The Role of Knowledge Management in Supporting Innovation and Learning in Construction

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of thesis is the result of work which has been carried out since the official commencement date of approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Signed:

Tayyab Maqsood

June, 2006

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GLOSSARY OF TERMS

ABS =	Australian Bureau of Statistics
ADSL =	Asymmetric Digital Subscriber Line
CATWOE =	Customer, Actor, Transformation, Weltanschauung, Owner, Environment
CIB =	International Council for Research and Innovation in Building Research
COP =	Communities of Practice
CRC CI =	Co-operative Research Centre in Construction Innovation
EDMS =	Electronic Document Management System
HTTP =	Hyper Text Transfer Protocol
HRM =	Human Resource Management
IC =	Intellectual Capital
ICT =	Information Communication Technologies
ISDN =	Internet Service Digital Network
ISP =	Internet Service Provider
IT =	Information Technology
K-adv. =	Knowledge Advantage
KM =	KM
LAN =	Local Area Network
MBO =	Management by Objective
PERT =	Program Evaluation and Review Technique
SSM =	Soft Systems Methodology
TQM =	Total Quality Management
WAN =	Wide Area Network
WWW=	World Wide Web

ABSTRACT

The research investigates the role of Knowledge Management (KM) in supporting innovation and learning in the construction industry. The Construction industry is complex in nature and notoriously fragmented suffering high losses in productivity. Being a substantial part of the national economy, the construction industry greatly influences the country's GDP (Gross Domestic Product). Innovation has lately been regarded as the key to improve its productivity and to change traditional and fundamental thinking that has plagued the industry for a long time leading to new and more rational philosophies. The research demonstrates that KM may act as an enabler of such innovation by facilitating organisational learning.

The research is carried out in two phases. In Phase 1, the research employs grounded theory methodology to develop and map out the current state of knowledge related activities being undertaken in two leading Australian construction organisations. This results in the development of a model, the main depiction of which is a segregation between three crucial components (people, process & technology) of an organisation required to successfully carry out the construction work. It also helps identify the gap between the organisation's internal and external knowledge sources that restricts the pull of knowledge from external knowledge sources. The culture of the organisation is considered to provide this resistance. An improvement in this state through KM is the main objective of the research which is realised in Phase 2. Soft System Methodology (SSM) is utilised as a KM tool to achieve this objective in this phase. As one of the systems approaches, it has the capacity to make sense of intricate systems like construction where a complex interaction between people, process and technology occurs all the time. A mission critical business process of pre-tendering of a leading Australian construction contractor organisation is selected to carry out the SSM investigation that resulted in four SSM case studies. This investigation helps explain how KM initiatives through SSM improve the integration of people, process and technology; increasing the capacity of the organisation to pull external knowledge and improve its own internal knowledge bank. All these improvements help an organisation to transform itself into a learning organisation that could continually innovate.

Chapter 1
Introduction

This research is descriptive and qualitative in nature. It investigates the role of Knowledge Management (KM) in facilitating innovation and learning in the construction industry. The main objective of the research is to demonstrate a link between innovation and transformation of an organisation into a learning organisation through KM. This is essential for putting forward a convincing case for the construction industry to adopt a KM philosophy as a means of becoming innovative with greater ability to learn and adapt. Such an organisation would be better shaped and equipped to confront the challenging dynamics of the construction business and its inherent volatility. The theme of the research is pre-dominantly qualitative involving a general in-depth investigation of two leading Australian Construction Contractor organisations in the first phase and then a more detailed study one of these two in the second phase.

The aim of the research is to assist senior management to better understand the potential of KM and its promise to deliver innovation and learning within an organisation. This is achieved through developing model in phase one (with validation in phase two) that establishes an easy-to-understand link between innovation, learning organisation and KM.

This chapter provides an overview and outlines the scope of the thesis. It describes the research background, the rationale for the research, research objectives, research questions, research propositions, research methods, and scope and limitations of the current research.

1.1 Research Background- The relevance of KM to the construction industry

The construction industry is notoriously characterised by its culture of resisting change resulting from adoption and diffusion of innovative approaches and knowledge. This culture is then embedded in the organisations that collectively form the industry. For this reason, organisations are not only slow to absorb new innovative knowledge (Barthorpe *et al., 2000)*, but are also slow in harnessing the intellectual capital available to them in order to produce innovation (Egbu *et al*. 2001a). Being a substantial part of the national economy of any country, it is vital to challenge this situation. There is a need for the construction industry to

become more innovative and provide greater value for money through instilling learning in their organisations (Murray and Langford 2003).

For a considerable period of time the industry has experienced low productivity levels and huge material, labour and management energy waste. Researchers and practitioners alike have agreed that traditional construction management approaches that the industry adopts, is not a solution to the above identified problems and is unlikely to improve the industry's productivity and profitability. However, 'innovation' has gained recent popularity in the construction industry. The basic purpose of being innovative, therefore, is to delineate and differentiate new/creative thinking from old fundamental/traditional thinking. The search for 'innovative approaches' has thus become a contemporary theme in the construction industry.

Achieving innovation in the construction industry is dependent upon how its knowledge is managed—including knowledge generated by academia and collaborative research centres together with knowledge that organisations possess in the form of intellectual capital. KM is, therefore, being recognised as a vehicle through which innovation and improved business performance is possible (Kamara *et al*. 2002). Success of various KM initiatives in other industries - mainly pharmaceuticals (Normann and Ramirez 1993; Powell 1998), electronics (Sieloff 1999), and manufacturing (Andrews 1996) - provides a model for the construction industry.

KM itself is an innovation but its adoption and diffusion paves the way for developing other innovative knowledge (such as supply chain management, relational contracting, partnering, virtual reality etc) to be effectively adopted and utilised. KM allows organisations to devise mechanisms that could bring them closer to knowledge communities thereby generating new knowledge and producing innovations. This interaction can allow a flow of knowledge between internal and external knowledge communities so that instead of an organisation responding reactively to a knowledge-push it can pull that knowledge into itself, adapt it and effectively use it. At the same time, it establishes the mechanisms by which these intangible assets of the organisation are best exploited to benefit the organisation.

1.2 Rationale for the Research

The construction management literature discusses the importance of innovation as a means of improving productivity but it does not sufficiently describe mechanisms through which innovation can be embedded into the construction industry's operating culture. This may result in failure to innovate and/or tardy adoption and diffusion of innovation thus locking the industry into a status quo position. KM has the capacity to challenge this situation in the construction industry. Currently, KM research in the construction industry is relatively new. As with any new initiative, the current research initiatives are more related to clarifying and building the underlying sense of the KM domain, sculpting KM initiatives and developing appropriate tools/techniques (Egbu *et al.* 2001 a, b; Egbu and Botterill 2002; Kamara *et al*. 2002). These efforts indicate that a link between innovation, learning and KM may exist but this relationship has not been explicitly discussed.

Thus, it is fitting for this research to build upon the strengths of existing research carried out by noted authors and their research teams (i.e. teams such as that of Charles Egbu at Glasgow Caledonian University, UK; Chimay Anumba at Loughborough University, UK; Derek Walker at RMIT University, Australia, etc.) that investigate how KM is related to innovation and what role it can play in enhancing learning in an organisation with a view of transforming it into a learning organisation. This research undertakes this endeavour and strives to not only investigate the theoretical link between innovation, learning and KM but also practically demonstrate it with a view of providing enough proof of the concept that may eventually help the construction industry to adopt and practice KM.

1.3 Research Objectives

The rationale developed in the above section leads to the following set of objectives:

1. To investigate the role of KM as an enabler of innovation.
2. To investigate the role of KM in enhancing learning and transforming an organisation into a learning organisation.
3. To demonstrate the role of KM in enhancing learning and, more specifically, enhancing learning in construction organisations.

1.4 Research Questions

The research objectives translate into the following research questions:

1. How does KM support innovation?
2. How is KM supported by the learning organisation concept?
3. Can it be demonstrated that KM has a role to play in enhancing innovation and learning in the construction organisations?

1.5 Research Proposition

The two basic research propositions that are developed in this research are presented below:

1. Continuous innovation is important to improve the productivity of the construction industry.
2. Effective management of knowledge has the capability of producing such innovation by transferring an organisation into a learning organisation that continually enhances its capacity to learn and adapt.

1.6 Research Methods

The first two objectives and research questions were investigated by conducting an extensive cross-disciplinary literature review. The fulfilment of third objective and answering the third question required the research to be divided into two phases (Phase 1 and Phase 2). During Phase 1 of this research, the aim was to map out the current situation in the two leading Australian Construction Contractor organisations regarding the use of knowledge and related issues. A Grounded Theory approach was used in this part of the research that facilitated the development of the model. Phase 2 of this research dealt with the demonstration of KM in improving the weaknesses identified in the model developed in Phase 1. Soft Systems Methodology (SSM) was employed in this part of the research that served the dual purpose of a KM tool as well as a research methodology.

1.7 Research Scope and Limitations

This research is qualitative and has relied on an in-depth investigation of small sample size (i.e. two Australian Construction Contractors in Phase 1 and one Australian construction

contractor in Phase 2). The main research objective of the research is to demonstrate the effect of KM on innovation and learning. It can only be practically fulfilled by focussing on a small sample of case study examples and study these in detail. A quantitative study approach was deemed not suitable for this research for the reason that KM is relatively new in the construction industry and not many organisations are familiar with its underlying philosophy. They often confuse KM with an IT initiative. It is for this reason that the first two objectives of this study were fulfilled through a comprehensive literature review and not through empirical means. The results obtained in this research are specific to the organisations studied but may have general implications in understanding the role of KM in enhancing innovation and learning.

Phase 2 of the research involved the investigation of three components of the model developed in Phase 1 i.e. process, people, and technology. The investigation of the process component included six persons, but only three further volunteered to remain as participants in the research, when people component was investigated. The implications of this reduction in number of participants is not very concerning as it doesn't negate, or in any way effect, the basic premise and logic of the research methodology of Phase 2.

The SSM investigation consists of 7 stages. The last stage is an action taking stage where actions suggested in Stage 6 are actually undertaken and their effect recorded. This would present a complex lengthy and time consuming process, hence it was not practicable to implement these actions during the time limit available for conducting this study. Although actions were not implemented, general consensus of the participants were achieved on the viability and effectiveness of the proposed actions.

1.8 Structure of the Thesis

This thesis comprises seven chapters. Chapter 1 provides an overview of this research. It addresses the research background, research rationale, research objectives, research questions, research propositions, research methods and scope and limitation of the research.

Chapter 2 reviews the literature in diverse fields such as Management Science, Decision Making, Leadership, Innovation, KM, Construction Management, Cognitive Psychology, Organisational Planning and Development, Organisational Learning, Information Systems etc. It discusses the construction industry and its culture and develops a case for the KM deployment in the construction industry. It then explains terms as they are currently being

understood in the literature (such as KM, knowledge, and the knowledge economy). It provides a link between KM and innovation; and KM and Learning Organisations that is manifested in the form of a conceptual and theoretical model linking KM, innovation and learning organisations. The chapter ends after providing emerging directions of research in the field of KM.

Chapter 3 presents the research approach discussing the philosophical assumptions underpinning this research, the research study approach and the research design. The chapter also describes in detail, two qualitative research methodologies employed in this research i.e. Grounded Theory and SSM. This chapter establishes the basis for dividing the research into two phases (Phase 1 and Phase 2).

Chapter 4 describes the research work carried out in Phase 1 of the research that involved the employment of a Grounded Theory methodology. It put forward a model that was formulated as a part of the execution of Grounded Theory methodology. This model was then extended to show the effect of innovation and learning through KM.

Chapter 5 describes the use of SSM as a KM tool in Phase 2 of the research. The SSM investigation was carried out to study the three components of the people, process and technology model developed in Chapter 4. This chapter also presents SSM case studies for each of the component that ends with a list of actions which have the capability of causing an improvement when undertaken.

Chapter 6 describes how the list of actions that resulted from SSM investigation in Chapter 5 can be collated in order to realise the integration of three components of people, process and technology that lies at the heart of this research. This chapter also discusses how SSM as KM tool has played part in knowledge elicitation, creation and sharing.

Chapter 7 summarises the research findings that were related to the research questions. The chapter discusses the research contribution and recommendations arising from this research. It concludes with future research recommendations.

1.9 Summary

This chapter provides an introduction to this doctoral study. The main premise of this research is that continuous innovation is important for improving the productivity of the construction industry. While the current construction management literature emphasises the value of innovation, it does not explicitly and adequately describe the mechanism through which innovation can be embedded in the industry's culture. This maintains the industry's status quo in terms of its uptake of innovation knowledge. KM has the ability to challenge this status quo. Recent successes of KM in other fields and current research work undertaken to establish the underlying philosophy of KM in the construction industry, provides a rationale for this research to build upon the existing research to develop and demonstrate a link between KM, innovation and learning. This research may serve as sufficient proof of concept for the construction industry to consider a more widespread adoption of ideas offered in this thesis. After establishing the research rationale, this chapter states the research objectives and lays down the research questions and research proposition. It then provides a brief description of research methods employed in this research and ends by describing the limitations of the research and outlining the structure of the thesis.

Chapter 2
Literature Review

The purpose of this chapter is to provide a sound basis for understanding the concept of knowledge and KM and how it is related with organisational learning and innovation. The literature from the following disciplines were reviewed:

- Management
- Management science
- Decision Making
- Cognitive Psychology
- Organisational Planning and Development
- Leadership
- Innovation
- KM
- Organisational Learning
- Information Systems
- Construction Management

The start of the chapter highlights the nature of the construction industry, its culture and problems and presents a case of KM as an innovation having the capability of improving industry productivity. It then delves into explaining what is meant by term 'KM' and explains its evolution linking it with the present knowledge economy era. The concept of knowledge, which lies at the heart of KM, is established next. Various types and dimension of knowledge as available in the literature have been discussed. A section is devoted next, to understand the 'stickiness' of the knowledge that explains why it is difficult to transfer the knowledge from one entity to other. This creates a question about the effectiveness of the knowledge usually termed as 'tacit' knowledge that is being captured for use. Hence, the next section explains the often hidden tacit knowledge perspective.

Various researchers have studied KM from different perspectives and dimensions. These dimensions are the focus of discussion of the next section. Having established the basic concept of knowledge and KM, the following section describes successful and unsuccessful KM initiatives and discusses the causes of any failures. The same section also explains what it takes to deliver a successful KM initiative. Hence issues like culture, leadership, rewards and change management are discussed. The next two sections describe KM frameworks identified from the relevant body of research and what sorts of KM tools are currently available. The next few sections establish the role of KM in organisational learning and innovation to remove any confusion about these contemporary concepts relating to improving an

organisation's productivity. Two emerging directions in KM research are then discussed, followed by presentation of a model (linking KM, innovation and organisational learning) that forms the basis of this research. The chapter ends with a brief summary of various concepts discussed in the chapter. The author of this thesis was a key researcher in the team that investigated the various ways that KM could be applied in the Australian Construction Industry. This involved intimate work on both the literature review stage and in co-writing numerous publications as provided at the start of the thesis.

2.1 The Construction Industry

2.1.1 Contribution in National Economy

The construction industry is a vital element of any economy and has a significant impact on the efficiency and productivity of other industries. The Australian construction industry, for example, in 2003-2004, contributed 6.1% to the gross product of all industries, as measured by production-based Gross Domestic Product (chain volume measures) (ABS 2006). The case with other developed countries is also not dissimilar. For example, The Bureau of Economic Analysis[1] in the U.S. reported that the construction industry contributed towards 4.7% of GDP in 2004. In 2004, the Canadian construction industry contributed 5.7% to Canada's GDP[2]. The GDP contribution of the construction industry in UK in 2004[3] was 6.2 %. A key study by Stoeckel and Quirke (1992) carried out in Australian context has indicated that a 10% gain in efficiency in construction could lead to a 2.5 per cent gain in GDP. This shows the construction industry greatly influences country's economic growth (GDP) which makes it necessary for the efforts to be put together in order to improve its productivity hence achieving increase in the GDP.

2.1.2 Nature of Construction Industry and its Culture

Murray and Langford (2003) gathered a series of UK government reports relating to construction productivity and the nature of the construction industry that provide meta-data of over five decades of history of the UK construction industry. The UK construction industry is

[1] http://www.bea.gov/bea/industry/gpotables/gpo_action.cfm?anon=174&table_id=14095&format_type=0 accessed September 2006.
[2] http://www40.statcan.ca/l01/cst01/econ41.htm accessed September 2006.
[3] United Kingdom National Accounts (The Blue Book) 2006, ONS http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=1143 September 2006

viewed as a stubborn, risk averse and highly traditional industry and has been criticised as being a laggard at adopting innovation when compared to other advanced manufacturing industries such as automotive, ship building or aerospace. The situation in Australia is similar to that of the UK (Lenard 1996; Lenard and Bowen-James 1996).

The construction industry by its very nature has a very complex structure. Public sector/private sector involvement, uses a variety of financing/funding sources, deploys numerous procurement methods, and involves number of actors (organizations /trading partners) that cause considerable fragmentation. Also, firms often work for their individual benefits with the competitive basis of selection of actors being aimed at achieving low cost often ignoring its impact on quality/safety. This generates adversarial relationships mostly ending in expensive litigations and giving rise to win-lose attitude. Coupled with above, complex human-technology interaction and aversion to risk have flooded the industry with a series of problems of both macro and micro scale. All these attributes contribute towards the formation of a culture that resists new adoption and diffusion of innovation, be it a new innovative technology or innovative process (Latham 1994; DETR 1998; Department of Industry Science Resources 1999). Most innovative initiatives are very difficult to undertake and often lead to failure.

Barthorpe *et al.* (2000, p346) observe:

> "The casual, fragmented and hierarchical nature of the construction industry illustrates the incapability of the industry to operate in a co-ordinated, homogeneous way when dealing with universal issues such as training, quality standards, education, research and development, innovation, skills certification, public relations, marketing and government lobbying. Levels of innovation in the construction industry compared to other industries have been at best modest. The industry portrays a conservative and at times 'laggardly' approach to new ideas, mainly due to its fragmented nature and lack of ability to invest time and money into innovation, research and development".

Building and civil construction organisations, made up of contractors, subcontractors and specialist contractors, are different when compared with other innovative organisation in various industries. Construction is a very demanding and stressful process (Lingard and Sublet 2002). Construction teams work long hours and are constantly under pressure to meet deadlines in order to save their organisations from liquidated damages. Under such

circumstances it is extremely difficult for the people to spend their time and creative energy in developing alternative innovative solutions to carry out tasks, even though they are capable of it. The main concern of the organisation is 'to get the work done' as early as possible to avoid the threat of project time loss. Experimenting with new ideas and seeking innovative alternatives are often considered as increasing uncertainty and may put project success at risk. This risk avoidance culture deters people from performing innovatively.

Many innovations go unnoticed by construction industry practitioners with few innovations penetrating its resistive culture, even after being successful applied in other industries (e.g. Total Quality Management, Information Communication Technologies (ICT), KM etc.). Even penetration does not guarantee full adoption and diffusion and chances of successful implementation remain dubious. Resistance to change, inflexible culture, lack of motivation and reward systems, weak leadership, poor strategy and vision, absence of learning mechanisms, lack of awareness about the direction of construction research and not foreseeing the immediate benefits of adopting innovations lead to this discrepancy (Oglesby *et al.* 1989; Bresnen and Marshall 2001; Gann 2001; dos Santos *et al.* 2002).

Effective adoption and diffusion of innovation has the potential to increase construction industry productivity. Jones and Saad (2003, p268) argue that the construction industry has considerable barriers to accepting innovation in general, mainly due to its culture of conservatism, lack of appropriate leadership, a poor learning organisational orientation, lack of investment in people and its timidity in leading the adaptation of new technologies. The Latham report (1994) highlighted this as being a likely result of low profit levels and clients who insist on a dominance of lowest-price criteria to award contracts. These issues make it very difficult for the construction industry to make significant inroads in investing in the adoption and diffusion of innovation with technology push rather than demand pull being the dominance influence on the construction industry considering to adopt new technologies (Maqsood *et al.* 2003a).

2.1.3 The Case for KM as an Innovation in the Construction Industry

Murray and Langford (2003) report that construction industry leaders and governments have expressed, through various construction industry reports, the need for the industry to become more innovative and provide greater value for money through instilling learning in their

organisations. The construction industry must accept the challenge to change and modernise if it is to match the performance of industries that generate higher profits and can more easily attract high-calibre talent (DETR 1998). Success of various KM initiatives in other industries - mainly pharmaceuticals (Normann and Ramirez 1993; Powell 1998), electronics (Sieloff 1999), and manufacturing (Andrews 1996) - provides a model for the construction industry.

While there are encouraging signs of changes to the way that construction industry and construction research knowledge exchange operates, these are relatively few and under-developed. For example while there are signs of the construction industry embracing a more systemic approach to innovation through supply chain management in the UK (Jones and Saad 2003), and a relationship-based procurement approach in Australia (Walker and Hampson 2003a), innovation adoption still tends to be generally characterised by incremental or modular *ad hoc* adoptions rather than system or radical innovations (Slaughter 1998; Slaughter 2000). (Winch 1998) argues that the project integration process is partially to blame for this because it is complex using fragmented teams, so innovation tends to happen on projects rather than as company wide initiatives (where lessons do not readily transfer from the project boundary to the organisational units involved in the project). The above literature suggests that most construction contractors in many countries are deeply rooted in traditional practices with a climate of suspicion of risks involved in trying new products or processes—unless there are well-established examples to follow.

KM allows organisations to devise mechanisms that could bring them closer to knowledge communities generating new knowledge and producing innovations. This interaction can allow a flow of knowledge between internal and external knowledge communities so that instead of an organisation responding reactively to knowledge-push it can pull that knowledge into itself, adapt it and effectively use it.

KM has gained attention in the last eight years in the construction industry. The increased chance of success of adopting KM principles, and its diffusion into construction organisations, is beginning to act as an impetus for academic researchers to develop best practice KM for construction organisations (Walker 2005). This is evident from increasing numbers of publications and conferences on the topic of KM in the construction industry (see for example the ARCOM[4] and construction industry CIB W102[5] conferences proceedings

[4] http://www.arcom.ac.uk/current-conf/conferences.html

2.1.4 Benefits for the Construction Industry

Knowledge is being recognised as a vital resource and source of competitive advantage in today's dynamic and changing business environment (Burton-Jones, 1999). Organisational and individual knowledge is vital for business entrepreneurship and for managing change (Nonaka and Takeuchi 1995; Egbu 2000). Knowledge identification, creation, acquisition, transfer, sharing and exploitation is now generally accepted as vital for efficient working in projects and for improving organisational competitiveness.

