has won a Quality award (e.g. EFQM, Malcolm Baldrige and others) or been finalist in its sector within the last five years for	1	2	3	4	5	N/A

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
its quality system						
10. We anticipate customers' needs by analysing the market trends and competitors' innovative successes	1	2	3	4	5	N/A

Comments:

People						
Please tick the appropriate box to indicate your response	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Don't know**
1. We have people with the ability to implement change and move quickly to adopt innovation culture.	1	2	3	4	5	N/A
2. We encourage our employees to be innovative to increase efficiency and productivity.	1	2	3	4	5	N/A
3. We are committed to addressing any innovative issues that staff may have come across.	1	2	3	4	5	N/A
4. As long as they are contributing to the clearly defined objectives of the organisation, people are allowed to work in the way they see most appropriate.	1	2	3	4	5	N/A
5. We all help each other here and always get and offer whatever support is needed.	1	2	3	4	5	N/A
6. We set up idea capture scheme for our company	1	2	3	4	5	N/A
7. Everyone is actively encouraged to come up with good new ideas and to help see them through.	1	2	3	4	5	N/A
8. Our people are aware of our innovation policy and some have specific roles and responsibilities	1	2	3	4	5	N/A
9. Our organisation regularly undertakes a training and learning needs analysis of its staff and other necessary business partners and launches training programmes as appropriate to drive culture of innovation and change	1	2	3	4	5	N/A
10. We train our employees for creativity and innovation	1	2	3	4	5	N/A

Comments:

Process						
Please tick the appropriate box to indicate your response	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Don't know**
4. We have analysed our current business process and identified the bottlenecks and inefficiencies in our current innovative practises	1	2	3	4	5	N/A
5. We have a well defined strategy for adopting & promoting culture of innovation in our organisation.	1	2	3	4	5	N/A
6. We have a well defined innovation process for the selection of innovative practices.	1	2	3	4	5	N/A
7. Our existing business & innovation processes are flexible enough to accommodate new business & innovation practices	1	2	3	4	5	N/A
8. We have designed new Web-enabled innovation processes.	1	2	3	4	5	N/A
9. All levels of the organisation are proactive in generating, evaluating and developing ideas for new products/services/processes.	1	2	3	4	5	N/A
10. Our key stakeholders are consulted in developing our innovation policy and are regularly consulted in updating our innovation strategy	1	2	3	4	5	N/A
11. Our company has undertaken a baseline review or assessment of the economic impact of its operation and benchmarked performance against best of breed	1	2	3	4	5	N/A
12. We have appropriate reward systems for innovation	1	2	3	4	5	N/A
13. We actively undertake systematic approach to relocate and assess good practice elsewhere	1	2	3	4	5	N/A
Comments:						

IR investment						
Please tick the appropriate box to indicate your response	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Don't know**
1. Our business has learnt from the successes and failures of other IR-led projects/initiatives.	1	2	3	4	5	N/A
2. We are committed to allocating adequate resources in terms of time, staff and budget, required to implement innovation and new ways of working	1	2	3	4	5	N/A
3. We have effective procedures in place to share (in-house) the successes and failures	1	2	3	4	5	N/A
4. One of our strengths is that finance is always made available to exploit good ideas	1	2	3	4	5	N/A
5. The company allocates a budget to innovation & research development	1	2	3	4	5	N/A
6. The company takes maximum advantage of all	1	2	3	4	5	N/A

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
government schemes to support IR along with tax incentives.						
7. We identify that innovation is the last remaining preventative measure in our business environment which leads the company to achieve least cost, high performance	1	2	3	4	5	N/A
8. We develop new ideas and knowledge and are capable to respond quickly to unforeseen problems and events	1	2	3	4	5	N/A
9. Innovation helps us to achieve our overall goals and objectives	1	2	3	4	5	N/A
10. We analyse the implications for the business of future trends and issues, using the expertise of both internal/external and technical specialists.	1	2	3	4	5	N/A
Comments:						