The foregoing is also true for construction industry. Effective management of knowledge in the construction industry is likely to produce innovation, reduce project time, improve quality and customer satisfaction (Kamara *et al.* 2002; Love *et al.* 2003). Through the process of KM, the exploitation of an organisation's intangible assets creates value and knowledge both internally and industry wide. (Snowden 1999; Davenport and Prusak 2000; Liebowitz and Megbolugbe 2003). In the project environment, KM will assist project managers to improve communications within teams. It will also provide informed knowledge to the project manager and project teams. KM can ensure better sharing of best practice documents, lessons learned, project management and system engineering methodologies, and review and document the rationale for strategic decision-making (Liebowitz and Megbolugbe 2003). Failure to capture and transfer project knowledge leads to an increased risk of 'reinventing the wheel', wasted activity, and impaired project performance (Siemieniuch and Sinclair 1999a). These potential benefits of KM are convincing enough for the construction organisations to venture into adopting its principles.

A successful KM initiative will install learning and facilitate knowledge-sharing culture and environment, provide vision and effective leadership to overcome learning barriers. This will help an organisation to be transformed into a learning organisation that is open to learn new techniques and continuously changes itself based on learned knowledge. This change increases the absorptive capacity of the organisation, which is a function of how organisations retain and distribute knowledge internally to practically exercise KM (Cohen and Levinthal 1989; Cohen and Levinthal 1990). Furthermore, prior knowledge of particular knowledge domains tends to make it easier to understand new knowledge (Burton-Jones 1999). It enables organisations to recognise the value of new information, assimilate it and apply it to

[5] http://cibworld.xs4all.nl:8080/4DCGI!index.shtml?RSES=2005223107106993

commercial ends (Cohen and Levinthal 1990). Liebowitz and Megbolugbe (2003) observe that with the creation and capture of knowledge, learning takes place and knowledge is applied and embedded within individual and organisational processes. Organisations may learn effectively from the experiences and utilise them efficiently.

2.2 KM

2.2.1 Background

The quest for obtaining knowledge and effectively utilising it is not new. This struggle is as old as the history of human thought (Spiegler 2000). Plato, Descartes and Kant have all made attempts to define and understand the nature of knowledge and to unearth the forces underpinning various phenomena in life. The methodologies used by these philosophers in their pursuit to obtain and construct knowledge still serve today as the fundamental guidelines for basic and applied research.

Research in KM has gained tremendous pace since its inception in the last decade as evidenced by the extensive existing literature and its further growth (Ponzi and Koenig 2002). This section describes the concepts of KM in depth and explains different dimensions of it.

2.2.2 What is KM?

KM is multi-faceted and incorporates different inter-linked processes (Egbu *et al.* 2001b). The purpose is to create a thriving working and learning environment that fosters the continuous creation, aggregation, use and reuse of both personal and organizational knowledge in the pursuit of a new business value (Kikawada and Holtshouse 2001). Quintas *et al* (1997) express the same view about KM where they consider it as the process of continually managing knowledge of all kinds to meet existing and emerging needs, to identify and exploit existing and acquired knowledge assets to develop new opportunities. The integration of the key management issues and achievement clarity and cross functional awareness is a key to be successful in KM (Webb 1998.) Egbu *et al.* (2001b) present their understanding of KM as the identification, optimisation, and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage. Egbu *et al.* (2001a) argue that KM mobilises intangible assets (intellectual capital IC) of an organisation that is often of

greater significance to the organisation than its tangible assets (IT). By developing a body of methods, tools, techniques and values through which organisation can acquire, develop, measure, distribute and provide a return on their investment (Snowden 1999).

Bhatt (2000) explains that it is the interplay between the different types of knowledge that creates a rich and continuous cycle of knowledge development. Because of these complex dimensions, management of knowledge becomes so important. KM encompasses various processes. Ruggles (1997) considers these as generating, codifying and transferring knowledge. Egbu *et al.* (2001a) state that KM is about the processes by which knowledge is created, captured, stored, shared, transferred, implemented, exploited and measured to meet the needs of an organisation. Tiwana (2002) categorise these process as create new, package and assemble, apply, and reuse and revalidate knowledge. This is in accordance with processes mentioned by Siemieniuch and Sinclair (1999b) cited in Carrillo *et al.* (2004) who consider these processes as generate, propagate, transfer, locate and access, and maintain and modify. All these processes can be iterative and cyclic and having different requirements (Laudon and Laudon 2000).

2.2.3 Evolution of KM and Emergence of the Knowledge Economy

The quest for obtaining knowledge and effectively utilising it is not a new endeavour. The discovery, creation and construction of knowledge encapsulated in a form of various management theories in the twentieth century supported the industrial revolution, which evolved later into the information revolution. In turn, this has made it possible to attain business goals in a more profound and realistic way. But it was not until mid 1980's that individuals and organisations began to appreciate the increasingly important role of knowledge in the emerging competitive environment (Wiig 1997).

Tiwana (2002) asserts that KM grew from the 1950's in the form of various management philosophies that have developed and modified over time. Table 2.1 describes such management philosophies and managers tools. The purpose of all these tools is to strive for better performance. KM epitomises all these tools.

Table 2.1: Manager's tools through the decades (Modified from Tiwana (2000))

The 1950s	Management by objective (MBO), Program Evaluation and Review Technique (PERT), Diversification, Quantitative Management, Electronic Date Processing
The 1960s	Theory Y, Conglomeration, T-groups, Centralisation and Decentralisation
The 1970s	Strategic Planning-Mintzberg and Porter, The Experience Curve, Portfolio management, Automation
The 1980s	Total Quality Management (TQM), Management by Walking Around, Corporate Culture, Theory Z, Downsizing,
The 1990s	Core Competencies, The Learning Organisation, Reengineering, Strategic Information systems, Intranets and Extranets
The 2000s	KM, IC, Enterprise Integration, Knowledge Sharing Culture

For this reason Collins (2000) notes that he was struck by an eerie sense of *déjà vu'* when analysing 'knowledge work'. The current KM philosophies find their roots in many initiatives started in late 1980's and early 1990's under the name of knowledge engineering, artificial intelligence, and expert systems. These initiatives did not achieve strong adoption by the business communities. This failure and non-use is attributed to the complexity and poor usability of such technologies, rendering them ineffective (O' Brien 1997).

Wiig (1997) provides the following perspective of evolution of KM by considering the historical economical developments over time as shown in Table 2.2

Table 2.2: Evolution of KM based on historical economical developments (Adapted from Wiig (1997))

Agrarian Economies	Creating products for consumption and exchange
Natural Resource Economies	Natural resource exploitation dominate while customer intimacy was pursued separately by expert tradesmen and guilds
Industrial Revolution	Operational Excellence through efficiency that means emphasise leadership in price and customer convenience by minimizing overhead costs, eliminating intermediate productions steps, reducing transaction and friction costs and optimizing business processes (Treacy and Wiersema 1993)
Product Revolution	Product leadership through variability and sophistication. Which means emphasise creation of a stream of state-of-the-art products by services by being creative, commercialising ideas quickly and relentlessly pursuing new solutions often by obsolescing their own products (Treacy and Wiersema 1993)
Information revolution	Continued focus on operational excellence and product leadership
Knowledge Revolution	New focus Customer intimacy which means emphasise tailoring and shaping products and services to fit and increasingly better definition of the customers needs to personalize offerings to make the customer successful (Treacy and Wiersema 1993)

The knowledge revolution in the last decade has set the foundation for knowledge economy and it is becoming far more complex and involved. Organisations and individuals are increasingly required to understand more and more about their customers and their customers' needs. Hence to gain a competitive advantage knowledge and understanding is becoming far more important than data and information. The role of knowledge economy is evident in providing value for customers, the way in which each individual plays his/her part and more about how individuals play their part so that continual improvement can be achieved through improving product process and relationships. It is important to know how to get customers to articulate and contribute to innovation through their knowledge and exploration or speculation of what they might want or need. This focus on customer feedback and interaction has developed into a sophisticated interest in customer relationship management that is based on customer knowledge (Berry 1983; Gronröos 1994; Kavali *et al.* 1999).

Gary Hamel and C.K. Prahalad argue that existing approaches to business strategy were failing to deliver true innovation. They argue that the key to creating business sustainability lies in organisations competing for the future by delivering true value to customers and the broader community. They maintain that this can be achieved through a constant cycle of organisations reinventing and re-skilling themselves to be able to anticipate and align themselves with their customer's customer needs in order to deliver unique products and services. They reason that in doing so this would radically transform organisations and reconfigure existing industries and generate entirely new ones (Hamel and Prahalad 1994).

Intellectual Capital (IC), under the current focus on information and knowledge services is being considered as critical resource, people being the critical asset and development of new ways of unleashing ideas, intellect, and creative energy as the core response (Boudreau and Ramstad 1997).

Knowledge and information is not only used to drive business performance but is also used to enable transformation of opportunities into reality through innovation. The emergence of this knowledge revolution has led to the rise of the perceived value of the knowledge worker. It started in the last quarter of the 20th century with phenomenal growth in the influence of information and communication technologies specialists but now the focus interest and influence has shifted to KM and more recently to developing ways in which human and social resources can be harnessed. The emerging elites are those that enable, energise and are activists in the use of knowledge of a wide and deep range of an empowered workforce to

unleash innovation and creativity (Edvinson 1997; Sveiby 1997; von Krough *et al.* 2000; Handy 2001).

Stewart (2000, p15) explains how knowledge about money, finance and other tangible resources has become more valuable than the tangible object itself with an air travel industry example illustrating the growth of the perceived value of knowledge as a product.

> "*The air travel industry has become two different industries: the flying industry, which is marginally profitable at best, and the information-about-flying industry, which makes money hand over fist*." (2000, p15)

Another example is that of Boeing which has repositioned its business enterprise from being suppliers of aerospace products through to service and maintenance providers and are now providers of strategic and operational information about aerospace products and services (Szymczak and Walker 2003). This is really the 'The Race for the Future', where business is shaped and sculpted around knowledge about tangible goods to provide intangible services.

Walker (2004) notes that this notion of shaping the future requires organisations like Microsoft, in moving from being an operating software supplier to e-business applications coordinator. These organisations need to continually learn to learn and also how to learn to unlearn. Skills required are not only specific to the technology at hand but also enable organisations to know how to move from delivering one technology, product or service to a new one. These 'competencies and skills relate to acquiring existing knowledge, generating new knowledge, sharing and morphing new and existing knowledge and knowing how to discard or recast knowledge that has exceeded its use-by date' (Walker 2004).

2.2.4 KM a Fad?

Spiegler (2000) states "Reading recent KM articles, one cannot escape the impression of a recycled concept" but later concedes "knowledge is the essence of KM without which this new endeavour is a merely recycling of management topics. Without articulating the K word, the whole area may turn out to be yet another fad that will fade away with time". Spiegler was comparing KM with concepts like BPR (Business Process Re-engineering), EIS (Executive Information System), MIS (Management Information System), DSS (Decision Support

Systems) etc. All these concepts were put forward to improve the performance of the organisation but their narrow focus on data and information make them different when compared with KM. Kanter (1999) states that broadening the definition of knowledge to include implicit knowledge carried in an individuals mind and not presented in company databases suggests something of a new direction.

Vanhoenacker *et al.* (1999), while criticising Business Process Change and the concept of Business Process reengineering, argue that failure to develop and exploit and capitalize on the organisation knowledge for inducing business change is a key reason behind the unsuccessful applications of business process change methodologies. It is for this reason that after a decade of experience with the business processes phenomenon, there are still fundamental problems restricting its successful applications (Vanhoenacker *et al.* 1999).

This suggests KM is far from being a management fad like TQM, BPR, downsizing, etc (Hilmer and Donaldson 1996; Wiig 1997; Kidd 2001; Malhotra 2004). It is fundamentally different in both objective and scope. It is broad, multidimensional and covers most aspects of the enterprise activities (Wiig 1997). It is paradigm in its own right and occupies a separate domain of investigation (Maqsood *et al.* 2004).

2.3 Understanding Knowledge

2.3.1 What is Knowledge?

The concept of Knowledge can be described by a simple world "understanding". This understanding gives birth to reality that humans construct in their minds as a result of experiences and interpretation. Davenport and Prusak (2000,p5) comprehensively states the concept of knowledge as follows:

> "a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates in and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms".

Knowledge is ‘a body of understanding and skills that is mentally constructed by people’ (Standards Australia 2001,p7). Stewart (2000) mentions knowledge, while differentiating it from data and information, as ‘a conclusion that is drawn from data and information’. Data is just a raw product. It is set of discreet objective facts about events and a collection of any number of required observations on one or more variables (Levin 1987; Davenport and Prusak 2000). When data is processed to provide certain useful context it becomes the information and can be used in decision making (Standards Australia 2001). Further processing of information provides an understanding and grasp of reality that is then termed as knowledge. Knowledge is the power to act and to make value-producing decisions that adds value to the enterprise (Polanyi 1962; Kanter 1999; Vail 1999) and is held to be true in a given context to drive people to action (Bourdreau and Couillard 1999).

2.3.2 Types of Knowledge

Knowledge is a slippery and fragile thing that is hard to define or categorize (Spiegler 2000). Egbu *et al.* (2001b) consider knowledge as a 'messy' concept that cannot be characterised by a linear pattern of categorisation. The literature in cognitive psychology and management broadly classify knowledge into two types. These are explicit knowledge and tacit knowledge (Nonaka and Takeuchi 1991; Nonaka and Takeuchi 1995). Best (1989) describes the classification of knowledge as declarative knowledge ‘knowledge that’ and procedural knowledge ‘knowledge how’.

Declarative knowledge or Explicit knowledge is formal and systematic (Carrillo *et al.* 2004). It is a type of knowledge that can easily be explained in explicit terms. It is flexible and can often be reorganised to suite our purposes (Best 1989). In theory it can easily be recorded for later use in textual, pictorial or other recorded forms. In organisations it exists in a form of code of practice and product specifications. This is the knowledge that is taught in class rooms and available through books. It is easy to communicate and hence share. For this reason it can be easily encoded in programs to run machines.

On the other hand, tacit knowledge is often embedded in procedural knowledge is ‘knowledge how’. The organisation of procedural knowledge is often unknown to us, nor is procedural knowledge usually very describable (Best 1989). Tacit, according to the dictionary, means silent, not openly expressed but implied, understood or inferred—from the Latin *taceo* I am silent (Macquarie 1987, p1727). This type of knowledge is highly personal, individualistic

and concomitant with various surrounding contexts within which it is shaped and enacted. It is the type of knowledge that refers to underlying skilful actions (Quinn *et al.* 1996) and follows the saying "it is easier to show than tell". A bicycle rider would find it easier to show his skills by riding a bike rather than telling how he actually rides a bike. Polanyi (1997) explains this concept by giving an example of face recognition. He mentioned that we can recognise a particular person's face, even someone from the past or someone whom we have never met, from the thousands and indeed millions of faces presented to us yet we cannot explain how we know that particular face (Polanyi 1997, p136).

Reuber (1997) and Carrillo *et al.* (2004) consider procedural knowledge or tacit knowledge as expertise developed from experience. The hard to formalize nature of tacit knowledge renders it difficult to communicate and share. Fernie *et al.* (2003) argue that tacit knowledge is a problematic esoteric concept that doesn't lend itself easily to codification. Hence a belief that knowledge can be easily captured and shared through machines is not a realistic belief.

Collins (1995) sees three types of tacit knowledge that present challenges to epistemological concerns of management. Embodied knowledge describes a type of knowledge that is a function of the physical environment. It cannot be easily transferred from one brain to another, as it is specific to the unique 'hardware' that accompanies an individual's brain, it is an integral part of the unique make-up of the human body. For example, a boxer's knowledge of fighting may be transferred to a professor but the latter may not be physically able to use that knowledge in practice (Egbu *et al.* 2001b). Embrained knowledge describes a type of knowledge that is specified by the exclusive physicality of an individual brain and encultured knowledge describes a type of knowledge that is embedded within a social context and cannot exist apart from it.

2.3.3 Other Knowledge Classifications

Drew (1999) comes up with four types of knowledge while trying to understand the concept of knowledge as:

1. What we know, we know
2. What we know, we don't know
3. What we don't know, we know
4. What we don't know, we don't know.

Zack (1999,p42) provides the following typology: declarative knowledge (knowledge about or *know what*), procedural knowledge (*know how*), causal knowledge (*know why*), conditional knowledge (*know when*), and relational knowledge *(know with*).

2.3.4 Dimensions of Knowledge

Davenport and Prusak (2000,p70) rather than providing an explicit classifcation of knowledge toiled to develop an understanding of knowledge by explaining various dimensions of knowledge. They propose seven dimensions of knowledge shown in Table 2.3 below.

Table 2.3 – Dimensions of knowledge (Source: (Davenport and Prusak 2000))

Scores 1		**Scores 5**
1 Tacit	⟷	Explicit
2 Not teachable	⟷	Teachable
3 Not articulated	⟷	Articulated
4 Not observable in use	⟷	Observable in use
5 Rich in subtext/context	⟷	Schematic
6 Complex	⟷	Simple
7 Undocumented	⟷	Documented

It is important to have a typology such as this because it provides us with a basis for gaining valuable insights into how to effectively transfer knowledge. Table 2.3 becomes a guideline to craft a strategy that can address several dimension of knowledge while carrying out KM. It is clear from Table 2.3 that *tacit* knowledge is difficult to explain through the spoken word or in text form—that is to be made *explicit*. In order for knowledge to be easily transferable and available through out an organisation, it must be able to be explained explicitly. Some knowledge is *unteachable* in that the only way to learn it is through experience. Faith-based knowledge is an example. Many balance-type sports like bike riding, surfing etc come in this category. Their techniques and theory can be taught (Knowledge What) but it is only by experimenting and experiencing these sensations that let the body's peculiar sensing systems take over from programmed 'rule-based' knowledge to develop the subtle knowledge of the 'how' to balance and why to do so in each of these sports. Some knowledge cannot be easily *articulated* because other physical senses are more useful for this purpose. Culinary skills for example involve using knowledge extracted from the physical senses relating to judgement of taste and consistency of substances like pastry. This knowledge may be explicitly transferable, however, with difficulty by using ingenious and highly resource-consuming means such as the use of multi-media and experiential learning (Walker 2004). Nonaka and

Takeuchi (1995) discuss the Japanese invention of a bread-making machine as an example. This innovation required a production design engineer to undergo sustained period of apprenticeship and interaction with an expert pastry chef in order to enable the chef to articulate and make explicit concepts such as dough consistence and kneading techniques. Once this was successfully accomplished the production engineers designed the bread-making machine by using the chef's transferred knowledge and developed the machine through further experimentation using trial and error.

Some knowledge is *not observable*—hidden inside the mind. An example is the creative thought processes of artists, musicians and elite sportspeople. Knowledge may be *schematic*, easily reducible to rules and patterns, or be so rich in context (known only from using multiple senses) that definition clouds all clarity that might be sought to explain this kind of knowledge. Schematic knowledge lends itself to being framed in tables, rules and other forms of clear representation. *Complexity* versus simplicity also defines ends of a knowledge spectrum. Knowledge about predictions like weather predictions or any other types of prediction represent this dimension. Finally, some knowledge is *documented* and other is not. Knowledge of ancient languages is dependent of documented sources—whether inscribed upon rock, on papyrus or paper. More prosaically, lessons learned from projects are often rarely documented in the commercial building industry (Walker and Sidwell 1996).

Table 2.4 - Twelve types of knowledge

Knowledge type (E) **Action type (A)**	**E1: Explicit**	**E2:** **Tacit**	**E3:** **Self-transcending**
A1: Performing	Know-what	Knowledge in use	Reflection in action
A2: Strategising	Know-how	Theory in use	Imagination in action
A3: Mental modelling	Know-why	Metaphysics in use	Inspiration in action
A4: Sculpting	Know-who	Ethics/aesthetics in use	Intuition in action

Claus Sharmer expresses a view of knowledge being much like an iceberg. Above the water line he envisages explicit knowledge. Below the water line he identifies embodied tacit knowledge (knowledge in use) and what he calls self-transcending knowledge (not yet embodied knowledge) (Scharmer 2001, p70). This notion led him to categorise four types of action in using knowledge; delivering results that create value (performing); improving the process of performing (strategising); reframing the assumption of performing (mental modelling); and re-conceiving the identity of performing (sculpting). Through developing a

matrix of the three types of knowledge he identified four actions of knowledge use. He developed a categorisation of knowledge into twelve elements as illustrated in Table 2.4.

2.3.5 Strategic Implications of the Knowledge

Zack (1999,p139) discusses the process involved in developing a knowledge strategy. This is presented in Figure 2.1 below.

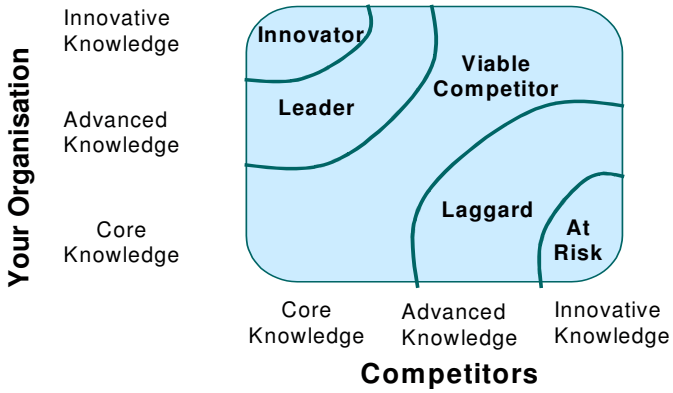


Figure 2.1 - Knowledge strategic analysis

He stresses that organisations need to have '*core knowledge*' which is the minimal knowledge they require to stay in the business. *Advanced knowledge* enables a firm to be viable relative to its competitors, while it may have generally similar scope and quality of knowledge to its competitors but it may be able to have specific differentiated knowledge that places it in a niche market situation. *Innovative knowledge* allows it to lead its industry segment(s) and significantly differentiate itself from competitors.

Zack argues that knowledge is dynamic- advanced knowledge today would just become core knowledge tomorrow. In Figure 2.1 he provides a useful map to illustrate the competitive positions of organisations in terms of being 'at risk', a 'laggard', a 'viable competitor', a 'leader' and an 'innovator'. This simple model clearly indicates the value of having advanced and innovative knowledge to have the chance to be able to stay ahead among competitors. Dixon (2000, p149) shares the same notion where she identifies a "*shift from thinking about knowledge as a stable commodity to thinking of knowledge as dynamic and ever changing*". This knowledge is seen not as a commodity locked in a warehouse, but as a flow like water across the organisation.

2.3.6 Knowledge Stickiness

Stickiness can be characterised as a property of knowledge by which it makes its transfer from one mode to other or from one individual to other difficult. In simple words, it is to refer to barrier to knowledge transfer. Burton-Jones (1999) describes some kinds of tacit knowledge as 'sticky', that is, difficult to codify or explain–it tends to stick to the person with that knowledge and is only transferred with a fair bit of consideration and effort. Stickiness of knowledge poses considerable problems for organisations wishing to maximise the conversion of tacit knowledge in people's heads into explicit knowledge that has been codified.

Kulkki and Kosonen (2001) graphically present conversion of knowledge from tacit to explicit in and is shown in Figure 2.2. This makes it clear that the conversion process is not an easy and simple one.

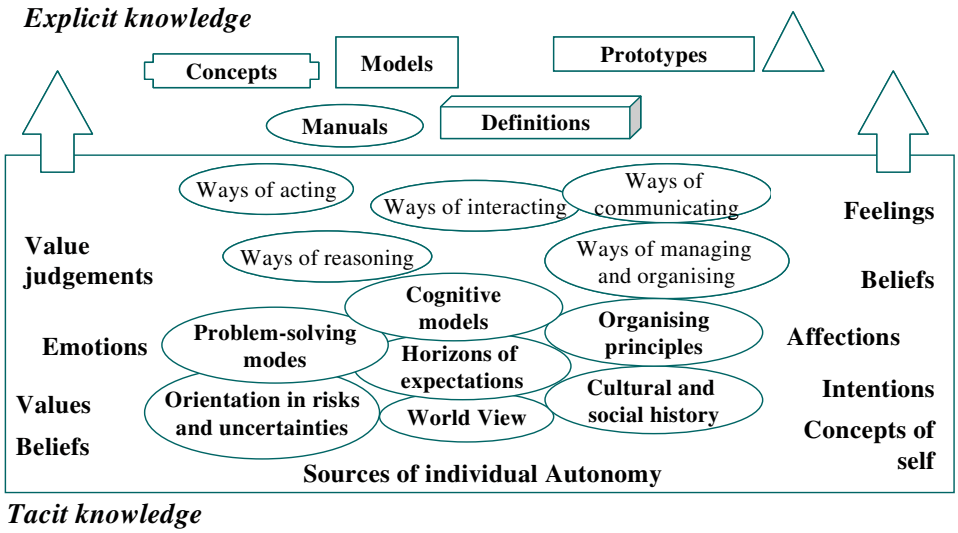


Figure 2.2: Knowledge from tacit to explicit

(Source: Kulkki and Kosonen (2001))

Szulanski (2003) discusses stickiness of knowledge in great depth by conducting a series of studies into the transfer (often failure to fully transfer) of best practice within organisations and concluded that the three major sources of knowledge stickiness (barriers to transfer of knowledge) were *absorptive capacity, causal ambiguity and the quality of the relationship between source and recipient of knowledge*.

Absorptive capacity essentially is a capacity to absorb knowledge. Cohen and Levinthal (1990) argue that this is largely a function of prior related knowledge—people learn best by

association, linking related accumulated knowledge and experience. Walker (2004) explains for this reason that if you get used to 'toolbar' on any one application in Microsoft Suite of Office products, you will find a similar 'feel' for other applications. Companies that encourage R&D or who encourage their employees to undertake training and development courses find it less difficult to be prepared for knowledge transfer. Thus an absorptive capacity is a crucial factor in knowledge being transferred either from tacit to tacit or tacit to explicit—the recipient is bounded by his/her absorptive capacity to understand the shared knowledge content and context. Causal ambiguity is the inability to be able to make a cause and effect link. If a link cannot me made, then mistakes are repeated. This will become an inability to replicate best practice and the management of valuable knowledge becomes extremely difficult. The third major influence on knowledge stickiness is the relationship between the source and recipient of knowledge. If the source disseminated the knowledge in a user friendly way, the recipient will get it easily. For example in the case of search engines as a source, and we as recipient, we get either few 'matches' or we get an overwhelming number of them that hinders our capacity to deal with the information provided. When the source is people and the recipient is also people (people to people), the issue of culture and communication plays a major and often critical role. An organisational culture can encourage or inhibit knowledge sharing.

2.3.7 Knowledge Transfer for Overcoming Knowledge Stickiness

Dixon (2000, p169) is at the forefront of the research in knowledge transfer. She has provided great insights into her research of KM used in company such as Bechtel, BP, Buckman Laboratories, Chevron, Ernst & Young, Ford, Texas Instruments and the US Army. She identified 5 types of knowledge transfer shown below in Table 2.5:

Table 2.5: Five knowledge transfer strategies (Source: Dixon (2000))

Serial Transfer	the knowledge a team has learned from doing its task that can be transferred to the next time that particular team does the task in different setting (context). Such tasks are frequent and non-routine using both tacit and explicit knowledge. **Examples** include the **US Army's** *After Action Reviews* (AAR) and BP's "Learning during" reports and Bechtel – Steam Generator group reports;
Near Transfer	the explicit knowledge a team has gained from doing a frequent and repeated task that the organisation would like to replicate in other teams that are doing very similar work. Such tasks are frequent and routine using explicit knowledge. **Examples** include Ford's use of best practice replication, Texas Instruments' Alert Notification, and Ernst & Young's KnowledgeWeb;

Far Transfer	the tacit knowledge a team has gained from doing a non-routine task that the organisation would like to make available to other teams that are doing similar work in another part of the organisation. Such tasks are frequent and non-routine using tacit knowledge. **Examples** include BP's Peer Assist, Chevron's Project Development & Execution Process CPDEP, and Lockheed Martin's LM21 Best Practice;
Strategic Transfer	the collective knowledge a team needs to accomplish a strategic task that occurs infrequently but is of critical importance to the whole organisation. Such tasks are infrequent and non-routine using both tacit and explicit knowledge. **Examples** include BP's Knowledge Assets, the US Army's Centre for Army Lessons Learned CALL and also their use of Learning Histories;
Expert Transfer	the technical knowledge a team needs that is beyond the scope of its own knowledge but can be found in the special expertise of others in the organisation. Such tasks are infrequent and routine using explicit knowledge. **Examples** include Buckman Labs' Techforums, Tandem's Second Class Mail, and Chevron's Best Practice Resource Map

Far, strategic and expert knowledge transfer involves high profile impact upon organisations. Serial and near knowledge transfer provides high level overall rewards and benefits, along with far transfer due to the value gained from frequently reaping rewards.

Dixon (2000, p147) explains the above transfer by developing a decision tree which was based on four questions:

1. Will the same team be using the lessons learned?
2. Is the knowledge tacit?
3. Does the knowledge impact upon the whole organisation?
4. Is the task both routine and frequent?

Knowing this, helps organisation to be highly responsive and effective. They don't have to reinvent the wheel so they will act quickly and by transferring the knowledge from one context to another, they use the knowledge and also create a new knowledge as they apply the knowledge to a new context.

Holden (2002) is as an expert in linguistics. He carried out research in the cross-cultural knowledge transfer process which he views as knowledge translation He studied four transnational companies (TNC's) case studies, Novo Nordisk and Lego both of Scandinavian origin, Matsushita (Japanese origin) and , Sulzer Infra (Swiss based). Each of these case studies were concerned with cultural adjustment across these TNCs' international operations to 'roll out' the corporate systems, processes and organisational culture (Holden 2002). The interesting aspect of these studies were that Holden looked at these case studies as examples

of knowledge transfer. Considering, Dixon's framework, Holden's case studies could be classified as being 'strategic transfer' and also, to a lesser extent, expert knowledge transfer. He argues that as tacit knowledge (in particular) is exchanged and socialised it is translated into different contexts and worldviews and thus both parties gain benefit from gaining a glimpse into the other's way of internalising this knowledge. This truly takes knowledge transfer to a state of knowledge creation.

Knowledge is sticky and both expensive (in terms of transaction costs) and difficult to transfer because knowledge is more than just facts and information. Knowledge is about context, the history and hidden myriad inferences and cause and effect loops that explain why something did or did not happen in a particular way. Documented manuals and procedures fail to cover all eventualities and are time consuming to access and absorb. The next section sheds light on another side of tacit knowledge, often hidden.

2.4 The Hidden Side of Tacit Knowledge

The main focus of current KM research is to capture the knowledge that tacitly resides in the employees' heads and to turn it into the explicit form for others to use. Researchers agree that knowledge is a very 'messy' and esoteric concept. Therefore, capturing it is a task fraught with difficulties. But if captured and put into explicit form, tacit knowledge is a driving force behind any sort of innovation, be it new technology, new process or a new technique. Tacit knowledge, by its very nature, actually 'emerges' from the people's heads. The various mental processes that shape and construct certain types of knowledge are very difficult to comprehend. This sort of knowledge is a key behind exercising judgment in human decision-making and employing intuition or 'gut-feeling'. It is seen in experienced managers; because of their tacit knowledge and expertise based on this sort of knowledge, they are able to make better-informed and effective intuitive decisions. However, there is also a probability of these managers making a wrong judgment ending up in wrong decisions.

This section examines (when trying to capture tacit knowledge) what can be done to make sure that tacit knowledge stays effective when captured and used in decision-making. Help from the literature in cognitive psychology has been sought and presented below.

2.4.1 Human Information Processing - Factors affecting Knowledge Construction

It is important to know how human information processing occurs as sensing information and utilizing it is a key to further knowledge construction in a human mind.

Perception and Recognition

The first element involved in the human information processing that facilitates knowledge construction is perception of the event, and then use of memory to give this perception recognition. Figure 2.3 illustrates how perception of displays occurs through stimuli generated by various sensory inputs - e.g. vision, audition, chemical senses - i.e. smell and taste.

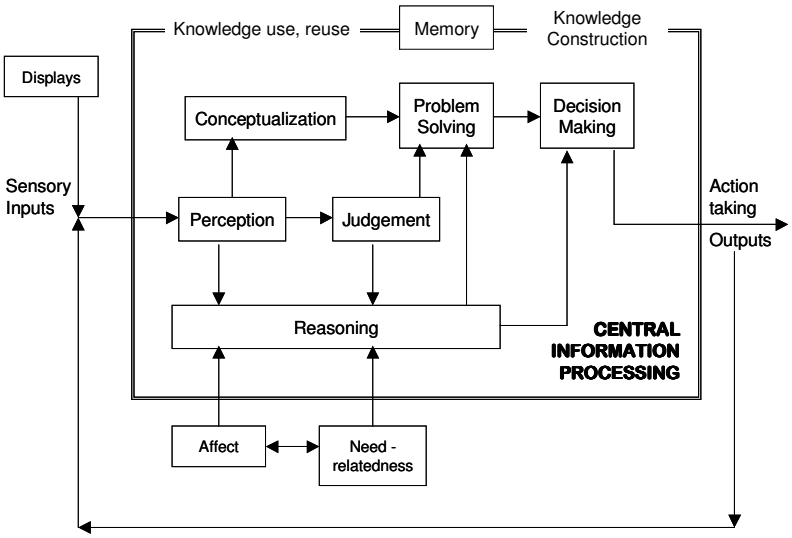


Figure 2.3: Human information processing (Modified from Kolasa (1982))

This system recognizes the information, assembles it, and makes comparisons with previously stored material (knowledge). Knowledge is used, reused and iteratively reconstructed. Perception is a selective process and certain amounts of information from the outside are selected because not all of the information coming in can be assimilated. Perception is affected by factors such as attitudes, values, motives, stress and a person's background.

Cognitive Styles

Gigch van (1991) defines cognitive style as "an individual's way of performing perceptual and intellectual activities". It depends upon genetic makeup and environmental factors such as education and experience. Managers or thinkers can be classified as systematic, intuitive, receptive and perceptive. The diversity in their education and experience causes differences in their perception and judgment thus rendering their cognitive styles different. Their cognitive structure guides their decision making style whether heuristic or deterministic or a mixture of the two. Cognitive style may also be referred to as high analytical or low analytical.

Heuristics and Biases in Judgment

'Heuristic' is a term used by psychologists to denote general problem solving procedures that often work in solving everyday problems. It is a rule-of-thumb, a guideline for coming up with a solution (Best 1989). Skitmore *et al.* (1989) argue that cognitive heuristics or principles are systematic rules that operate instead of a detailed analysis of the available information thus conserving mental effort. The use of heuristics is very widespread in the construction industry (Flanagan and Norman 1993). Although employment of heuristics enables the mind to analyse very complex situations, it sometimes leads to severe and systematic errors or biases. Biases have high potential for coming into play when a decision task has a high degree of complexity, high degree of procedural uncertainty and when it is performed under circumstances involving a high degree of stress and time pressure. The susceptibility of human judgment to errors and biases can be attributed to the limitations of human cognitive capacity - the capacity to store, retrieve and process information.

Tversky and Kahnemann (1974) have described three common heuristics: Representative, availability, adjustment and anchoring. The representative heuristic states that the probability that event A is related to event B is evaluated by the degree to which A resembles B. The representative heuristic involves search and compare strategies (Chi and Fan 1997). The answer to the more familiar problem is adopted as the most likely solution to the present one. Availability of heuristics determines the instances of large classes of problem solutions being usually recalled better and faster than instances of less frequent classes. Events that are easily computed are perceived as more common and are consequently more available than events whose likelihood is hard to compute (Best 1989). Adjustment and anchoring refers to the development of beliefs by starting from a particular reference and adjusting it according to the

available information. This adjustment process is often faulty. Baron (1998) finds that the influence of this heuristic appears to be quite strong and occurs unintentionally and unconsciously.

Functional Fixedness and Mental Set

Baron (1998) describes 'functional fixedness' as a tendency to use a device or things in a way they have been used in the past and not thinking of creative uses. A mental set is the impact of past experience on present problem solving, specifically the tendency to retain methods that were successful in the past even if better alternatives now exist. It is common on construction sites to deal with repetitively occurring problems in a routine way, even if better ways are available.

Mental Models

Best (1989) describes mental models as internal representations of problems that are formed over a period of time by various experiences of a similar nature. Organisms do more than react to their environment, they learn about it. Learning consists of building representations of the environment that are consulted prior to behaviour. These representations are known as cognitive maps ((Tolman 1948) cited in (Vandenbosch and Higgins 1996)). Barlett (1932), cited in (Vandenbosch and Higgins 1996) proposes that memory is guided by a mental structure called a schema, an active organization of past reactions, and past experiences. The active nature of a schema is that it is emergent in nature and constantly changing and developing in response to experiences. These mental models determine how environmental stimuli will be interpreted and incorporated or synthesized. Mental models also make knowledge and information processing more efficient by making it unnecessary to construct understanding from the start each time similar stimuli are encountered. They facilitate learning by allowing humans to fill gaps in both information and memory.

2.4.2 Variations in Learning Style and Knowledge Acquisition

Every human has a unique learning style. Learning depends on the ability of the individual for the acquisition of information and for using it properly and in a timely way for effective decision-making. The key to better decision-making lies in obtaining relevant, accurate and timely information and using the cognitive capacity of the individual, then translating information into knowledge and decision-making (Wilson 1995). Learning emerges from the

interaction of the stimulus and the mind of the learner and results in the change of the learner's mental model (Vandenbosch and Higgins 1996). Ford and Ford (1983) observe that individuals differ in ways in which they can and do structure information in learning and problem solving contexts. Norman (1982) cited in (Vandenbosch and Higgins 1996) identifies three modes of learning: 'Accretion' is the addition of new knowledge to existing schemata. This is the most common mode of learning. 'Structuring' is the formation of new schemata. The existing models are not sufficient to handle the problem faced so new models have to be developed. 'Tuning' is the fine adjustment of knowledge to a task. Adjustment is needed because the existing schemata are too general or because they are mismatched to the particular use that is required of them.

2.4.3 Tacit Knowledge Construction – a practical example

The learning process of a new graduate joining a construction site starts when s/he begins working as a site engineer. Engineering education doesn't contribute greatly to the knowledge required to handle construction tasks (Warszawski 1984), so site engineers tend to learn everything from the site process. While passing time in this trade s/he will go through various mental model building and maintenance stages to develop expertise. The development of expertise is different for various site managers even if they spend the same time on the job (Baird 1989). This shows that expertise is not only a matter of spending time in a certain trade. The number of years passed is only a crude measure of gauging expertise in placing confidence in the person. However, the person who has passed adequate time observing site processes but is not able to develop adequate expertise will not perform as effectively as the person who has developed enough expertise. There are no direct measures of criteria to determine expertise. It can be indirectly gauged by observing the quality of performing site processes. This leads to the point that tacit knowledge elicited by these site managers would be of different nature and quality, even if they have experienced similar work routines.

2.4.4 The Importance of Context

Fernie *et al.*(2003) discuss the importance of context when comparing organizations with a view of utilizing knowledge gained in one sector and applying to other sectors. They emphasized that while doing so - industry context, which involves political, economic, social, technological, legal, environmental and structural factors inherent in each sector - must not be overlooked. Knowledge needs to be extracted from one context and be converted and adapted

to another context. Thompson *et al.* (2001) consider this process as recontextualization. Sometimes recontextualization alters knowledge to such an extent that it represents new knowledge (Fernie *et al.* 2003).

Every task in a construction process has a certain context associated with it in which it is executed and completed. The constructed knowledge that occurs is deeply dependent on this context. This context provides the boundary conditions for the constructed knowledge, and it is considered valid provided it satisfies the limiting boundary conditions (i.e. context). Ideally it means that the knowledge can be applied repetitively to the situations if the context under which it is constructed remains unaltered. Practically, it is very hard to find a situation where the context is an exact replica of a previous event. Especially in a construction process, context is always varying. This difference in contexts is one of the reasons that construction managers are often misled into wrong decision-making when using tacit knowledge. The basis upon which they are making the decisions has shaped itself under a different context. If managers are aware of the context in which they gain a certain experience, and keep that context in mind to alter their decision-making processes to reflect the changes in the context, then they are in a position to minimize biases and hence have great chance of successful decision-making.

The same holds true while attempting to capture tacit knowledge. Capturing tacit knowledge without capturing the context in which it was constructed may seriously jeopardize its effectiveness. Knowledge managers need to be fully aware of this aspect of knowledge elicitation. When the captured knowledge is to be further shared and used, related context must also be communicated. It becomes necessary to recontextualize it to reflect the changes in the context to use it efficiently.

2.4.5 Importance of Timing

The human mind has a lot of limitations and one of the severe limitations is that the knowledge starts to lapse from memory or become faded and confused over time. Where construction tasks are heavily repetitive, this limitation may not be a problem. However, for unique and innovative tasks, delay in timing to capture a constructed knowledge may pose problems in the validity and effectiveness of the knowledge captured. Aligned with the concept of KM is a concept of project histories or project databases that may be maintained as

a part of KM initiative in an organization and contains knowledge generated in various projects to be used on future projects.

Schindler and Eppler (2003) have reviewed and discussed various ways to harvest project knowledge. They identified two ways of capturing project knowledge. Process-based methods (Project Reviews/Audit) gather lessons learned from the concluded projects and documentation-based methods (Micro Article, Learning Histories, RECALL) to learn from project experiences on an on-going basis. Documentation based methods are superior to the process based methods because they offer continuous project learning through regular reviews. The events are more recent and the subsequent learning can be recalled more easily (Schindler and Eppler 2003).

2. 5 Dimensions of KM

The above discussion on knowledge and KM paves the way for developing more understanding in the area of KM. KM research has seen a variety of conceptual models and dimensions advanced. McAdam and McCreedy (1999) would prefer to call these as models of KM. Because these models express different dimensions of KM and represent a certain school of though in the debate of KM, it is logical to classify these as 'dimensions' instead of presenting them as mere 'models'. A review of KM literature presents three dimensions of KM. McAdam and McCreedy (1999) identified three models of KM: category, IC and socially constructed. A dimension based taxonomy will consider these as Categorical Dimension, IC Dimension of KM and Socially Constructed Dimension of KM

2.5.1 Categorical Dimension of KM

The Nonaka and Takeuchi (1995) SECI dimension illustrated in Figure 2.4 serves as a useful starting point in understanding this dimension of KM and how knowledge creation occurs as a flow from tacit to explicit knowledge and a combination of knowledge push and pull. Nonaka and Takeuchi (1995, p71) explain the process as beginning with a Socialisation phase, sharing and exchange of tacit to tacit knowledge. *Tacit* knowledge is more difficult than explicit knowledge to create, capture, codify, communicate and transfer because it is highly intellectually energy intensive.