Technology

Please tick the appropriate box to indicate your response	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't know
1. Our current ICT infrastructure is enough for supporting our staff and current business processes.	1	2	3	4	5	N/A
2. Our current ICT systems are flexible to accommodate rapid change and scalability.	1	2	3	4	5	N/A
3. We have a well maintained company intranet for storing and sharing data.	1	2	3	4	5	N/A
4. Our organisational culture is well suited for the adoption of technological innovation and new ways of working.	1	2	3	4	5	N/A
5. Our company has a dedicated team with overall responsibility for information technology	1	2	3	4	5	N/A
6. Our information technology is accessible to majority of our office staff and site workers	1	2	3	4	5	N/A
7. We are closely monitoring the technological developments that will have an impact on our products and services in the future	1	2	3	4	5	N/A
8. The company takes on high technological risks aimed at long-turn results, based on a varied project portfolio	1	2	3	4	5	N/A
9. There is a medium or long-term technology plan in line with future market demands and with company's strategy	1	2	3	4	5	N/A
10. The company has the mechanisms and tools necessary to identify, structure and absorb new knowledge	1	2	3	4	5	N/A
Comments:						

You have successfully completed the assessment

------------------Thank you for your contribution and time --------------------

APPENDIX E: ICON MODEL EVALUATION AND

VALIDATION QUESTIONNAIRE

The aim of this questionnaire is to evaluate a self-assessment prototype model developed to help construction companies to assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry

Please Tick One Option		Poor	Average	Good	Very Good	Excellent
Q1.	The effectiveness of the questions in capturing the overall innovation issues					
Q2.	The formulation easy to understand each aspect of the questions					
Q3.	The extent to which the elements and the different categories capture overall essence of innovation issue					
Q4.	The usefulness of the model to aid organisation innovation implementation process within the construction industry					
Q5.	Is iCon a good assessment tool?					
Q6.	Is iCon easy to use					
Q8.	Is iCon format easy to navigate					
Q9.	Is iCon error free					
Q10.	Your overall assessment of iCon					

Please Comment

Q11.	What is you opinion about the questions in each category? Do any need to be rephrased? If Yes, which Question/s? Please state rephrased version below
Q12.	Do any new questions need to be added? If Yes, please specify below
Q13.	In what ways could the overall Model be improved?
Q14.	In your view what are the benefits of using iCon?
Q15.	In your view how can iCon be improved?
Additional Comments:	

Name:
Role:
Dept/Business Unit:
Date:

Thanks for your assistance

APPENDIX F: INNOVATION AUDITS

Higgins' Innovation Audit Categories

Strategy	Stated working innovation strategy. Market orientation. Innovation performance objectives. Innovation review. Prioritise commercialisation of ideas a priority. Innovation capability stretching. Customer knowledge and links.
Structure	Structural mechanisms to facilitate innovation. Innovation teams. Innovation centres. Links between innovation teams and the rest of the organisation. Flexibility. Alliances. NPD focussed structure.
Systems	Rewards for innovation. Celebrate success. Innovation management systems. Formal idea assessment systems. Lab-market transfer system. Formal and informal information exchanges. Suggestion programmes.
Style	Vision creation. Mistake tolerance. Suspend judgement on new ideas. Empower subordinates. Problem solving management style. Transformational leadership. Management of innovative personnel.
Staff	People are a vital source of competitive advantage. Recruit people who can generate new ideas. Innovation Champions. Train people to be creative. Use creativity processes. Provide time for reflection. Provide facilities for idea exchange and creative thinking.
Shared Values	Creative people held in high esteem. Encourage new ideas and risk taking. Value and practice openness. Belief that the organisation is innovative. Manage organisational culture for innovativeness. Value Change. All employees have innovation objectives.
Skills	Proactive creation of new opportunities. Continuous new product creation. Continuous and Big-Bang innovation. Knowledge management. Organisational learning. Resource leverage. R&D investment.