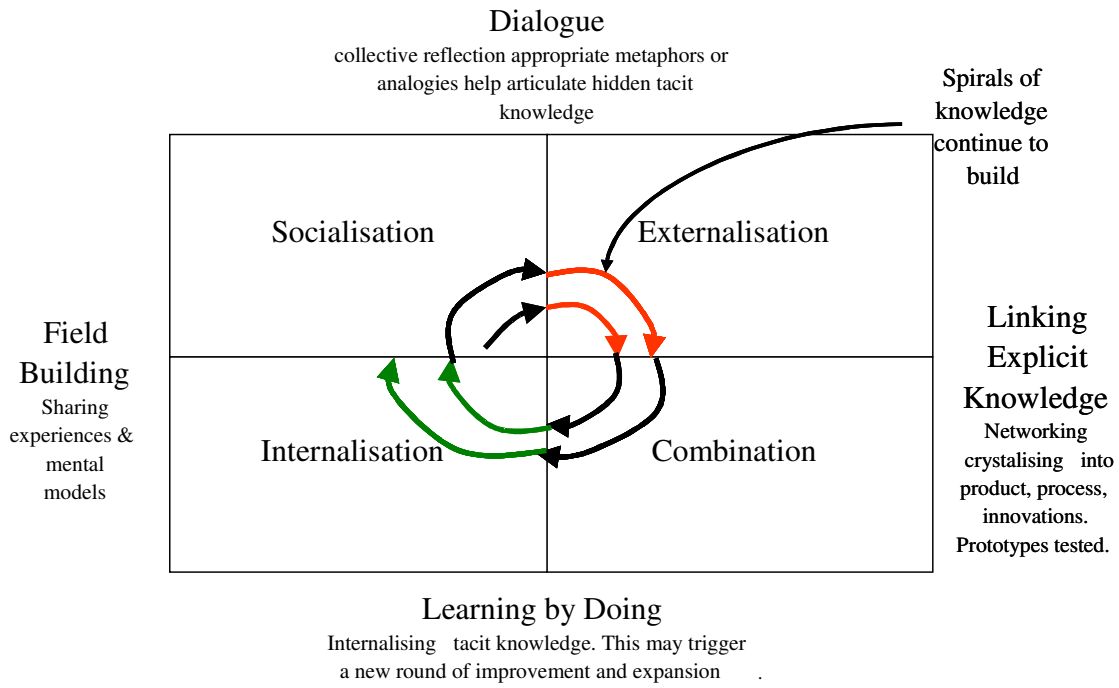


Figure 2.4: Nonaka and Takeuchi KM Model exhibiting categorical dimension of KM

Explicit knowledge is openly available in books and recordings on all kinds of communications media. However, explicit knowledge often does not have an accompanying explanation of the context of that knowledge. While explicit knowledge may be conveniently available, it is of less value than sound tacit knowledge because tacit knowledge embeds context. When people socialise their tacit knowledge they swap stories about contexts and experiences and thus expand their repertoire of how to use that knowledge. The output from this process is *externalisation*, involves turning value-added tacit knowledge into an explicit form often through metaphors for example 'it is like this …' when designing something or planning an action using existing knowledge in a novel way. This includes documentation, explanation or recording the cumulative experience of the situation under consideration. This allows knowledge *combination* to occur where the new knowledge is combined with existing knowledge stocks to make the result explicit. This leads to people *internalising* the knowledge whereby they experiment and then reshape in their mind how this knowledge is of use and how it can be usefully deployed. Essentially, the SECI dimension incorporates learning as well as a knowledge creation and the cycle continues in a spiral rather than a circular mode.

	Individual	Group Organisation	Interorganisational Domain	
Articulated Knowledge	Knowing calculus	Quality circle's documented analysis of its performance	Organisational chart	Supplier's patients and documented practices
Tacit Knowledge	Cross-cultural negotiation skills	Team coordination in complex work	Corporate culture	Customer's attitudes to products and expectations

Figure 2.5: Heduland and Nonaka's KM dimension (Source: Hedlund and Nonaka (1993))

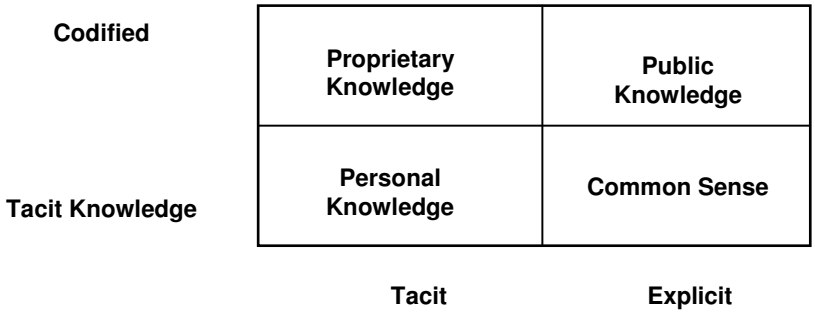


Figure 2.6: Boisot's knowledge category dimension (Boist, 1998)

Other categorical dimensions that share similarity with Nonaka and Takeuchi's model are Hedlund and Nonaka (1993) and Boisot (1998) shown in Figure 2.5 & 2.6. These representations are basically an attempt at giving high-level conceptual understanding of KM and essentially consider KM as a knowledge creation process occurring across levels of an organisation rather than amongst small groups of individuals. The knowledge transfers in organisations is much more complicated and complex than these simple matrix dimension suggest. This dimension is 'mechanistic' in its approach to knowledge categorisation even though that some aspects of the models emphasize socialisation (McAdam and McCreedy 1999). Crossan et al. (1999) propose a 4 I's model of organisational learning: Intuiting, Interpreting, Integrating and Institutionalising occurring at the individual, group and organisational level. This posits that a complex social process is taking place with context understood in terms of prevailing cultures as illustrated in Table 2.6 (Crossan *et al.* 1999, p525).

Table 2.6: The 4 I's knowledge processes

Level	Processes	Inputs/Outputs	Comments
Individual	Intuiting	Experiences Images Metaphors	Socialisation and dialogue, self-reflection - external knowledge pull
	Interpreting	Language Cognitive map Conversation & dialogue	Culture providing means to interpret and share insights - external knowledge pull
Group	Integrating	Shared understandings Mutual adjustment Interactive systems	Culture providing means to interpret and share insights – internal knowledge building push & pull
Organisation	Institutionalizing	Routines Diagnostic systems Rules and procedures	Culture and combination re-framing and adapting

The Crossan model envisages the SECI approach being very much both a push and pull of knowledge between individuals and their wider societal groups and various categories shown in Table 2.6 helps to better visualise the role of groups and the role of culture in facilitating dialogue (that is knowledge push and pull) so that knowledge is framed, re-framed, challenged through activity and routines. Crosson *et al.* (1999) argue that metaphors, rooted in culture that transcends the need for explicit descriptions in words, provide a powerful set of contextual meanings. They argue that knowledge is fed forwards (pulled) by individuals to groups and hence to the wider organisation as well as knowledge being fed back (pushed) from the top down through rules, procedures, performance measures etc.

2.5.2 Intellectual Capital (IC) Dimension

Another school of thought in the KM debate views KM as IC management. A number of models can be found in the literature espousing this point of view. A typical IC example is the Skandia IC dimension as illustrated in Figure 2.7 that was adapted from Edvinsson (1997, p369). This dimension assumes that IC (the management of which is KM) can be segregated into human, customer, process and growth elements categorised as comprising human and structural capital (McAdam and McCreedy 1999). This dimension assumes a scientific approach to knowledge and is more about what knowledge is assumed to be as an asset rather than how it is developed and the model completely ignores any political and social aspects. Like the Category Dimension this IC Dimension also assumes that KM can be decomposed into objective elements rather than being a socio-political phenomenon where intangible objectives can be tightly controlled (McAdam and McCreedy 1999).

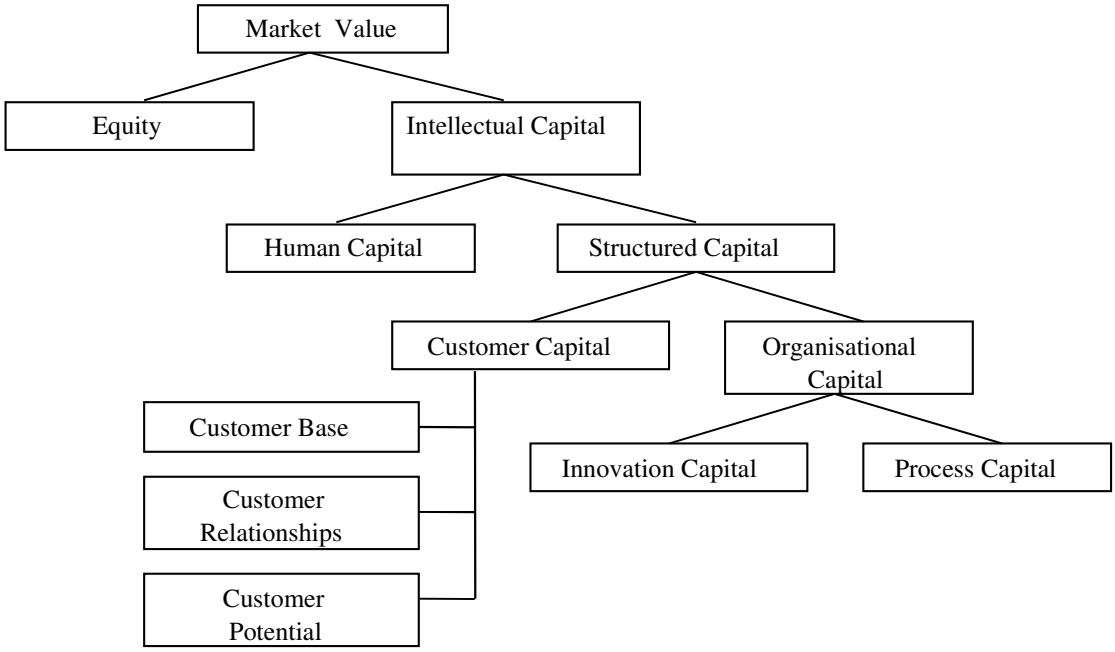


Figure 2.7: Intellectual capital dimension of KM (Skandia)

This way of understanding knowledge and how it may be managed is useful to the extent that it views knowledge as an important and strategic asset to be nurtured.

2.5.3 Socially Constructed Dimension of KM

This dimension according to McAdam and McCreedy (1999), is considered as more probably a true representation of what KM is and should be. The socially constructed dimension of KM is intrinsically linked with the social and learning process within the organisation. A socially constructed model modified by McAdam and McCreedy (1999, p98) from Demerest (1997) is shown in Figure 2.8.

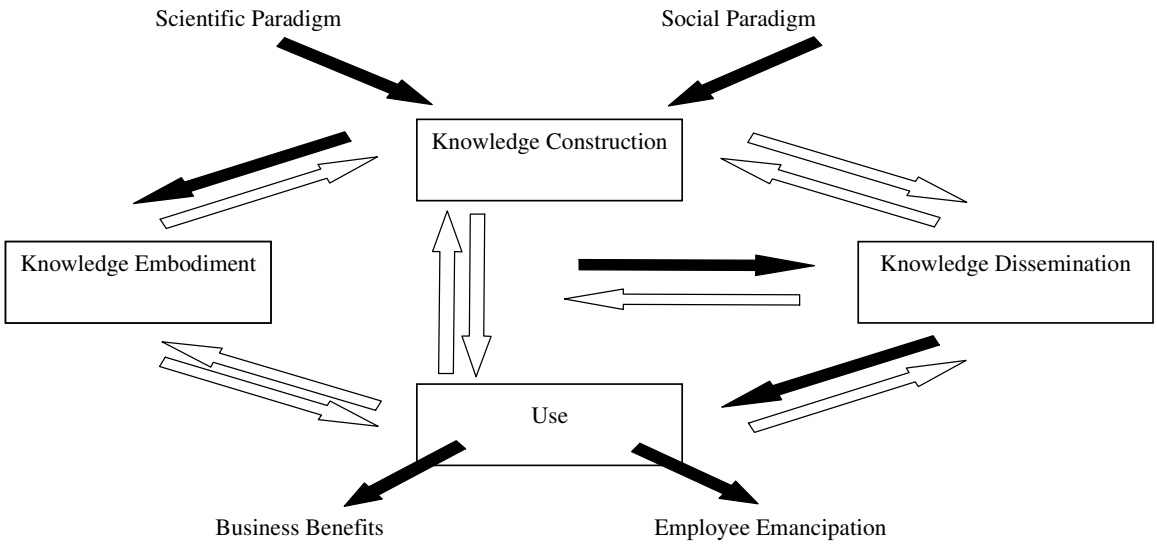


Figure 2.8: Socially constructed KM model and dimension

This dimension gives a more balanced approach between the scientific and social approaches to KM. The 'uses/benefits' of KM are viewed as both emancipatory and business oriented. Knowledge flows are seen as highly recursive rather than as sequential and mechanistic. According to McAdam and McCreedy (1999) this model allows KM to be associated with the emerging social paradigm while at the same time contributing to the current scientific paradigm

Conferences, workshops, professional development gatherings of colleagues are events that follow the Figure 2.8 model. This is because participants are able to construct their own personal knowledge through scientific knowledge being disseminated in a conference while at the same time provide them with an excellent opportunity to further enhance knowledge being gained through socialisation with other experts and knowledge carriers attending the conference. Emmitt (2001) found, from a study, predominantly of design professionals, that the perception of learning from other experts is viewed as being far more attractive than receiving trade literature or speaking to technical sales representatives. The above models clearly indicate the importance and complexity of social factors that facilitate and inhibit knowledge generation and exchange. While they are useful, they do not adequately illustrate what is happening in a particular knowledge exchange activity.

Social Network, Networking and Community of Practice

The socially constructed dimension of knowledge also entails developing social networks and networking where tacit knowledge transfers and sharing is possible (Bresnen et al., 2003; Augier and VendelØ, 1999 and Swan et al., 1999; Hearn et al., 2002). A further adaptation of this concept is the development of communities of practice (Wenger and Snyder 2000) that construct knowledge from active participation by communities of practice (COPs). Etienne Wenger defines COPs as "*groups of people informally bound together by shared expertise and passion for a joint enterpris*e" (Wenger and Snyder 2000, p139). These communities of practice may be real and exist in the physical form of conference/seminars/workshops, or in the virtual form of online forums or web-discussion boards. In either form, experts can interchange ideas and leave their expertise and knowledge in the forum for others to utilise and share further (Liebowitz and Megbolugbe 2003). This reflects a shift in thinking from "*knowledge as it resides with individuals to thinking of knowledge as embedded in a group or community*" (Dixon 2000, p149).

Orr (1990) , Brown and Duguid (1991) and Davenport and Prusak (2000) quote the example of a Communities of Practice (COP) of photocopying machine technicians who formed an informal (but highly focussed) technical support group to help them solve complex and often perplexing problems relating to breakdowns and malfunctions of these machines. Through this COP, a number of individuals share a common enterprise and objective of repair and maintenance of photocopying machines. Their support group share both knowledge and perceptions through narratives (war stories) where they discuss details of problems, their contexts, the messiness and quirkiness of the situation in all its rich detail of tacit details and sub-text.

Key elements of the Orr example and that of many from COP has been categorised by Brown and Duguid (1991) as follows:

- Narration or 'storytelling' that provide the thick and rich subtextual knowledge that underpins understanding of complex situations;
- Collaboration that enables the development of joint problem solving by peers in a largely power dimension free environment so that individuals share knowledge as equals in terms of their potential contribution to results;

- Social constructions through sharing and developing insights and modelling mentally through what-if scenarios, alternative solutions or explanations by peers using a shared language that connects areas of tacit knowledge in the SEconstruction industry socialisation process;
- Bricolage—that is a tendency to cope with complex problems by making do with whatever is at hand so that ingenious use is made of materials, systems, knowledge etc to shape the materials at hand to perform the required task to solve the problem. Often this results in leaps of inspiration and innovation.

A COP is both reflective and analytical in purpose. This is what makes it different from an unfocussed chat between individuals. It analyses complex situations and probe them deeply for causal relationships and strive for feasible solutions. These COPs may be real and exist in the physical form of conference/seminars/workshops, or in the virtual form of online forums or web-discussion boards. In either form, experts can interchange ideas and leave their expertise and knowledge in the forum for others to utilise and share further (Liebowitz and Megbolugbe 2003). ICT has a valuable part to play in the process of bringing communities and individuals together in virtual space. One important way that it is used for socialisation is through using groupware communication technologies. A particular example of this is provided by John Seeley-Brown in discussing the BP Virtual team where a group of experts located in different places throughout the world were linked by email, video-conferencing and other group tools to work on finding innovative solutions to design the Andrew oil and gas drilling rig that saved over US$120million and 6 months off the schedule (Prokesch 1997, p156). BP like many companies these days routinely use groupware tools to facilitate knowledge transfer through 'virtual socialisation'. The BP COP software was later adapted and successfully used by one major UK construction contractor (Jewell and Walker 2005).

A COP requires a trusting and safe environment in which contributions are valued and where social capital is recognised as a highly desirable outcome from an organisation's activities. The next section deals with the issue of social capital and its implications on socially constructed dimension of KM and also on a COP

Social Capital and its implications

The need for support for generation of social capital is a prerequisite for COPs and also for effectively functioning KM. Walker (2004) considers social capital as providing credentials for members of a COP in the same way a credit card is used by purchasers and traders. This implies that social capital is embedded within networks of mutual acquaintance and recognition. The obligation of being in the network then feeds the process. An individual feels an enhancement in the status and reputation while sharing knowledge.

Social capital can be described in three dimensions (Nahapiet and Ghoshal 1998, p243). The structural dimension is the way that it is configured structurally through network ties having various network configurations; much of this is invisible and intangible. The cognitive dimension comprises shares codes, languages and narratives. The relational dimension comprises trust, norms and obligations. Nahapiet and Ghoshal (1998) advocate that through developing social capital in this way by socialisation, a combination and exchange of IC occurs and that this results in the creation of new IC as illustrated in Figure 2.9.

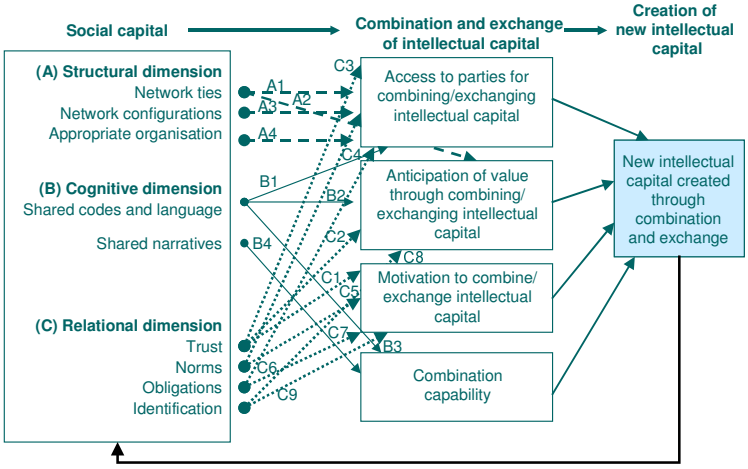


Figure 2.9: Social Capital in the creation of IC (Source: Nahapiet and Ghoshal (1998, p251))

This helps to explain how the second dimension of KM (IC) and third dimension (socially constructed dimension of KM) are supporting each other.

Walker (2004) gives his representation of the role of social capital in creating IC and hence providing knowledge advantage as shown in Figure 2.10 . This indicates that new IC is created through COP access to enable the exchange and combination of existing IC, thus access to both tacit and explicit knowledge sources is necessary. Walker (2004) also provides

a model of trust and commitment under tested conditions in Figure 2.11 to explain in more detail the role of trust and commitment in developing social capital and COPs.

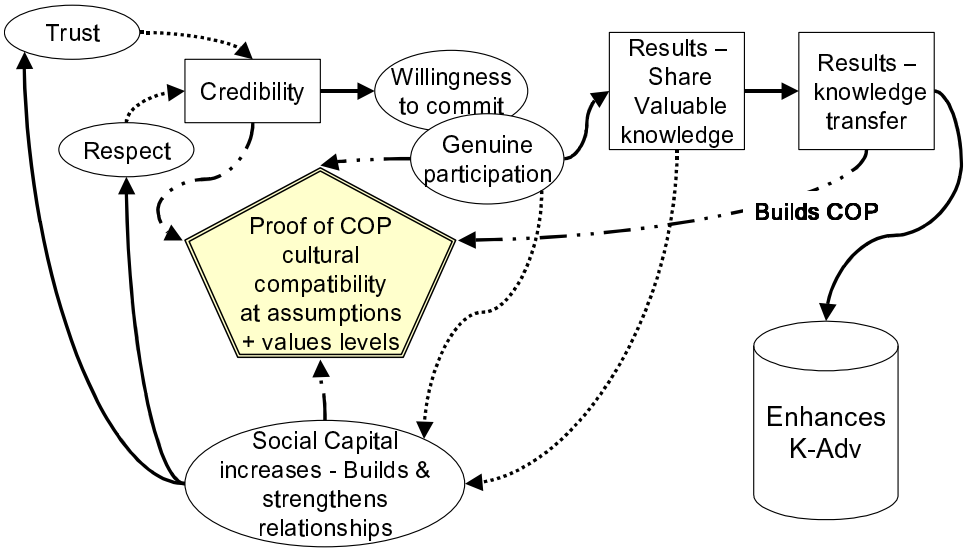


Figure 2.10: The Role of Social Capital in creating IC (Source: Walker (2004))

Commitment is the physical and mental manifestation of the concept of trust. It is the proof of trust. It is the willingness to reciprocate energy invested through trust in the process of transformation of this energy into tangible results. Loyalty occurs when trust and commitment are tested. It can be viewed as the bankable capital of goodwill to reciprocate trust in times of adversity (Walker and Hampson 2003a, p191). One demonstration of an act of loyalty is to sacrifice something in the short term to maintain a long-term relationship intact and functioning for mutual advantage.

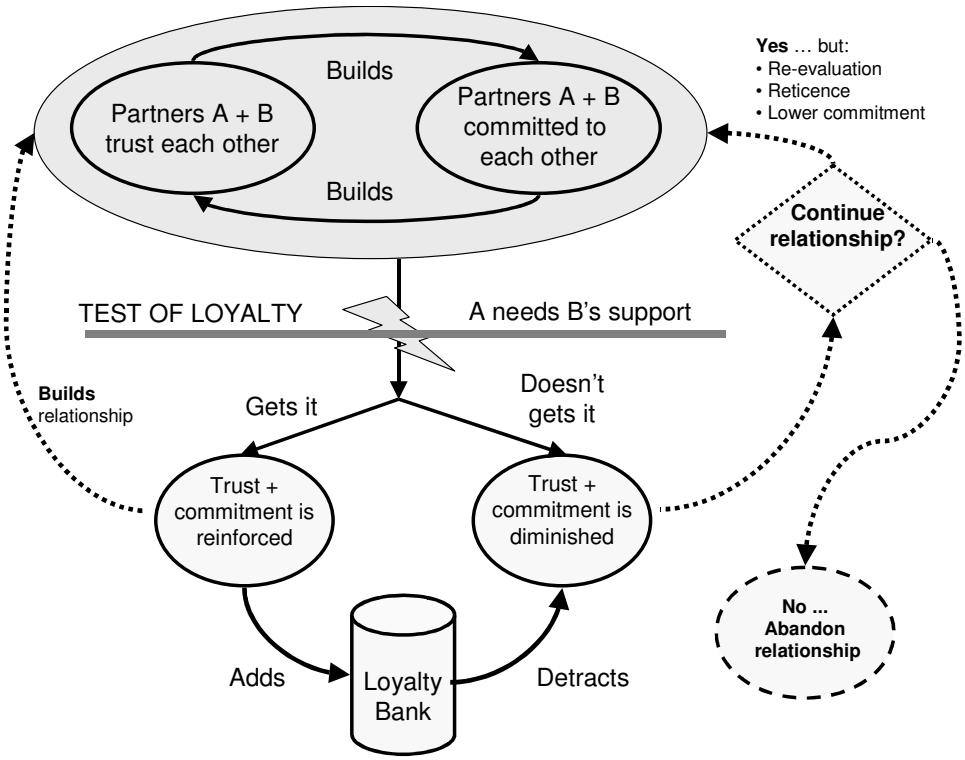


Figure 2.11: A model of trust and commitment under tested conditions (Source: Walker 2004)

2.6 Organisational KM Initiatives

The aim of this section is to illustrate various frameworks available in the literature that can be termed as organisational KM initiatives. This section also describes what constitutes a successful initiative and what are the reasons for unsuccessful initiatives in the past?

2.6.1 Unsuccessful Initiatives and Their Causes

Since the inception of the KM in last two decades, organisations have undertaken various KM related initiatives. Lucier and Torsiliera (1997) notes that 84% of KM programs fail to have any real impact and a very high proportion of programs initiated with great vigour are cut back within two or three years. Lawton (2001) quoted KM pioneer Larry Prusak, that may organisations who implemented KM systems with little thought to deployment methodology contributes to 50-60% of failure of all deployments.

KM took off as a technological initiative. Researchers and practitioner alike sought to develop a technology that could bring to reality the perceived vision of KM. It was manifested in the building of expert systems and knowledge base systems in late 80s and early 1990's (Kamara

et al. 2002). These technologies did not achieve strong adoption by the business communities. This failure and non-use is attributed to the complexity and poor usability of such technologies, rendering them ineffective (O' Brien 1997). As technology advanced and technologies such as ICT, the Internet, and intranets were available during the mid 1990s, organisations tried to exploit these to capture, codify, transfer and share knowledge. Unfortunately, these initiatives again met with failure (Aouad *et al.* 1999; Davenport and Prusak 2000; Fernie *et al.* 2003).

Consistent technological failure gave impetus to various researchers to identify the causes of failures and look for alternative ways of embarking on the KM challenge. The identified causes of these failures include (Davenport and Prusak 2000; Malhotra 2000; Kamara *et al.* 2002; Fernie *et al.* 2003; Liebowitz and Megbolugbe 2003; Walker 2004)**:**

- High technological dependence of these initiatives,
- Inability to properly understand the complexity of knowledge and its esoteric nature,
- Neglect of human related factors associated with any change,
- Lack of recognition of appropriate leadership, vision, strategy and culture,
- Ignoring individual value system and notions of trust, and
- Insufficient rewards systems and motivation.

Storey and Barnett (2000) conducted a study "KM initiatives: Learning from Failures" and suggest the main causes of failure of KM initiatives are insufficient specific objectives, insufficient focus on one or two strategic business objective, incomplete program architecture and top management sponsorship without active ongoing involvement (i.e. absence of leadership).

Tiwana (2002) provides advice for companies in order to save themselves from vendors that are re-branding their products as search engines, portals and AI (Artificial Intelligence) tools as KM tools & systems (Lawton 2001) as follows:

- KM is not a knowledge engineering; in fact it is a business problem and falls in a domain of information systems and management, not in computer science.
- KM is about process, not just digital networks,

- KM is not about building a smarter intranet. A KM system can use a company's intranet as a front end but this should not make an intranet as KM system
- KM is not about a one-time investment. It requires consistent attention and continued evaluations and hence attracts funds.
- KM is not about enterprise-wide "infobahns"

This suggests that the chances of success of IT based initiatives are quite meagre and that organisational and people issues not readily solved by IT systems need addressing (Kamara *et al.* 2002). Egbu *et al.* (2001b) recognises that good KM does not result from the implementation of information systems alone. Malhotra (2000) recognises over time that radical changes in the business environment suggest limitations in the traditional information-processing view of KM. The programmed nature of heuristics underlying such systems may be inadequate for coping with the demands imposed by the new business environments. It is therefore concluded that the new business environment, characterized by dynamically discontinuous change, requires a re-conceptualization of KM. It means that the conventional approach to KM (where knowledge is machined by developing knowledge based systems) has to be replaced by a new broad approach of KM that recognizes that humans possess and carry knowledge and should be regarded as IC (Malhotra 2000; Egbu *et al.* 2001b).

2.6.2 Successful Initiatives

Davenport and Prusak (2000,p173) argue that KM is predominantly a human interaction exercise with information and communication technologies (ICT) as providing a supportive and facilitative role. They suggest the ratio of 1/3rd technology 2/3rd people-related issues as being a useful guideline for successful KM initiatives. According to Egbu (2000), the human factor is so powerful and significant that they express it as having a contribution of 90% (with 10% contribution from technology) for a successful KM initiative. Cavaleri *et al.* (2005,p214) makes it clear that in terms of financial terms, because knowledge related initiative is a human and social processes, about 80% of all funding should be allocated directly towards human investment and 20% should be invested in support technologies.

The dominance of people related soft factors thus paves the way for describing these factors in more detail and is the aim of next section. Any new management initiatives inevitably induce organisational that is almost always resisted. McShane *et al.* (2003) explain that resistance to change can be grouped into several contexts such as:

- investment cost
- political issues
- fear of change
- intervention into routine
- difference with conventional systems
- unsuitability to norms.

Success of any change management initiative depends on how well these change resisting factors are handled or how well change management is incorporated into any new KM initiative.

Change Management

The forgoing is also significantly true for a successful KM initiative. Hence change management becomes an integral part of any KM initiative. Any change management program works on understanding and changing the culture of the organisation through effective leadership and reward systems. These are discussed as follows:

a) Culture

The concept of culture is central to the idea of change management.

William *et al.* (1993,p11) state:

> "When we know what culture is, we know what needs to be changed for culture to change. Only once we appreciate its nature can we understand how it might be changed. When we know its role, we can comprehend its importance"

Both the general management and construction management literature place great emphasis on the implicit relationship between organisational culture and organisational performance (Hofstead 1980; Handy 1993; Liu and Fellows 2001; Rowlinson 2001). Not only does culture become important from a change management point of view but also to achieve competitive advantage and improved performance (Schein 1997; Sadri and Lees 2001).

Various researchers have defined culture in several different ways. British anthropologist Edward B. Taylor is credited with being the first to use the term in its anthropological sense in 1871 (Barthorpe 2002). Helman (1994) and Barthorpe (2002) cite Taylor's definition of culture as "That complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society."

Kroeber and Kluckhohn (1963) state 'Culture consists of patterns, explicit and implicit, of and for behaviour, acquired and transmitted by symbols, constituting the distinctive achievement of human groups, including their embodiments in artefacts; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values; culture systems may, on the one hand, be considered as products of action, on the other as conditioning elements of further action'.

Bodley (1994) provides a categorized table showing various dimensions of culture based on the list of 160 definitions related to culture published by Kroeber and Kluckhohn, American anthropologists, in 1952. This is shown in Table 2.7.

Table 2.7: Dimensions of culture

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

Most of the definitions above are grounded in the field of anthropology and behaviour sciences but these definitions and understanding about culture are crucial when one ventures to understand culture of the organisation. Burack (1991) considers organisational culture as 'the ways things are done in the organisations'. He emphasised organisational culture is "shared assumptions, beliefs and value which define behavioural norms and expectations; this is the glue that holds the corporate community together". Scholez (1987) considered corporate culture as the implicit, invisible, intrinsic and informal consciousness of the organisation which guides the behaviour of the individuals and which shapes itself out of their behaviour.

Organisations in today's age have a mix of employees ranging from a young highly computer literate generation bought up with intensive use of computer technology to an older generation who are still anxious when faced with having to use IT. Not understanding these differences of attitudes within the organisation will be a barrier towards IT implementation. Understanding this factor assists formulating a strategy that may entice the older generation to use any newly adopted technology through reward and recognition systems. A KM initiative emphasises knowledge creation, transfer, sharing, socializing etc. Understanding the culture of the organisation is the first step that needs to be taken before implementing the initiative. A KM strategy has to be carefully crafted if any knowledge 'silos' exist within the organization, where people don't share knowledge, resulting from fear of possibly loosing a competitive edge and hence a place in the organisation. A 'one size fits all' KM strategy should be avoided (Cavaleri *et al.* 2005) because this has produced consistent failures over time. Egbu *et al.* (2003) provided a list of various aspects of organisational culture that would support a KM initiative. At the same time they also recognised various aspects of a culture that may affect an organisation negatively. These are summarised in Table 2.8.

Table 2.8: Various aspects of the culture promoting or inhibiting the organisational KM initiative

Aspects of culture contributing positively to KM initiative	**Aspects of culture contributing negatively to KM initiative**
■ An environment which encourages innovation to deliver better value ■ Willingness to embrace technological developments including IT ■ Awareness of the importance of KM including the provision of leadership ■ Degree to which individual initiatives & freedom are encouraged (e.g. empowerment) ■ Encourage employees to get formal training ■ Motive to become more entrepreneurial ■ High safety awareness/ continuously improving safety standards ■ High level of camaraderie ■ Culture of promoting research & development, experimentation ■ Effective, flexible top down, bottom-up, lateral communication |	■ Time pressure (e.g. limited time available to reflect on project ■ Inward looking silo mentality ■ Reluctance to change & embrace new ideas & developments In the sector ■ Inability & unwillingness to share knowledge across business ■ Difficulties encountered in finding the 'right' person, information, knowledge ■ Rigid QA arrangements which Increase paper-work ■ Lack of reward for wider organisational performance ■ Low level of job security ■ Paper-based document dissemination ■ Transience of company principles & objectives ■ 'Unrealistic' strategic targets

■ Sense of pride in company achievements ■ Encouragement to network with different regions Facilitating peer-learning ■ Senior members of staff have hands on approach to day to day activities ■ Usage of project review	■ An endemic blame culture in organisations

b) Leadership

Leadership is a force that drives whole change producing initiative vigorously. In the absence of leadership nothing much can happen. The role of leader and concept of leadership is widely and thoroughly investigated by management researchers. Through leadership, a person influences others to accomplish an objective and directs the organization to achieve some unified goal (Dwyer 1993; Northouse 2001; Harris 2002).

Leadership is a necessary component behind the formation of any supportive culture so that it not only supports diversity in the ways people think and 'know' beyond traditional approaches, but also sets out a clear vision of how people within an organisation can be energised to maximise their own creativity and build upon the ideas and knowledge of others they interact with (Collins and Porras 1996).

Leadership is about empowerment, energising and enabling people to use knowledge and tangible resources to achieve their vision. However vision by itself is inadequate for the purpose and it needs to be translated into effective action. While leadership helps create the vision, it needs sound project management skills and a hands-on leadership style and practical application of the vision to deliver and deploy the conceptual big-picture vision (Kotter 2001). One of the most strategic leadership features is envisioning a preferred future and charting a way to get to that future. A knowledge vision provides corporate planners with a mental map of three related domains: the world they currently live in; the world they ought to live in; and the knowledge they ought to see (von Krough *et al.* 2000, p103). A knowledge vision should specify what knowledge that members need to seek and create. Cavaleri *et al.*(2005) explicitly mention that an era of the knowledge leader is emerging and is inevitable. It is through leadership that a successful KM initiative can be undertaken. Maqsood *et al.* (2004) also provide the case of forming a separate KM department with a view of having a knowledge manager as a 'knowledge leader' to advance organisational KM initiatives.

C. Reward Systems

Rewards system development is critical for the success of KM initiatives. The literature supports the strong influence that incentives and rewards have on people's commitment to sharing knowledge. Pedler *et al.* (1996) identify reward flexibility as a key driver of change with a number of case studies to illustrate their argument.

Griego *et al.* (2000,p9) found two significant factors in their gender-balanced study of 48 professionals from a wide range of backgrounds participating in a Human Resource Development Master's Degree program that investigated predictors of learning in organisations. The two significant factors were rewards and recognition followed by training and education.

Wageman (1997,p56) focused upon 43 team leaders at the Xerox Corporation Customer Service organisation and identified seven critical success factors for creating superb self-managing teams. She advocated linking rewards to strategy and high levels of team reward and maturity for self-evaluation against goals. She proposes rewarding team members equally in where at least 80% of the reward should be awarded equally to individuals within a team with the residue being either used to reward team leaders for demonstrating supporting action such as coaching etc or rewards being divided unequally but on a transparent rational and generally agreed basis.

Stretch goals represent outcomes that are realistically achievable. They are short-term performance targets used to specify the outcomes that can be fairly confidently expected to be achieved in the near term. The whole purpose of stretch goals is to inspire efforts to go well beyond what is currently feasible and such goals are only achievable if they stimulate and inspire creativity, invention and innovation. Anil Gupta and Vijay Govindarajan in their paper on lessons learned from the highly innovative and successful US steel company Nucor Steel, acknowledge significant stretch goals coupled with high powered incentives sparks breakthrough thinking that moves organisations well outside continuous gradual improvement (Gupta and Govindarajan 2000,p78). The important role of stretch goals as the trigger for incentive schemes cannot be understated. It has been used as a risk and reward driver for the enhancement of the concept of partnering to embrace project alliancing and was particularly successful in its application on the National Museum of Australia project (Walker *et al.* 2002; Walker and Hampson 2003b).

In strict KM terms, knowledge creation is a process of framing and re-framing knowledge, it is therefore difficult to determine exactly who owns the resultant knowledge and therefore who should be rewarded and on what basis. Therefore, considering knowledge sharing is a communal activity, it could be appropriate to rewards teams for delivering knowledge assets rather than rewarding individuals that my enter and leave teams (and organisations). The financial capabilities relating to various stages in the life cycle and human capital capabilities leading to an organisation's absorptive capacity should have a major impact on the application of team-based pay (Balkin and Montemayor 2000).

Cacioppe (1999,p325) summarises six key points relating to reward systems drawing upon the lessons learned from the development of high performance teams at Motorola and Trigon that share knowledge and are highly innovative. These are as follows:

1. Have a clear strategic purpose for teams and rewards;
2. Communicate about the rewards and the team results;
3. Plan the type, criteria and use of rewards and recognition;
4. Have financial measures and stretch objectives;
5. Include training in interpersonal and teamwork skills; and
6. Evaluate and review the reward system'.

Change Management Model

The above three factors, culture, leadership, rewards are vital components of any change management program. A successful KM initiative needs to have a change program built in. Various researchers explain the change management process. One example is illustrated in Figure 2.12, the Galbraith (2002, p74) 'Star' that presents a dynamic change model.

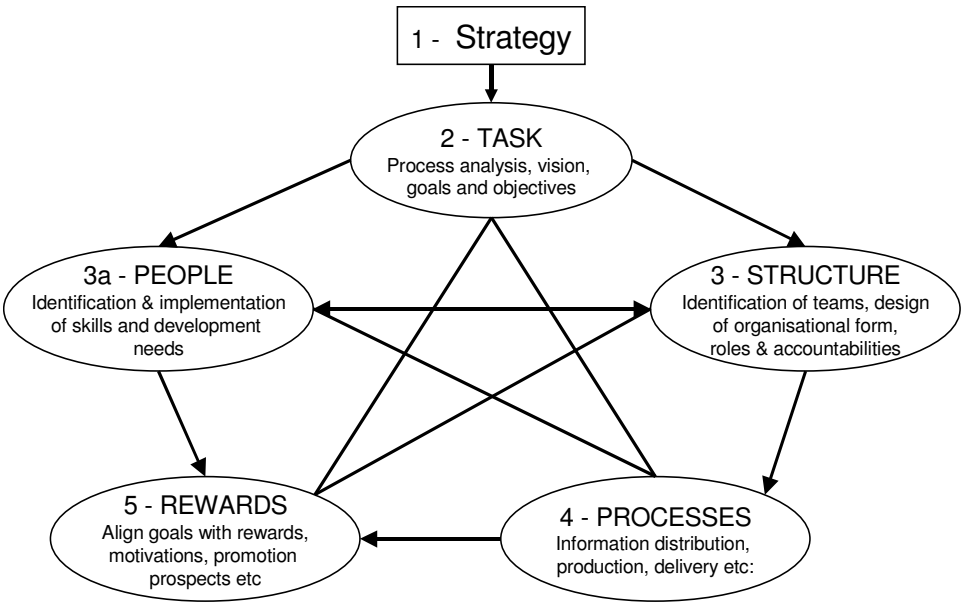


Figure 2.12: The Galbraith 'Star' model of change management (Source: Galbraith (2002 ,p10))

It is not adequate to merely introduce change by training and development to diffuse knowledge or any other change initiative. First, an organisation needs to have a strategic vision to want to change. Strategic intent needs to be translated into action through a process of analysis of the situation and developing goals and objectives to achieve the vision. People can then work in communities and in organisational structures, whether formal or informal, and for that to effectively occur. There needs to be an agreed set of role and accountability issues—that is structure. People undertake this but people cannot implement change in isolation. For the strategic intent to be realised through people there needs to be an identification and implementation of the skills required to make change happen. There also needs to be a set of processes that provides for the communication, production and transfer of knowledge. People need to be motivated by the correctly aligned reward system to make their change efforts worthwhile. Galbraith's mode is a dynamic one, as any part of this star model is changed it impacts upon other parts of the system. For example if strategy is changed then this will require changes to all other nodes of the star. Likewise a change in structure affects people and may require a different reward regime to be deployed, which in turn requires amended processes.

Another concept associated with change process is that of 'Anxiety' put forward by Edgar Schein and his seminal work is vital for understanding the psychological process of change motivation. Considering people are at the centre of change process and acknowledging change

is a painful prospect for most people, Schein (1993,p86) expresses a notion that two types of anxiety govern people's willingness and commitment to change.

Anxiety 1 is the feeling associated with an inability or unwillingness to learn something new because it appears too difficult or confronting. In this situation people deny the problem, search to blame others for the symptoms requiring the change, or simplify the perceived problem triggering change in terms that when seen in retrospect, appears ridiculous. Unfortunately, Anxiety 1 behaviours are universal and all too evident with a management response to mount more pressure to conform to the expected response. This can exacerbate the situation as it drives people towards panic.

Anxiety 2 is the fear, shame, or guilt associated with not learning anything new, particularly when survival is challenged without action being taken, is the type of anxiety that change activists *need to* cultivate (Schein 1993, p88).

Change agents need to ensure that Anxiety 2 pressure is greater than Anxiety 1. Organisations often find this difficult to accept, as it requires expensive and extensive support and resourcing to provide the relief from this form of anxiety. For this reason a usual way that organisations follow in a change process it to opt for a strategy of putting pressure on individuals or business units and then leaving them to sort out the dilemma. Apparently this strategy superficially appears to cost less but it always cost more through failed plans, dreams and commitments inhibiting delivery of the expected results. The result is frequently blame and negativity. If Anxiety 2 is responded to, then change agents can make a positive difference through providing enabling support systems. They can prepare a general outline for a solution to the problem that enables people to find their own way to channel their energies and commitment to move from a position of defensiveness to one of confidently addressing the change deployment.

Kotter (1995) another well respected writer on leadership and change management, proposes an 8-step process for successful change that is line with on-going change management discussion. These can be summarised as follows:

1. Establish a sense of urgency
2. Forming a powerful guiding coalition
3. Creating a vision
4. Communicating the vision

5. Empowering others to act on the vision
6. Planning for and creating short-term wins
7. Consolidating improvements and producing still more change
8. Institutionalising new approaches.

2.7 KM Initiatives and Frameworks

The above discussion sets the basis for the conceptualising of successful KM initiatives. Tiwana (2002) proposes his 10-step knowledge road map as follows:

1. Analyse the Existing Infrastructure
2. Align KM and Business Strategy
3. Design the KM Infrastructure
4. Audit Existing Knowledge Assets and System
5. Design the KM Team
6. Create the KM Blueprint
7. Develop the KM System
8. Deploy, Using the Results-driven Increment Methodology
9. Manage Change, Culture and Reward Structures
10. Evaluate Performance, Measure ROI (Return on Investment), and Incrementally Refine the KM system

Tiwan's road map gives due consideration to change, culture and reward system and hence increase the chances of the success of the KM initiative in the organisation. Tiwana (2002) notes and cautions that this is a road map not a methodology with a deceptive look of 'cookie-cutter' formulation. The KM strategy and the system will have to be unique for each company.

Kamara *et al.* (2002) and Al-Ghassani *et al.* (2002) provide a methodology for developing KM strategies within the CLEVER (Cross-sectional learning in the Virtual Enterprise) research project. Kamara *et al.* (2002) indicate that the main focus of the CLEVER project was on organisational and culture dimensions of KM within a project context. The aims were as follows:

1. To generate 'as-is' representations of KM practices in project environments both within and across enterprises in the manufacturing and construction sectors.

2. To derive generic structures for these practices by cross-sectoral comparisons.
3. To develop a viable framework for KM in a multi-project environment, within a supply chain context, together with requirements for support
4. To evaluate the framework using real-life projects and scenarios supplied by the participating companies.

The framework itself consists of 5 stages as shown in Figure 2.13:

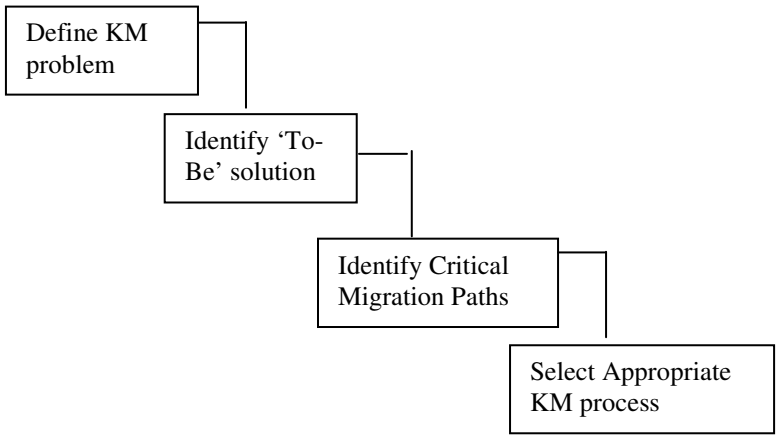


Figure 2.13: The CLEVER framework (Source: Kamara et al.(2002))

Egbu and Botterill (2002) and Egbu *et al.* (2001b) present a conceptual framework shown in Figure 2.14. This framework highlights people, process and systems, knowledge content and technology. Technology is considered only as an enabler but the important one enabling people, process and knowledge content and is show as dotted line. Other factors that are critical to the success of the KM initiative are also considered like organisational strategy and structure, culture, leadership and commitment, motivation and competition.