Categorisation of Higgins' Innovation Audit

Adaptation of Tidd et al.'s Innovation Audit

Does the organisation take a strategic approach to innovation?

Has the organisation established effective external linkages?

Are there effective implementation mechanisms?

Does innovation take place in a supportive organisational context?

Is this a learning organization with regard to innovation management?

International Trade Forum Innovation Audit Measures (2002)

Auditing innovation processes

On-going evaluation is the only way to make sure that your innovative process is working to your firm's benefit. Review your capacity to launch a new initiative, to manage innovation, to absorb new practices and new technologies, and to standardize or modularize your service.

The first step is to develop appropriate performance measures, which need to be linked to your innovation policy and procedures.

Sample performance measures

Performance factor	Sample measurement criteria
Concept generation	Number of new ideas.
	Number of new concept proposals.
Average innovation life cycle	Customer satisfaction with the innovation.
Innovation development	Average time for each phase of testing and integration. Net cost of innovation development.
Support for the process of innovation development	Number of continuous improvement developments.
Processing time	Percentage of suggestions implemented.
Leadership	Percentage of employees aware of the innovation policy.
	Number of pages in the annual report devoted to innovation.
	Types of awards given to employees for innovations, including innovations that have not quite worked.
Resourcing	Percentage of implementations delayed owing to lack of resources.
Systems	Increased customer satisfaction with technology support.
	Percentage of team leaders trained in creativity techniques.
Contribution to firm's knowledge	Number of new best practices identified.

Sample areas of focus for innovation audits

While applications to services are still new, extensive work has been done on technological innovation audits. The most common approach is to develop a score-card that allows you to see quickly how well you are performing, followed by an in-depth systems review.

Area of focus	Questions
New concepts	What are the means used to obtain ideas directly from customers?
	How are customer complaints monitored?
	Is feedback obtained from contact staff?
	Are inputs obtained from back-office staff?
	Is there a cross-functional screening of new ideas?
	Is there a process for matching capabilities to potential customer needs?
	Is innovation incorporated into the firm's strategic plan?
	What is the innovation policy?
Planning	What is the process for prioritizing the launch of innovations?
	What are the screening criteria for adopting innovations?
Creativity	How are new ideas elicited and supported?
Processes	How early is input obtained from customers and staff?
	What mechanisms are in place for test marketing?
	Are there cross-functional implementation teams?
	Have checkpoints and guidelines been established?
Technologies	Do the systems monitor information technology trends?
Leadership	Does the leadership support value and breakthrough innovations?
	Does it support a benchmarking process?
	Have performance measures been defined?
	Has an investment been made in staff training on innovation skills?

APPENDIX G: ARTICLES & AWARDS

1- Innovation & Research Focus: Article No: 70
2- Company A's Internal In-house Newsletter
3-iCon: Innovation Award (short listed)

INNOVATION

iCon: An innovation assessment tool

CiCE

A new online assessment tool, iCon, has been developed to encourage innovation within the construction industry. It has been prepared at CICE, Loughborough University by Maxmood Gesey.

iCon provides a rapid online assessment of innovative practices and competencies in construction companies. By filling in a simple questionnaire, it allows managers to assess their innovation performance and highlight the areas where improvement is needed. It enables them to integrate innovation-related strategies and/or best practice guidelines into their business activities and to benchmark their performance with peers within the construction industry.

The iCon system is built around the assumption that, in order to be innovative, an organisation is required to excel in six categories:

Leadership to drive policies and strategies, and to ensure successful implementation;
Management that believes in innovation and takes strategic measures to drive its adoption, implementation and usage, thus delivering business benefits;
People who have adequate skills and understanding, and who believe that innovation is the successful exploitation of new ideas;
Process that enables and supports the successful adoption of innovation;
IR Investment which is one of the key determinants of innovation or technology in any industry;
Technology tools and infrastructure necessary to support the business functions.