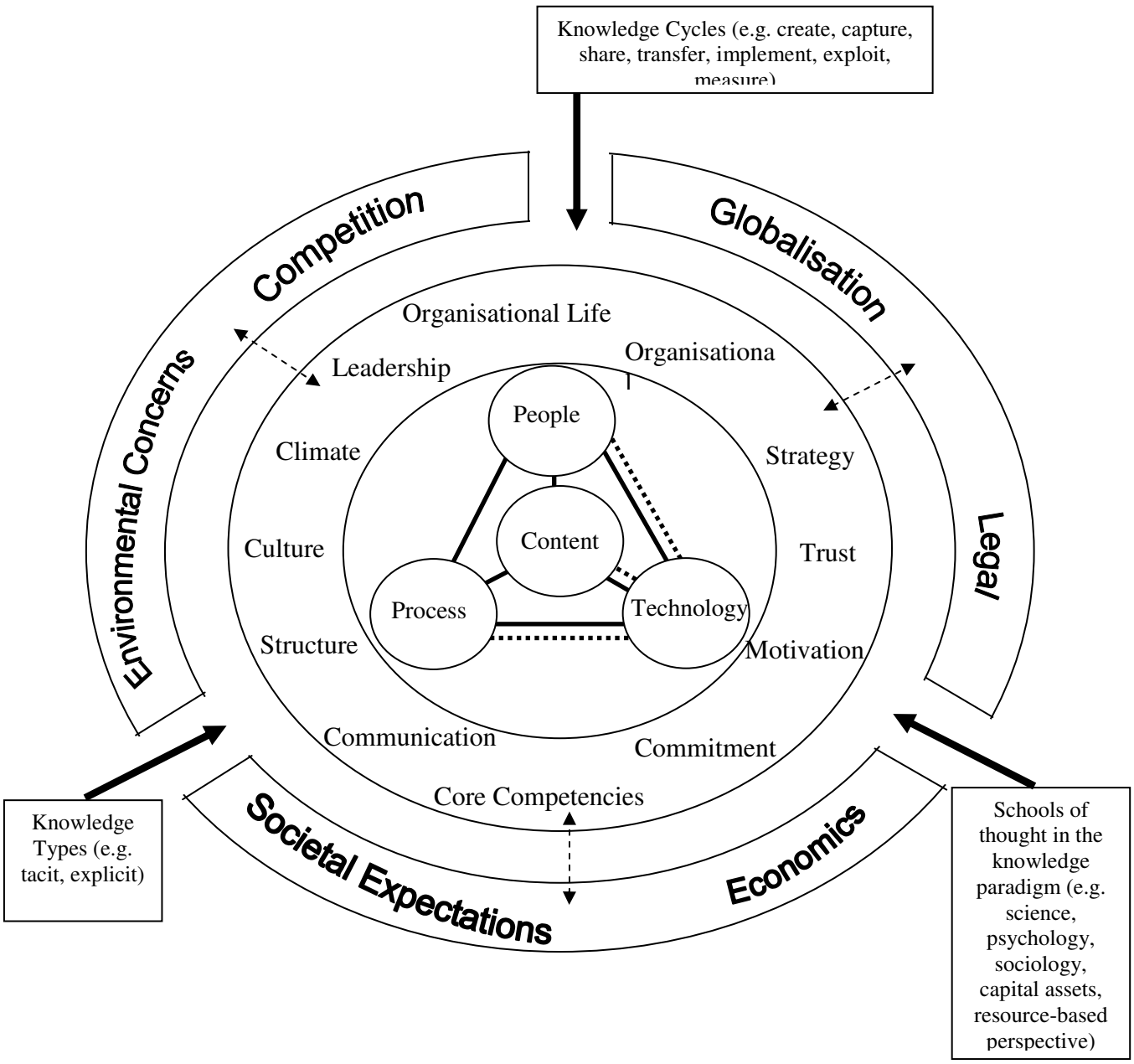


Figure 2.14: KM: A conceptual framework (Source Egbu et al.(2001b) and Egbu and Botterill (2002)).

Walker (2004) and Walker (2005) provide a detailed framework that they name as "K- Adv" (Knowledge Advantage). Walker (2004) states while explaining the concept of K-adv as:

> An organisation's K-Adv is its capacity to liberate latent creativity and innovation potential through effective management of knowledge both from within its organisational boundaries and its external environment.

The model comprises of three elements facilitating delivery of a K-Adv:

- Knowledge leadership that provides the organisational support, backing, championing and vision to create strategies and implement them;
- A well-functioning and supportive ICT infrastructure to enhance communication, coordinate problem solving activities that generate knowledge in new contexts and transfer of both explicit (easier to achieve) and tacit (highly complex to achieve) knowledge; and
- A supportive and facilitating people infrastructure to focus in particular on the highly problematic tacit knowledge as well as transferring explicit knowledge.

The K-Adv requires a coordinated approach in addressing leadership actions to establish and deploy a vision of what the K-Adv means to the organisation, to support the people infrastructure necessary to effectively use knowledge in their business activities, and to provide the necessary enabling information and communication technologies (ICT) infrastructure to do so. Figure 2.15 illustrates the K-Adv model.

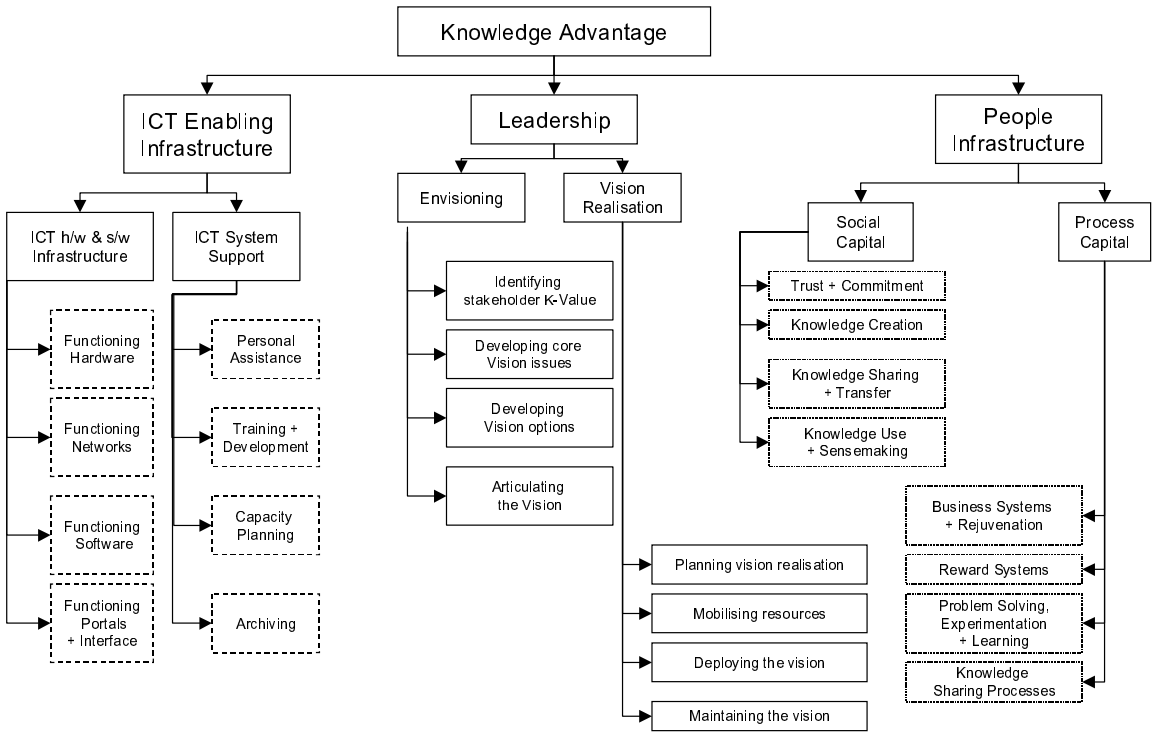


Figure 2.15 – The K-Adv Model

The central and focal point of the concept is knowledge leadership. This is linked to the ICT and people infrastructures that help turn the idealised knowledge advantage vision into reality. These three components or attributes dynamically interact to shape a preferred future. If we

first concentrate upon the knowledge leadership element we see that strategy and its enactment comprises two sub-elements—envisioning and vision realisation. Knowledge leadership recognises that a K-Adv is realised through people and their creative energies and knowledge that is grounded in their individual experience and ability to interpret and re-interpret meaning from experience. Thus, a knowledge vision depends upon people, moreover, it depends upon a range of people from both within and external to any organisation. An important part of the K-Adv is an ability to envision a preferred future knowledge strategy through the identification and value of useful stakeholder knowledge. That depends upon first identifying and understanding stakeholder environments, which naturally leads to identifying stakeholders and the knowledge that they possess.

Liebowitz and Megbolugbe (2003) provide their framework in order to aid project managers in conceptualising and implementing initiatives. The framework is shown in Figure 2.16.

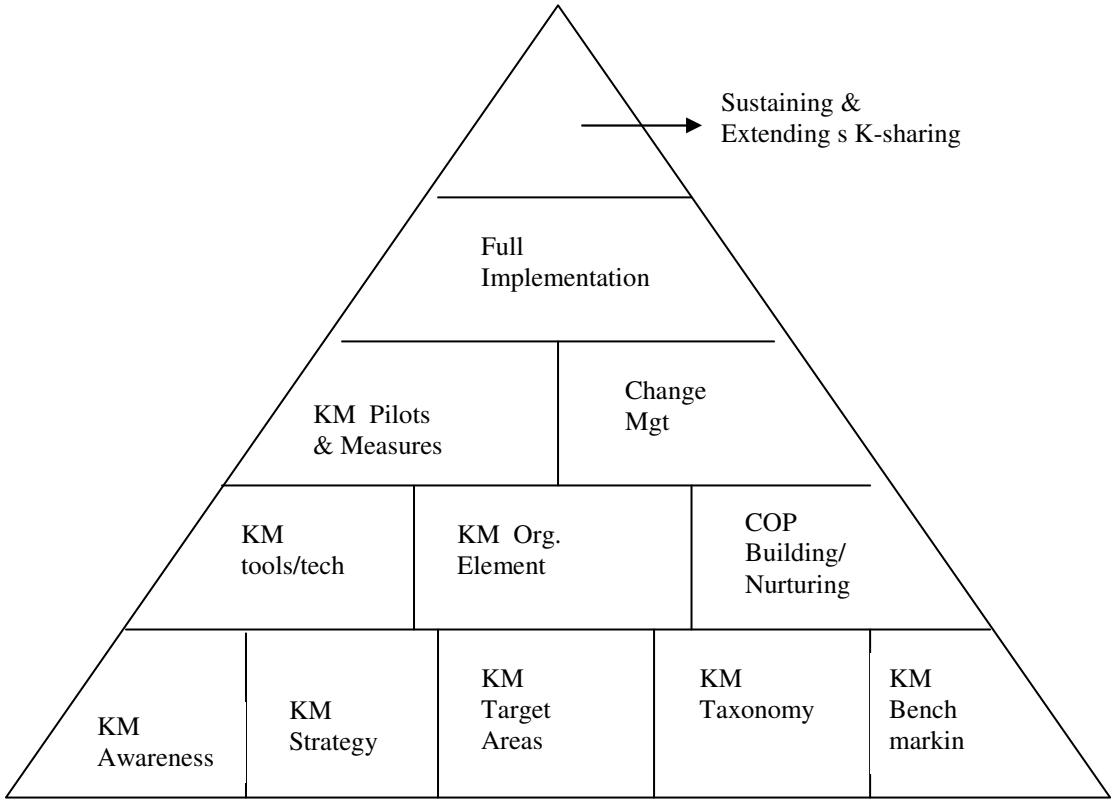


Figure 2.16: Building a KM pyramid (Source: Liebowitz and Megbolugbe (2003))

They take a pyramid approach where the first level which they refer to as 'building blocks' is concerned with: providing awareness of KM; performing knowledge benchmarking to see what other organisations of similar nature are doing; developing a knowledge taxonomy to serve as a vocabulary and structure while construction the KM system; developing a KM strategy; and targeting areas where that would mostly use KM initiatives. The next level involves selecting techniques and tools, developing a KM organisational infrastructure and building and nurturing of online communities of practice (COP). As this happen, KM pilots can be conducted and measurements can be made. It is to taken in conjunction with a change management process with in the organisation. Finally it will result in full implementation of KM systems and process and this needs to be maintained and sustained by upholding a knowledge sharing culture.

2.8 KM Techniques and Tools

Egbu *et al.* (2003) completed a comprehensive study on KM in Construction in the UK. They recognise techniques and technology employed for the purpose of managing knowledge not necessarily are IT based. They quoted a study of Al-Ghassani (2002) that considered, the term 'KM techniques' for non-IT based tools and "KM tools" for IT based tools in order to bring simplicity to the understanding of term 'tools and techniques' in KM debate. Various techniques and tools are shown in Table 2.9.

Table 2.9: KM tools (Modified from Egbu et al. (2003))

KM Techniques- Non-IT tools	**KM Tools- IT tools**
Brainstorming, Face-to-face interaction, communities of Practice (COPs), Post-project reviews, Recruitment, Apprenticeship, mentoring, Training	Data and text mining, Groupware, Intranet, Extranet, Knowledge bases, taxonomy, Ontologies

KM techniques have high focus on tacit knowledge, easy to implement and maintain. These are affordable to the organisations. Most organisations employ these techniques one way or another as matter of performing day to day work. KM tools have focus on explicit knowledge (work manual, procedures, specifications, etc.), require a dedicated IT infrastructure, difficult to maintain and involve significant financial commitments (Al-Ghassani (2002) in Egbu *et al.* 2003). It is the effective and balanced combination of both KM techniques and KM tools that is required to act as a successful enabler of KM initiative.

In another study Egbu and Botterill (2002) investigate the use and effectiveness of KM techniques and technologies in construction organisations in UK. The results are shown in Table 2.10 below:

Table 2.10: The usage and effectiveness of KM tools and techniques (Source: Egbu and Botterill(2002)).

Techniques and Tools	**Mean Values**		**Techniques and Tools**
	Usage	**Effectiveness**	
Telephone	4.3	4.1	Telephone
Internet/Intranet	4.0	4.0	Face-to-face meetings
Documents and reports	3.9	4.0	Documents and reports
Face-to-face meetings	3.9	4.0	Interaction with supply chain
Interaction with supply chain	3.7	4.0	Internet/Intranet
Formal on-the-job training	3.5	3.7	Formal on-the-job training
Formal education and training	3.4	3.7	IT-based database
IT-based database	3.4	3.6	Informal networks
Work manuals	3.3	3.6	Formal education and training
Informal networks	3.2	3.4	Coaching and mentoring
Brainstorming sessions	2.9	3.3	Brainstorming sessions
Project Summaries	2.8	3.2	Project Summaries
Coaching and mentoring	2.7	3.1	Cross-functional teamwork
Bulletin boards	2.6	3.1	Work manuals
Cross-functional teamwork	2.5	2.9	Job rotation
Help Desks	2.1	2.8	Knowledge-based Expert systems
Knowledge-based Expert systems	2.0	2.7	Bulletin boards
Job rotation	1.8	2.5	Decision support systems
Communities of Practice	1.8	2.4	Help Desks
Decision support systems	1.8	2.4	Quality circles
Storytelling	1.7	2.2	Communities of Practice
Quality circles	1.5	2.2	Video-conferencing
Knowledge Maps	1.4	2.1	Knowledge Maps
Groupware	1.4	2.0	Storytelling
Video-conferencing	1.4	2.0	Groupware

The above results are based on a questionnaire survey of 55 usable questionaries from five UK based project organisations. The respondents were asked both use and effectiveness of KM tools and techniques on the scale of 1 to 5, with '1' representing as never used/least effective and '5' as highly used/highly effective.

The above study highlights various techniques and tools that can be used for KM. It also highlights what is the general perception of the organisation towards use and effectiveness of these technologies. Egbu and Botterill (2002) do not make it clear whether these organisations use these tools specifically for carrying out KM or just for carrying out their daily routine procedures. With a limited proliferation of KM philosophy in the construction industry so far, it is highly unlikely that these organisations have some KM initiative being undertaken and these tools are specifically used for KM purposes. However, the organisations have to manage

the work and related knowledge, in their daily routine. This study sets the basis for understanding the tools that are currently being used to carry out the work. Telephone, Intranet and Documents and reports are regarded as having high usage and effectiveness. This clearly indicates most of the organisations are concerned with the management of explicit knowledge. Although the telephone may facilitate tacit knowledge sharing, it is more likely to be used as a medium of communicating information or responsibilities, or at the most disseminating work progress. This strays away from the objective of knowledge creation and sharing. Tacit sharing techniques like COPs, story telling and Groupware to share both tacit and explicit knowledge are rated low both in usage and effectiveness. This indicates that awareness of these tools to enhance knowledge sharing and to serve as effective KM is very restricted. This suggests that organisations studied in above research weren't involved in any significant live KM initiatives.

2.9 Organisational Learning and Learning Organisation

2.9.1 Organisational Learning and a Learning Organisation

Learning is generally associated with better outcomes. Having learnt lessons avoids 'reinventing the wheel' and 'making the same mistakes again'. Argyris and Schön (1978) and Senge (1990) introduce the idea of single loop learning and double loop learning, organisational learning and the learning organisation.

Organisational learning is the set of processes used to obtain and apply new knowledge, behaviour, tools and values (Bennis and Manus 1985). Through this process, members of the organisation detect errors or anomalies and correct them by restructuring the current organisational model (Argyris and Schön, 1978). Organisational learning is a collective process of inquiry and experimentation that uses groups as a forum to help employees draw new meanings from their paste experience (Cavaleri et al. 2005). This results in improved actions through better knowledge and understanding. It is the process of information leading to changes in a range of potential behaviours (Huber 1991).

Learning is so insinuated in the fabric of life that you cannot *not* learn (Senge 1990). Pedlar *et al.* (1991) agrees, observing that an organisation can facilitate the learning of all its members

and so continuously transform itself. Such an organisation has the skills to create, acquire and transfer knowledge, and then modifies its behaviour to reflect new knowledge and insights (Gravin 1993). In resolving the discrepancy between terms of 'organisational learning' and 'learning organisation', Love et al. (2000) state that organisational learning is used mainly as a descriptive term to explain and quantify learning activities and events. The 'learning organisation' tends to refer to organisations designed to enable learning and having an organisational structure with the capability to facilitate learning. Mirvis (1996) notes that the learning organisation focuses on managing chaos and indeterminacy, flattening hierarchies, and decentralization. It also encourages the empowerment of people, teamwork and cross-functional teams, network relationships, adoption of new technologies and new forms of leadership and mentoring.

2.9.2 Link with KM

It is clear from the above discussion that the concept of organisational learning and that of learning organisations is not very different from KM. Newcombe (1999) notes that a parent organisation will not learn from their projects if they do not have in place the mechanisms to capture knowledge. For learning to occur, there is need for processes and structure to be in place to help people create new knowledge, allowing them to continuously improve themselves and the organisation (Love *et al.* 2000). Love *et al.* (2000) also note that currently there is no defined road map for construction organisations to follow if the learning organisation is its destination. They have quoted Gravin (1993) as identifying the following five activities that a learning organisation in construction should be skilled at:

- Systematic Problem Solving
- Experimentation with new approaches
- Learning from their own experiences and past history
- Learning from the experiences and best practice of others
- Transferring knowledge quickly and efficiently through out the organisation

Cavaleri et *al.* (2005, p215) argue that knowledge is assumed to be product of organisational learning processes, but many current organisational learning processes have not been aligned with knowledge processes in a pragmatic way. Pragmatic knowledge is the ultimate action

knowledge because it is continually being customised and upgraded based on the effectiveness of action taken in producing expected results (p31). The aim and vision is to become a learning organization but methods for realising this vision have typically been so vague that many mangers consider it more of an intellectual exercise than tangible way to contribute to business performance. They propose the simplest way to achieve this vision is to integrate organisational learning process with KM initiatives.

From the previous discussion, it appears evident that KM successful initiatives (comprising of balanced use of technology and people factors) help organisations to become learning organisations. Hence, we can deduce that successful KM initiatives facilitate transforming the organisation into a learning organisation. Removing confusion and clarifying these terms is useful to practitioners and research community members to distinguish between organisational learning, the learning organisation and KM.

2.9.3 Challenge of Project Learning through KM

In project environments such as the construction industry, it is highly desirable that lessons learnt captured from one project are put into use on subsequent projects, achieving reduction in project times and subsequent efficiencies (Kamara et *al.* 2002). Construction organisations usually develop project histories and databases as repositories to keep such knowledge of the lessons learnt. KM provides a structured way for developing such repositories and ensures that knowledge is disseminated in a timely fashion to the users. Where project histories have been captured, their details are obtained through using a variety of debriefing techniques. Schindler and Eppler (2003) classified these techniques into process-based methods, and documentation-based methods.