Individuals using iCon complete an online questionnaire. This comprises a series of statements to which respondents are required to indicate the degree they agree or disagree with each (see Figure 1) The system relies on the judgement of the respondent in the context of their organisation, department, business unit or group.

Once all the questions are completed, respondents are presented with their overall innovation performance in all six categories. This is in the form of a report, which includes colour indicators to visually depict the level of innovation in an area (see Figure 2).

A Radar Diagram is also generated automatically (see Figure 3), enabling construction companies to undertake competitive benchmarking against their peers and the construction industry as a whole. These reports can then be used as the basis for innovation enhancements.

The iCon prototype was evaluated using methods such as self-evaluation and peer review during the development phase and then through both academic and construction industry practitioners such as innovation managers, business improvement and development managers, and innovation, technology and/or R&D managers. Evaluation was based on the functionality of the prototype application, its user-friendliness, errors, and its relevance to construction industry.
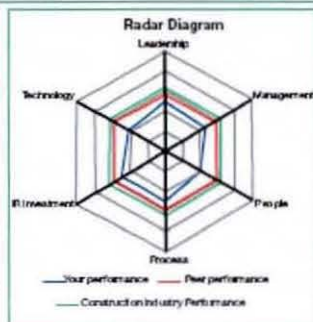
Figure 1 (below) *A typical iCon questionnaire page*
Figure 2 (bottom left) *Benchmarking of Performance with Peers and Construction industry*
Figure 3 (bottom right) *Overall Innovation Performance Benchmark*

Please tick the appropriate box to indicate your response					
Leadership	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1 Senior management is fully supportive of the development of our innovations	●	●	●	●	●
2 Our leaders are aware of the potential rewards and risks of our innovations	●	●	●	●	●
3 We recognise the benefits of being an innovative organisation	●	●	●	●	●
4 Our organisation has a director/manager at board level with overall reponsibility for innovation and research (IR) issues	●	●	●	●	●
5 Teams here have a lot of discretionary power	●	●	●	●	●
6 Senior managers are "hands ready" knowing exactly when and when not to get involved	●	●	●	●	●
7 When problems occur, our leaders immediately act to provide appropriate support and guidance	●	●	●	●	●
8 Our organisation has an agreed set of operating principles/codes of conduct to support and facilitate the achievement of its long term vision of innovation	●	●	●	●	●
9 Our company has has a vision and/or mission statement, which sets the organisation's direction in relation to innovation	●	●	●	●	●
10 Our company has a definintion of innovation in construction for internal and external use	●	●	●	●	●

Category Name	Mean Score		
	Your Company	Peers	Construction Industry
Leadership	2.5	2.8	3.2
Management	2.3	2.9	3.2
People	2.0	2.9	3.2
Process	2.5	2.9	3.2
IR Investment	2.5	2.9	3.3
Technology	2.1	2.9	3.2

Radar Diagram

2. Company A's Internal In-house Newsletter

one team

iCon-ic

Radar Diagram

Figure 2: Overall Innovation Performance Benchmark

AN INNOVATION Assessment Tool called iCon has been developed by Maxmood Gesey, Business Excellence Team, Highway Services, Birmingham, with the help of iProNET as part of his research project in "Innovation Management in the Construction Industry" at Loughborough University. The research project explores ways of promoting a culture of innovation and research within the construction industry, developing strategies and best practice guidelines. This is to enhance the industry's competitiveness through the implementation of technological innovation and new ways of working.

iCon provides a rapid online assessment of innovative practices and competencies in construction companies. It allows construction companies to: assess their innovative performance; help them to focus on the areas where they want to make progress; integrate innovation related strategies/best practice guidelines into overall competitive strategies; and benchmark their innovation performance with peers and within the construction industry.

'iCon system is built around the assumption that, in order to be innovative, an organisation requires leadership to drive

policies and strategies with a belief in innovative practices. This includes people who have adequate skills with an understanding and belief of innovation, to successfully exploit new ideas with processes and technology tools that enable and support. Also IR investment being a key determinant in any industry.'

The icon application comprises of a series of statements with which respondents may or may not agree to varying degrees. iCon relies on the judgement of the respondent (ie. end-user) as to whether or not he/she agrees with the statement/s in the context of their organisation, department, business unit(s) or group.

The report collates the mean scores of the user on each category (ie. leadership, management, people, process, IR investment and technology) and the total mean score with interpretation of scores as illustrated in Figure 1. It benchmarks each category mean scores of individual organisations with peers of similar business

Your performance matrix score

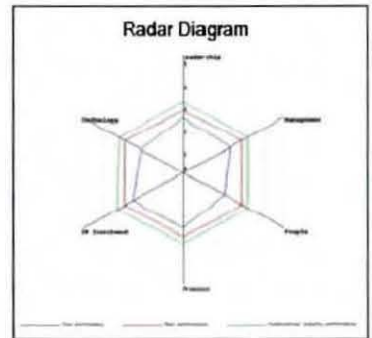| Category Name	Mean Score		
	Your Company	**Peers**	**Construction Industry**
Leadership	25	23	32
Management		24	32
People		23	32
Process	25	23	32
IR Investment	26	23	33
Technology		23	32

Figure 1: Benchmarking of Innovation Performance

types (eg. clients, contractors, consultants etc), group types in terms of turnover as well as the construction industry as a whole.

Once all the questions are completed the end-users are instantly presented with their overall innovation performance in all six categories. This is in the form of a report, which includes colour indicators to visually depict innovativeness. Also, a Radar Diagram is automatically generated (see Figure 2), which enables construction companies to do competitive benchmarking against the peers and the construction industry as whole. The report can then be used as the basis for innovation enhancements.

maxmood.gesey@atkinsglobal. com (Birmingham)

3. Short listed for the 2007 Business Excellence Awards: Innovation Award

| Maxmood Gesey | H&T | A Research Project Entitled 'Innovation Management in the Construction Industry' at Loughborough University |

INNOVATION AWARD

RachelEvans	H&T	Travel Plan Discipline Network Group – Fostering and Disseminating Experience and Dedication to Sustainable Travel Planning
Richard Samphier	DES	Oath Lock Sluice Fish Pass – Delivering Bio Diversity Benefit on a Structural Upgrade Scheme
Biju Antoney	Middle East & India	An Innovative Idea to Develop a Software Program that Generates Design Sheets in an Error Free Uniform and More Efficient Way
Jonathan McCue	DES	SaferSands – A New Beach Risk Management, Accreditation and Training Initiative
Donald Lack	DES	Energy Make Over All Saints Catholic School Mansfield
Adam Lawrence	DES	Adam Lawrence – The Development of Sotfware Solutions to Meet the Needs of the Acoustics, Noise and Vibration Team
Ian Mackenzie	F+G	Collaboration with the Centre for Innovation and Research - University of Teesside: The Development of a 4D Planning Tool
Colin Elliff	Rail	High Speed Rail in the UK - Developing the Atkins Vision
Doug Coutts	H&T	HGV Lane Two Restriction Trial (Optima) – An Innovative Solution to Assist in Reducing Journey Times and Prevent HGV Manoeuvres on Dual Carriageways
David Nancarrow	DES	Safety Survey for Water and Environment – A Range of Measures to Improve our Safety Culture
Maxmood Gesey	H&T	A Research Project Entitled 'Innovation Management in the Construction Industry' at Loughborough University
Colin Elliff	Rail	Developing a New North-South High Speed

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KEY DATES

DATES TO REMEMBER

Shortlisting	9 March
Announcement of Finalists	21 March
Online voting for People award	16 April
Final Judging	19 April