Table 2.11: Process-based Methods for History Collection (Source: Schindler and Eppler (2003, p222))

Parameter	Method			
	Project Review/Project Audit	Post control	Post-project Appraisal	After Action Review
Time of execution	After project completion or in the course of the project during individual project phases	Exclusively at project's end	Approximately two years after project completion	During work process
Carried out by	Review: moderators respectively auditor Audit: project-external people	Project manager	External post-project appraisal unit (a manager and four assistants), project homework group	Facilitator
Participants	Project team and third parties that are involved into the project	Project manager (inclusion of project team not neglected)	Project team and third parties that are involved into the project	Project team
Purpose	Status classification, early recognition of possible hazards, team-internal focus	Serves as delimitation/in addition to a more formal project end that focuses on the sole improvement of future project's goal conformity	Learning from mistakes, knowledge transfer to third parties	Learning from mistakes, knowledge transfer inside the team
Benefits	Improvement of team discipline, prevention of weak points and validation of strategies	Result is a formal document, which considers the ranges of aims of the project, quantitative goals, milestones, check points and budget goals and Contains an evaluation of the project result as well as a recommendation for future improvements	Best practice generation for large-scale projects, improvement of forecasts and proposals	Immediate reflection of the own doings to improve future actions
Interaction mode	Face to face meetings	Non-cooperative form of recording experiences, analysis of existing project status reports, milestones, checkpoints and budget targets are being compared in order to identify relevant backgrounds of differences between estimated and actual effort	Document analysis, face to-face-meetings	Cooperative team meeting
Codification	Partly in reports, usually no predefined circulation with knowledge transfer as a primary goal (excluding predefined distribution lists)	Partly in reports, usually no predefined circulation with knowledge transfer as a primary goal (excluding predefined distribution lists)	Booklets	Flip charts

The process-based methods illustrated in Table 2.11 gather lessons-learnt from the completed projects. These are the methods associated with approaches that include: Project

Review/Project Audits, Post-Control, Post-Project Appraisal, and After Action Review. The documentation-based methods collect project experiences as soon as they occur. Techniques using this approach include: Micro Articles, Learning Histories, and RECALL. Table 2.12 illustrates the variation between these techniques.

Table 2.12: Document-based methods for history collection (Schinder and Eppler (2003, p225))

Parameter	Method		
	Micro Article	Learning Histories	RECALL
Scope	Between half and one page	Between 20 and 100 pages	Several screens
IT-support	Possible but not required, unless multimedia is used	Not required	Mandatory (database interface)
Participants	Not explicitly stated, focus one author	Individuals and teams depending on the process step	individual user
Supported by dedicated roles	Author, reviewer	Learning historian necessary for all process steps	Working group for reviewing
Frequency	On demand, regularly	Maximum once per project: after completion	On demand
Anonymity	No	Yes	No
Embedding/ distribution	Paper-based, databases/intranet	Cases with accompanying workshops	Databases/intranet.

2.9.4 Project Learning Barriers

The project nature of the industry poses great challenge and barriers to the project learning. Schindler and Eppler (2003) explain the nature of these barriers as:

- Experience gained while solving a problem during the course of project is not adequately transferred to other people, when this is not a part of project's documentation practice. People complete the task and take any learning along with them to new teams.
- Relevant project documentation such as a feasibility study, a summary, a technical report etc is only produced superficially and provides only business figures or the projects results. They don't capture or records reasons for failures or how certain problem was resolved.
- The end of the project marks the end of the learning of whole team. Limited debriefing of the completed project occurs at the end of the project. It is because the team is disbanded and sent onto new projects. Organisational amnesia starts to happen

if these team members are not going to use that knowledge that they acquired from previous project again on a new project.

If KM integration with learning across projects takes place, it will ensure that experiences (as mentioned above) are accessible through informal networks. Also as problems happen, solution can be devised, effectively capturing problems, causes, and how these are carried out. This could also ensure that proper project debriefing occurs on projects and that documentation based methods are adopted to capture project knowledge as it happens.

2.10 Innovation and KM

Research in innovation and its management is more than 50 years old. Organisations have always looked for improved ways of business to keep themselves highly competitive and sustainable in the market. As a result they continually create knowledge with a view to differentiate and gain advantage over their competitors that may be termed as 'innovation'.

Rogers (1995) defines it as "*an idea, practice, or object that is perceived as new by an individual or other unit of adoption.*". Innovation obviously involves a perceived need to change from one state to another. Its purpose is Darwinian (evolutionary). It is about survival and growth and about ecological (market) niches that are being filled by the exuberance of a life force. Innovation is, therefore, a decision-making process to enact change in technology, process, services rendered or other management approaches (Walker and Hampson 2003b, p238).

Innovation is a pre-requisite for competitive advantage Egbu *et al.* (2001a). Product innovation involves creating a new product while process innovation involves introducing new ideas leading to an efficient method of production. Innovation can be radical or incremental. Radical innovation results in total and sudden change of modus operandi while incremental innovation deals with step-by-step improvement.

Schumpeter (1934) discusses how innovations occur, implications of innovation on the global economy and for firms and their competitively sustainable position. Dosi (1982) and Schumpeter (1934) see innovation as a process following a historical path. The impact of technological and scientific change has occurred during five long waves of innovation advancement. Sundbo (1999) and Jones and Saad (2003) describe these waves below. These

waves are identified after Kondratiev[6] (Kondratieff and Stolper 1935) who along with Schumpeter recognised the effect of innovation in terms of cycles.

1. the first ‘ kondratiev wave’ from 1785 to 1845 and which corresponds to steampower
2. the railways as the second ‘kondratiev wave’ from 1845 to 1900
3. the third ‘Kondratiev wave’ of 1900 to 1950 corresponding to electric power and the automobile
4. the fourth wave 1950-1980 corresponds to mass production
5. the fifth wave is attributed to information and communication technologies beginning in the early 1980’s

2.10.1 Models of Innovation

Jones and Saad (2003, p146) describe five models of innovation arguing that early models of innovation consider it as a linear process comprising a succession of activities but subsequent models considered innovation as a coupling and matching activity characterised by a multi factor process that requires high level of interaction and integration at intra- and inter-organisational levels. Following figure shows the progression of these models from single to multiple factor analysis.

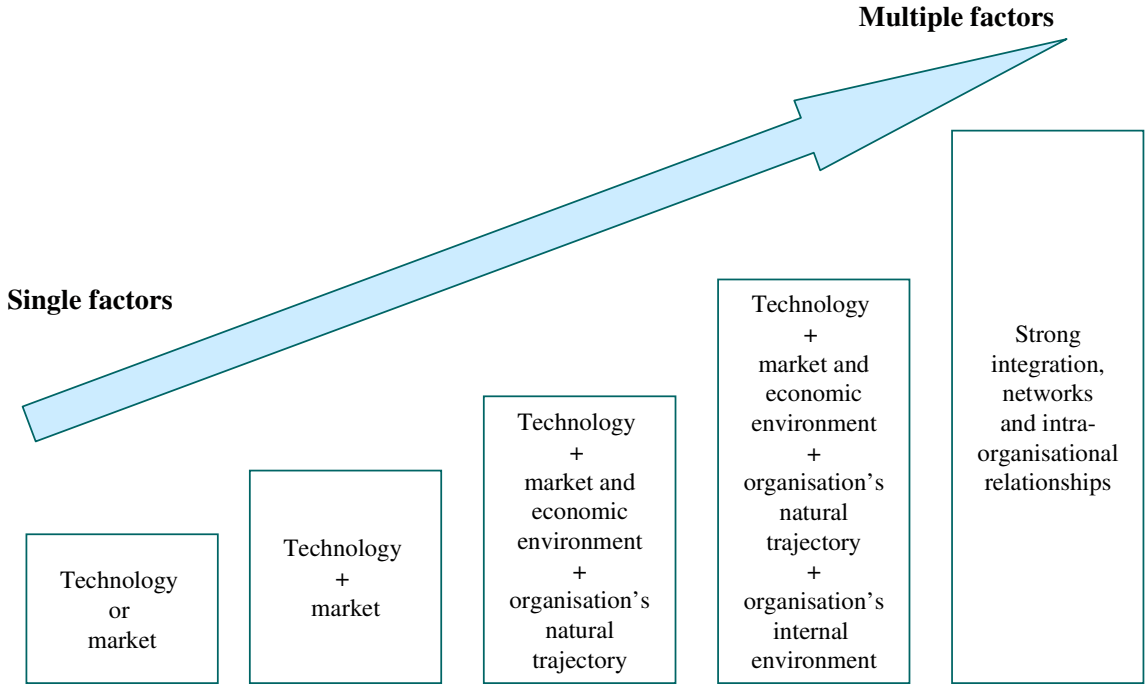


Figure2.17: Progression of innovation from dependence on single to multiple factor (Source: Saad (1991)and (2000) in Jones and Saad (2003, p149).

[6] Due to transcription from Cyrlic to Latin script kondratiev is often cited as kondratieff

Innovation also forms part of an organisation's competencies complementing the resource-based view of the firm (Grant 1991) and how its knowledge base and change capacity can be harnessed (Utterback 1994; Conner and Prahalad 1996; Grant 1996; Sundbo 1999; Slaughter 2000; Jones and Saad 2003; López 2005) to provide both price competitive advantage by enabling more cost-effective processes or by adding value to products/services offered (Porter 1985).

2.10.2 Stages of Innovation

Wolfe (1994,p410) notes 10 stages that form the part of the innovation process in the organisation. These stages are: Idea conception, awareness, matching, appraisal, persuasion, adoption decision, implementation, confirmation, routinisation and infusion.

Rogers (1995) offers to summarise the 10 stages of Wolfe into 5 stages as knowledge, persuasion, decision, implementation, and confirmation. This is shown in Figure 2.18.

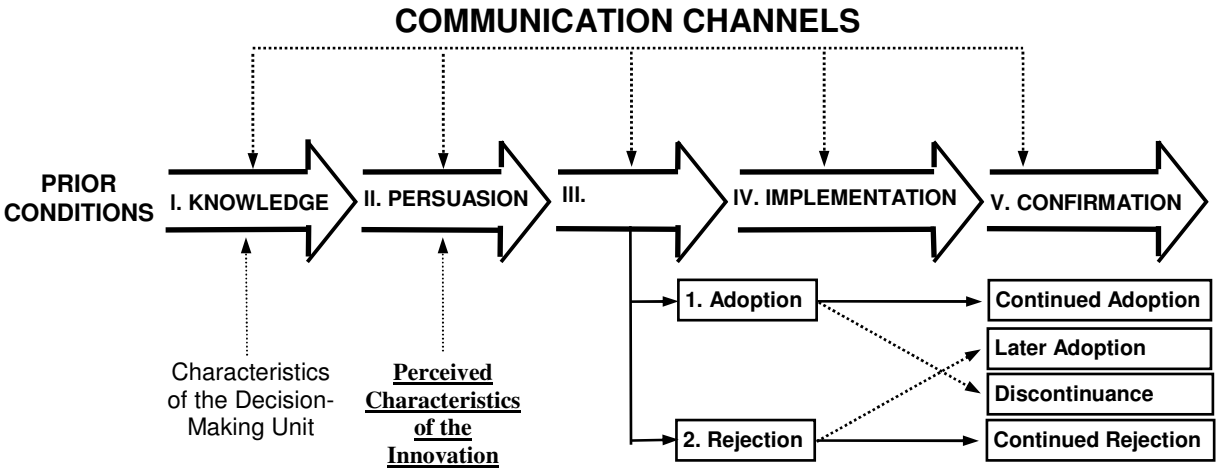


Figure 2.18: Model of the innovation-decision process

(Source: Rogers (1995, p 162))

The key concepts of the diffusion and innovation model are further explained by Awad *et al.* (1984) and Sultan and Chan (2000) in the following manner:

- An innovation has a specific source, and particular characteristics.
- The creation of technological knowledge requires communication through channels.
- Innovation decisions will occur over time.
- Innovation takes place within the context of a social system.

2.10.3 The Life Blood of Innovation- KM

Stewart (2000) explains that tacit knowledge of individuals is of immense value to the organisation as a whole, and is the 'wellspring of innovation'. The ability of KM to convert people's tacit knowledge into explicit knowledge is an essential part of innovation (Nonaka and Taguchei, 1995; von Krogh et al., 2000). People are the 'champions' and 'change agents' (Maidique 1980; Rogers 1995). They bring the change through social interaction and networking within and across organisations (Egbu *et al.* 2001a). Hence regulating this phenomenon through KM and continually striving to convert their tacit knowledge into explicit will facilitate innovation. A number of research initiatives are investigating the role of KM in producing and supporting innovation in the construction industry (Miozzo and Dewick 2002; Husin and Rafi 2003; Salter and Gann 2003).

Innovation is central to a forward movement that depends on trying something different or completely novel and testing theories about how the innovation could or should affect an outcome against reflection of the experience of the experiment. This requires a 'safe' environment where it is acceptable to experiment and make mistakes—as long as lessons learned are internalised, hopefully turned from tacit knowledge to explicit knowledge or at least shared (Nonaka and Takeuchi 1995; Nonaka *et al.* 2001).

2.10.4 Adoption and Diffusion of Innovation

Diffusion of Innovation or Innovation diffusion is defined as the process in which a new idea, concept or technology has been introduced throughout a social system over a time period (Rogers 1995). Three innovation diffusion theories have been discussed by (Harkola 1995; Larsen and Ballal 2005).

1. Cohesion theory states that social proximity of previous and potential users influences the likely potential users' subsequent decision to use that technology (Harkola 1994,p21). A recipient respects the expertise and advice of the influencer, often through social or professional networks. Emmitt (2001) describes how architects and specifiers respond to building product technical representatives and act as gatekeepers where the opinion leaders exercise strong power in adoption decisions.

2. Structural equivalence theory holds that adoption decisions are made on the basis of people searching for innovation solutions by closely monitoring those they deem to be equivalent in status/role so that they allow others to 'show the way' and they are content to be early majority follow (Rogers 1995).

3. Threshold innovation theory holds that adoption is regulated by the nature and strength of influence of group influence in communities (Granovetter 1978). This also recognises the strength within social networks where a small number of influential members can tip the balance in favour of a decision. This has more recently led to numerous explanations of how a tipping-point is reached (Granovetter 1978; Gladwell 2000; Kim and Mauborgne 2003). Larsen and Ballal (2005,p88) gathered data from 264 construction professionals, architects builders and engineers and analysed innovation motivation patterns, they concluded that at the diffusion opinion forming stages, cohesion more strongly influenced that structural influence but at the decision adoption stage, a personal awareness threshold theory dominated. The adoption-decision influences vary over the diffusion stage process.

Havelock's (1969) model of diffusion and utilisation of knowledge incorporates social systems, emphasising the importance of linkage, social interaction and problem solving. These seminal models of diffusion and innovation form the basis of classical diffusion theory, with the essential processes illustrated in Figure 2.19.

A new innovation that is adopted and diffused becomes transferred knowledge, percolating through the organisation that accommodates and then manages the knowledge. The diffusion of any innovation is a social issue and KM provides a comprehensive philosophy and mechanisms to diffuse new knowledge within the organisation.

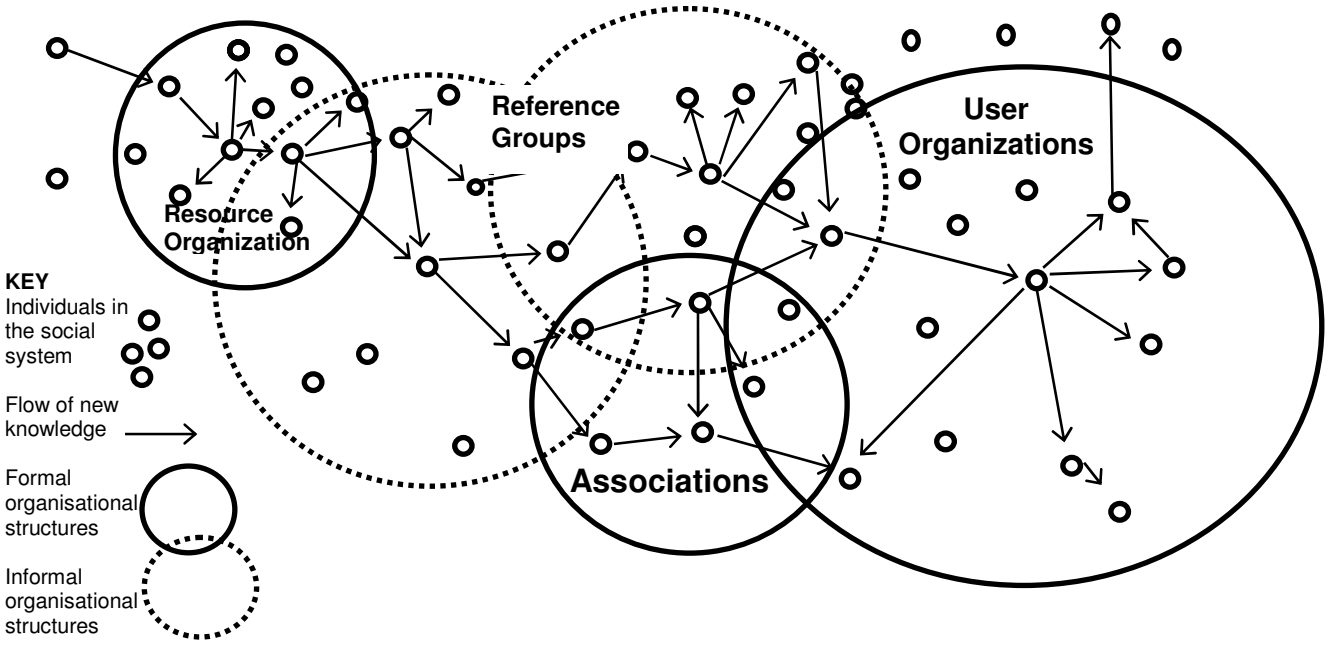


Figure 2.19: The social interaction perspective of diffusion (Source: Havelock (1969))

2.10.5 ICT as an Innovation in the Construction Industry

IT and ICT (including the Internet, e-commerce, and groupware) experiences significant growth in Australian businesses (Australian Bureau of Statistics, 2001)[7]. The Australian construction industry is still in the initial stages of industry-wide adoption of ICT (Peansupap *et al.* 2003), lagging behind other industries such as manufacturing, financing, and property and business services (NOIE 2001). However, leading Australian construction organizations have responded to the challenge of adopting ICT and recognise benefits that include helping them manage their complex and diverse communications needs and protocols.

2.10.6 Importance of ICT and Benefits to the Construction Process

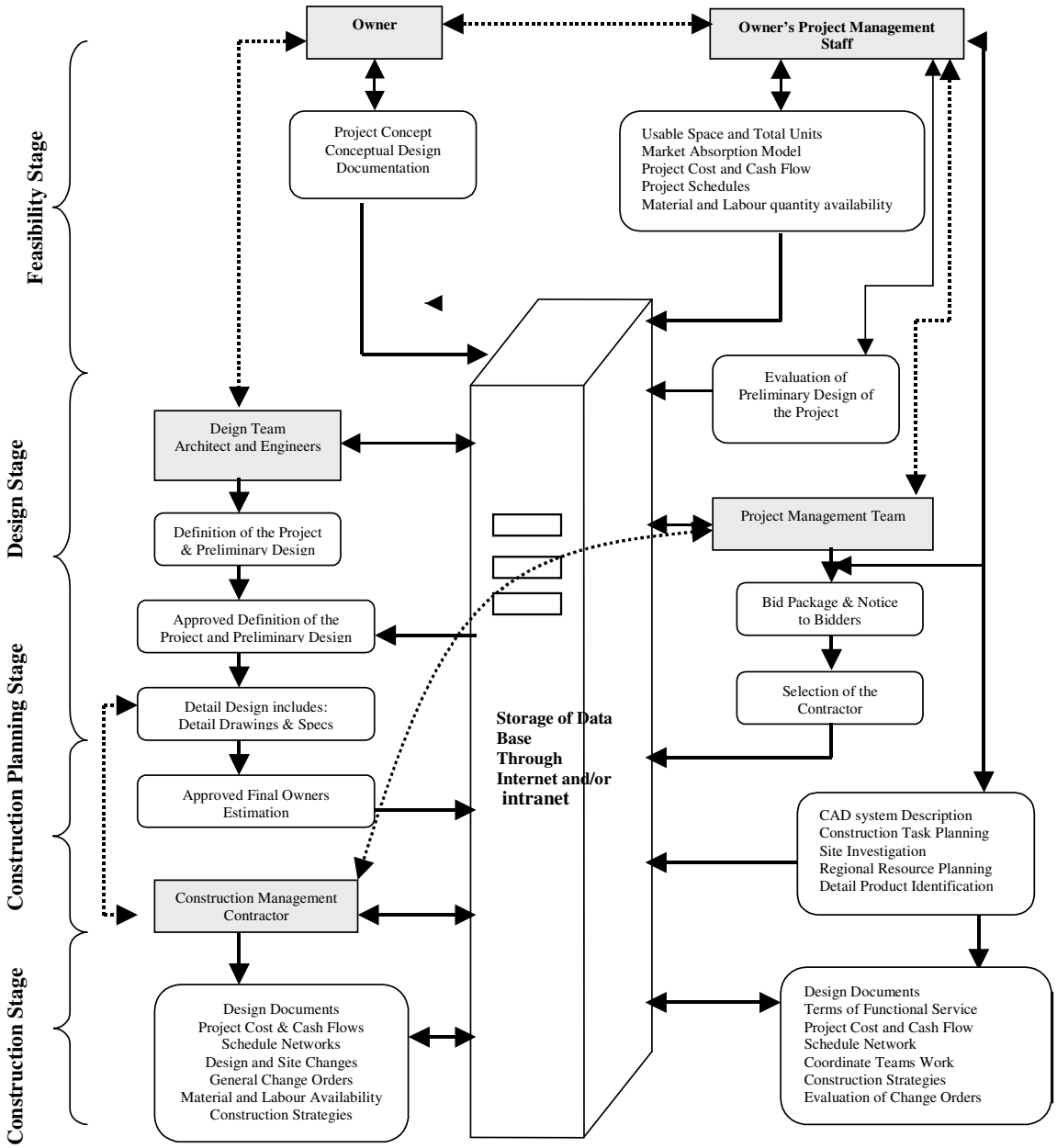
A major construction process demands heavy exchange of data and information between project participants on a daily basis. It is essential to provide clear construction-related information to project participants to avoid unnecessary problems. Duyshart (1997) notes that much of the paper-based information exchange during the construction phase involves duplication, continual translation and transcription from one medium or form to another, as

[7] *Business use of information technology, Australia, 1999-2000.* Commonwealth of Australia, 2001 [cited July 11, 2002. Available from http://www.abs.gov.au/.]

well as the loss of information. The use of ICT minimizes such problems. Figure 2.20 describes the diverse types of data flows in the various construction stages.

ICT applications can help improve project planning, scheduling and cost control (Abudayyeh *et al.* 2001; Sriprasert and Dawood 2002). Tam (1999) demonstrates that the development of a total information transfer system for project management can save considerable time and cost for document transfer. ICT can improve database distribution by the use of a web-based electronic document management system (EDMS), with all documents stored in central database and accessed from other locations (Björk 2002). ICT can encourage information integration between construction processes and help reduce data re-entry errors and support real-time construction project monitoring (Anumba 2000; Björk 2002). Integrated electronic communication exchange provides various tangible benefits (cost and time reductions) and intangible benefits (improved and effective service delivery) (Duyshart *et al.* 2003).

ICT has not only been used to decrease these integration problems, but also is used as an effective way for experts to share knowledge and jointly solve problems. The BP virtual office is one example where complex problems were solved using the expertise of a global network of experts linked electronically (Prokesch 1997). Even e-mail, which is considered to be information-poor due to being context-minimalist, is shown to be more effective than expected when used as a tool for low-level knowledge in a knowledge intensive firm where staff are familiar with it (Robertson *et al.* 2001).



Notes:

Solid Line representing how the date is sending to or receiving from the database storage

Dash line representing the interaction between the parties

However, the interconnection between the processes are taking place into one database

Figure 2.20: Data flows in various construction stages

(Source : Caballero et al. (2002))

2.11 Emerging Directions in KM

2.11.1 Enmeshing Supply Chain Management and KM

The emerging concept of supply chains and supply chain management is revolutionising the business world. This revolution is evident in changing the unit of competition from organisation vs. organisation to chain vs. chain. At the forefront of this philosophy lie long term and strong commitment and trust among the trading partners. This sort of commitment and trust emanates from sharing knowledge with other trading partners in the supply chain as well as joint problem solving within the concept of a 'super-team'. Conventionally, information flows from one end of the supply chain to other setting up potential KM elements of supply chain management because knowledge not information alone flows from one end of supply chain to the other. As a result, workmanship improves, quality gets enhanced and the number of defective items reduces, producing significant amount of time and related costs savings. KM principals are relevant to everyone in the supply chain. Reaping benefits from knowledge varies and depends on the organisation's position and role in the supply chain and the type of knowledge required by the supply chain. It would be misleading to assert that KM is principally applicable to large organisations—all organisations regardless of their size can benefit from KM. KM strategies based should be on customized for each organisation, dependent on its position in the supply chain.

Supply Chain Management (SCM)

SCM is an evolved form of purchasing and logistics-related activities (Croom *et al.* 2000; Tan 2001). For over a decade and half, the SCM literature shows a confusion of terminologies and definitions (New 1997). Some of these include; integrated purchasing strategy, supplier integration, supply base management, buyer-supplier partnership, supplier alliances, supply chain synchronisation, network supply chain, value added chain, logistic integration, lean chain approach, supply network, value stream, etc. (Dyer *et al.* 1998; Nassimbeni 1998; Ellinger 2000);(Tan *et al.* 1998). While each term addresses elements of a phenomenon, typically focussing on immediate suppliers of an organisation, SCM is the most widely used (but often abused) term describing this process (Tan 2001). The most realistic and comprehensive definition is provided by the Global Supply Chain Forum (GSCF), a group of non-competing firms and a team of academic researchers dedicated to improve the theory and practice of SCM. According to this group SCM is the integration of key business processes

from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders (Lambert and Cooper 2000). This sort of integration reduces the product delivery time, reduces waste, minimizes errors and saves on transactional costs thus increasing productivity.

Trust and Commitment: A common foundation for KM and SCM

Trust and commitment lie at the heart of knowledge sharing. One widely accepted definition of trust is "The willingness of a party to be vulnerable to the actions of another party based upon the expectation that the other will perform a particular action to the trustor, irrespective of the ability to monitor or control that other party" (Mayer *et al.* 1995, p73). The first important aspect to understand is that trust is a state of mind or perception. Party X trusts party Y in the sense that X believes that Y's actions can be predicted and that Y's actions will not harm X. The second aspect that needs to be understood is that trust is a state of your vulnerability that has to be tested to prove that this state of trust is not misplaced. Mayer et al's model, illustrated in Figure 2.21, provides a useful illustration of the influences at work.

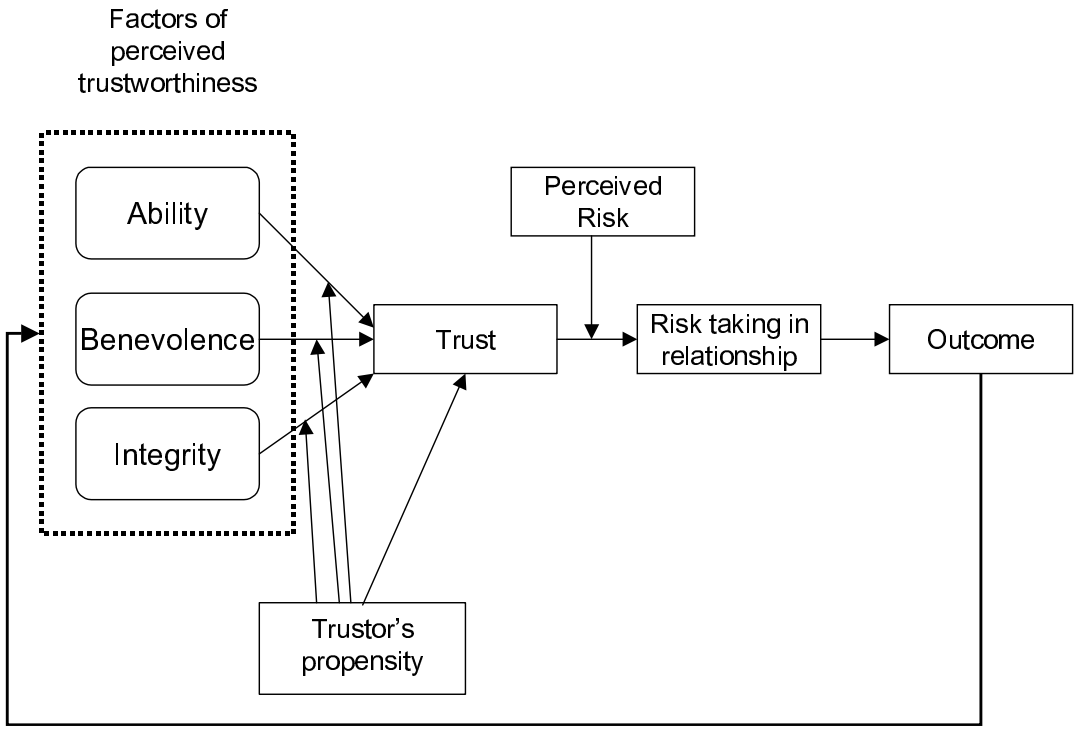


Figure 2.21: A model of trust (Source: Mayer et al. (1995, p715))

Figure 2.21 indicates three antecedents. *Ability* refers to the capacity to perform the predicted action. Ability is not constrained to a physical or cognitive capacity but that the environment in which a trust challenge may be situated allows Y to fulfil the response predicted by X. Party Y may be both physically and mentally able to do something but may be constrained by contractual-legal arrangements, hierarchy or some other influence and thus fail to be able to

respond as predicted by X. *Benevolence* is a sense that Y has X's welfare at heart so that Y will not harm X. Finally, *integrity* means that party Y has demonstrated through its past and current actions that it acts in a predictable fashion and that there is an internal consistency or logic—integrity—in actions taken. Ability, benevolence and integrity carry no specific moral weight and are in a sense a measure of transparency and logic. These three elements comprise the notion of trust.

Party X must also have a propensity to trust for trust to be evident. If party X has been severely disappointed with Y or other parties in the past then X may have a lowered propensity to trust and, trust of Y by X will be inhibited—even if Y can demonstrate high levels of ability, benevolence, and integrity.

Also, for trust to occur X needs to be put at risk in a situation arising where X is vulnerable to party Y. The risk taking event is crucial in building X's trust in Y because it results in a test that validates the trust of X in Y. The outcome of that trust refines the trustworthiness perception that X has in Y. Zand (1972) linked trust with problem solving where control and information disclosure are critical elements of the process of trust being generated, tested and the trust perception refined.

Lewicki and McAllister (1998) extend our understanding of trust by introducing the notion that parties neither trust nor distrust each other, rather they exist in a state of combined trust and distrust as illustrated in Figure 2.22. This is a useful observation as it provides a maturity model of the trust relationship. Further, as trust is essential for effective KM and SCM that benefits the whole supply chain, it reinforces its place as a common foundation for KM and SCM.

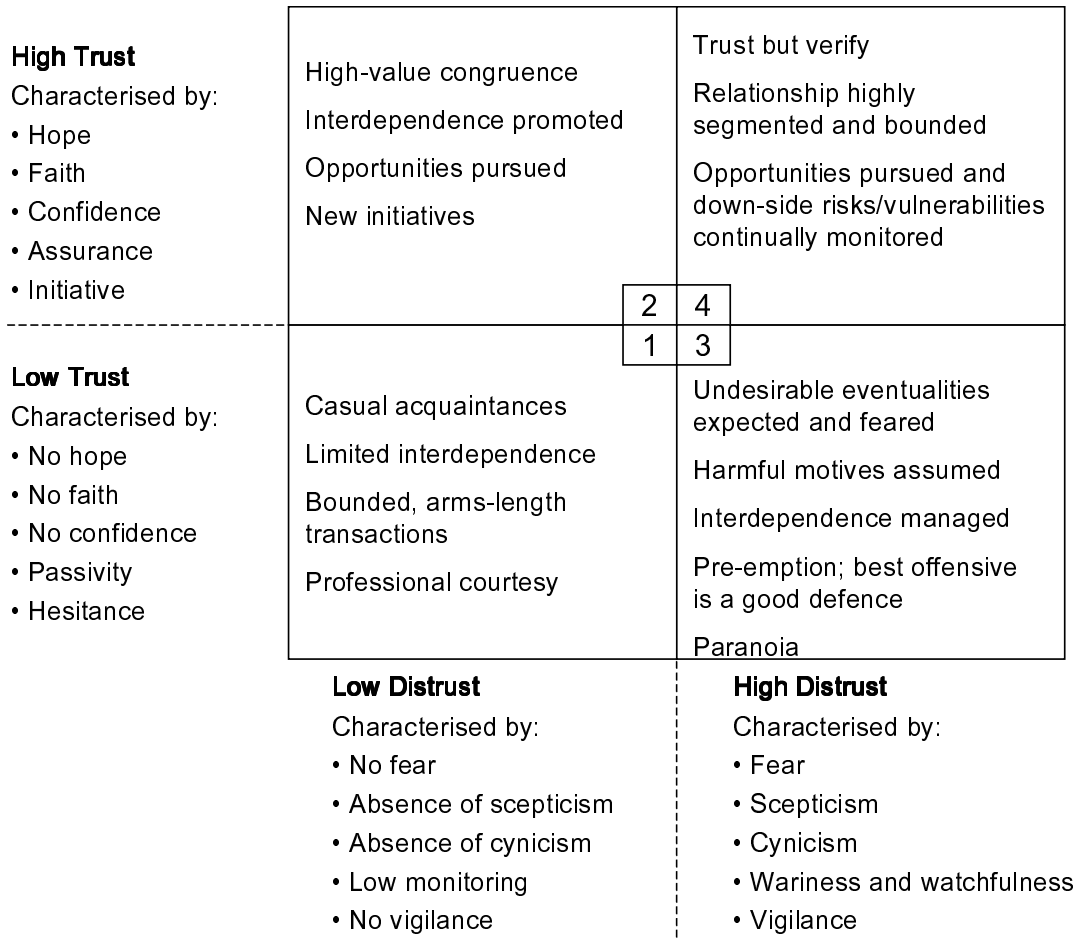


Figure 2.22: Trust and distrust (Source: Lewicki et al. (1998, p445))

At the naive trust maturity level there is a casual acquaintance relationship characterised by low trust and low distrust (quadrant 1). Parties X and Y have no particular expectations above the transactional nature of their interaction—no hopes, fears or expectations.

Interdependence is promoted and the trust relationship is fresh with opportunities and initiatives being pursued with high levels of trust and low levels of distrust (quadrant 2). This may be characterised by enthusiasm, confidence and high levels of faith but the testing of the relationship may be underdeveloped and so the relationship could be said to be 'hopeful' rather that 'trusting'.

A low trust and high distrust relationship (quadrant 3) may develop as challenges being encountered to that relationship being poorly managed with numerous 'withdrawals' from what the Walker and Hampson (2003a, p191) call a 'loyalty bank'. The business relationship may still exist but the quality of information is likely to be poor. Exercise of control is likely to highly asymmetrical with both sides enmeshed in a power struggle that can be dysfunctional behaviour and wasted energy being expended on negative relational behaviours.

The party with lower power will use various strategies and tactics to gain more power and control, perhaps through highly filtered and selected use of information and level of sharing knowledge to counter the imbalance.

The most mature quadrant of the Lewicki *et al.* (1998) trust-distrust model is high trust and high distrust (quadrant 4). This at first appears paradoxical because it seems incongruous to promote the notion of distrust. However, Lewicki *et al.* (1998) refer to this as a 'trust but verify' situation and they recognise in this that there are environmental limitations such as laws, rules and accountabilities to a plethora of stakeholders and. 'Trust and verify' is the most sophisticated state that a knowledge sharing relationship can aspire to because it provides critical feedback.

The key issue that emerges from our discussion on trust is that:

- Trust is a frame of mind, it requires challenges and conflict to be validated;
- That trust and distrust coexists;
- That the nature of trust changes over the time that the relationship continues;
- That power imbalances and quality of information and knowledge exchange are tightly bound up in the trust-distrust experience.

The implication of this is that trust influences commitment to share information and knowledge and it also influences the deployment of power associated with knowledge generation, exchange and use.

Commitment is the physical and mental manifestation of the concept of trust. It is the proof of trust. It is the willingness to reciprocate energy invested through trust in the process of transformation of this energy into tangible results. Commitment means that another party will take this trust on board and 'live up to' the spirit of the bargain by probably committing more personal pride and obligation to 'do the right thing' than would otherwise be the case. Meyer and Allen identify three types of commitment (1997, p11). *Affective* (want to) commitment requires intrinsic motivational responses. *Continuance* commitment (a need to comply) relates to a transactional exchange in which extrinsic rewards are provided. While *normative* (ought to) commitment results in obligation and duty in which grudging acceptance, or dutiful deference can prevail. One could see normative commitment as marginally higher than mere compliance.

Clearly the most sophisticated and valuable conditions for trust and commitment are represented by high levels of trust and distrust with a healthy appreciation and understanding of the limits to which party X can rely on party Y to do what it wishes or needs to do. It also required that the levels of ability, benevolence and integrity are high under this situation with the relationship having been successfully tested to both generate and maintain trust. There also would need to be affective commitment so that party X is comfortable with the experienced sense of vulnerability and that party X desires to trust and be inter-dependent with party Y. Mature sophisticated supply chains would more closely fit with this characterisation rather than being either dangerously naïve or sceptical to the point of being dysfunctional.

Trust and commitment is therefore depicted as providing a degree of predictability and transparency of both intent and action. It also indicates a matching or at least understanding of the values, norms, language and culture between the organisation and those dealing with it as stakeholders. The need for common or translatable value systems, language, symbolic artefacts and protocols or etiquette (Trompenaars 1993; Swierczek 1994; Brown 1998; Hampden-Turner and Trompenaars 2000; Holden 2002) has been shown to be important for developing shared understanding and thus enhancing the chance of trust and commitment. This environment should be created not only in any particular organisation but also across the whole SC so that each trading partner increases trust in the others in the SC to keep them committed.

A sense of commitment to creating an innovative solution to challenges is necessary because a differentiated competitive advantage generally relies on being unique or highly unusual so that it transcends the obvious or 'norm' (Nonaka *et al.* 2001). Commitment is fostered through an environment of trust and care where individuals feel positively obliged to share ideas and knowledge that benefits all within an organisation rather than the individual or small group concerned (Walker 2003; Walker and Hampson 2003a).

The Proposed concept of Learning Chain

In the construction industry, organisations come together with their specialities and knowledge to complete a construction project. Each organisation contributes its knowledge in a form of people, processes and technologies, to the construction process as shown in Figure 2.23 and 2.24. Traditionally, the selection of these organisations or trading partners is based upon a spot rate basis. This makes transactional exchange the dominant form of business in the construction industry (Dubois and Gadde 2000). The suppliers' competition in each transaction is assumed to be the most appropriate means of securing efficiency of operations. Therefore, actor constellations change all the time, making it difficult to utilise the experience gained in previous projects (Dubois and Gadde 2000). Cox and Thompson (1997) observe that this creates inefficiencies as the supplier climbs a new learning curve for each project. SCM deals with these problems by promoting relational contracting, long-term commitment and an atmosphere of high trust and commitment.

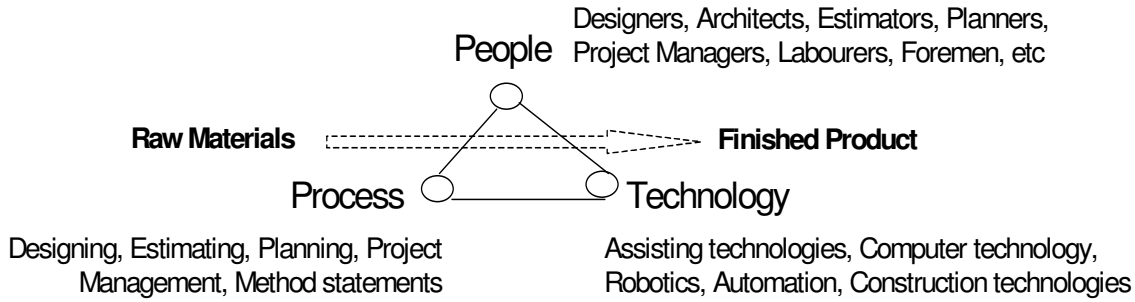


Figure 2.23: Construction process

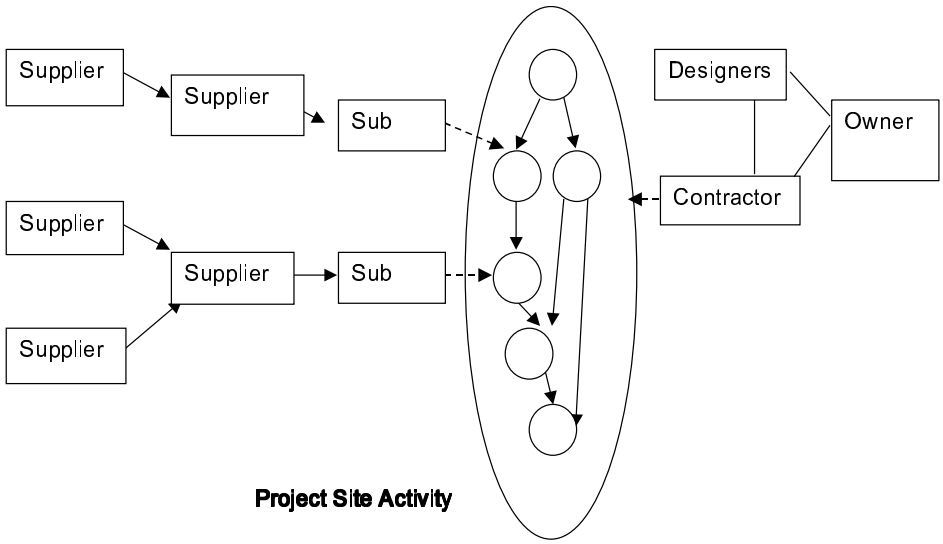


Figure 2.24: Supply chain in construction (Source: (O'Brien et al. 2002))

Through systematic KM, trading partners are able to minimise wasteful activities and improve productivity and efficiency. KM, together with SCM, will ensure that knowledge, not information alone, is shared with the trading partners. Whereas the information may simply specify what is required of the trading partner, KM can help to determine how best to deliver that product or ensure the swift availability of the related knowledge. Figure 2.25 descibes two such trading partners who are bound together by trust and committed for long term relationship and have their key business process integrated under SCM. Each process gets assistance from a knowledge layer set under KM on the top of these processes.

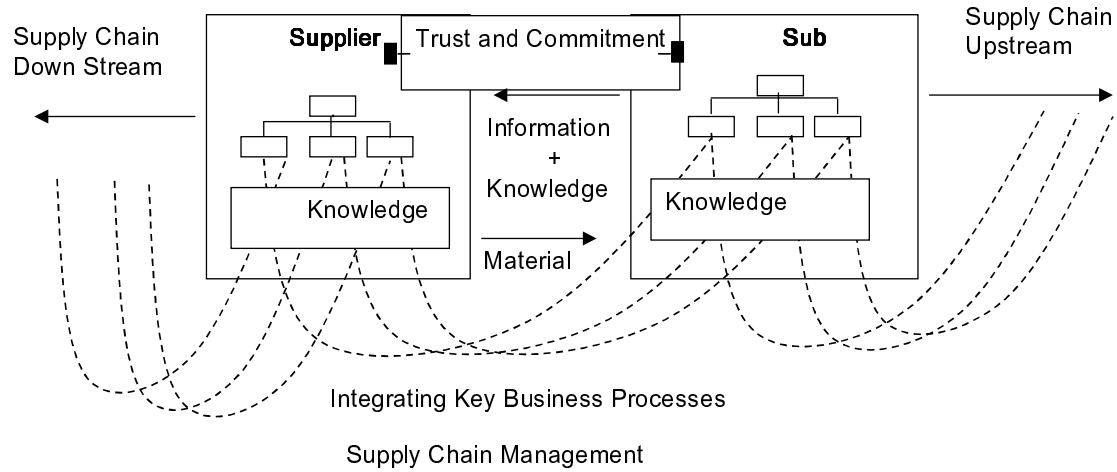


Figure 2.25: Trading partners adopting SCM and KM

The mechanism of this nature would ensure that best available knowledge is utilized to deliver the product and service and experiences gained on the projects would be efficiently stored and utilized throughout the supply chain. Spekman *et al* (1998) presented another point of view based on which a trading partner can decide how much knowledge it wants to share with other trading partner. Figure 2.26 distinguished between three modes of interaction, co-operation, coordination and collaboration. Cooperation is the starting point of knowledge sharing while collaboration leads to maximum sharing of knowledge.

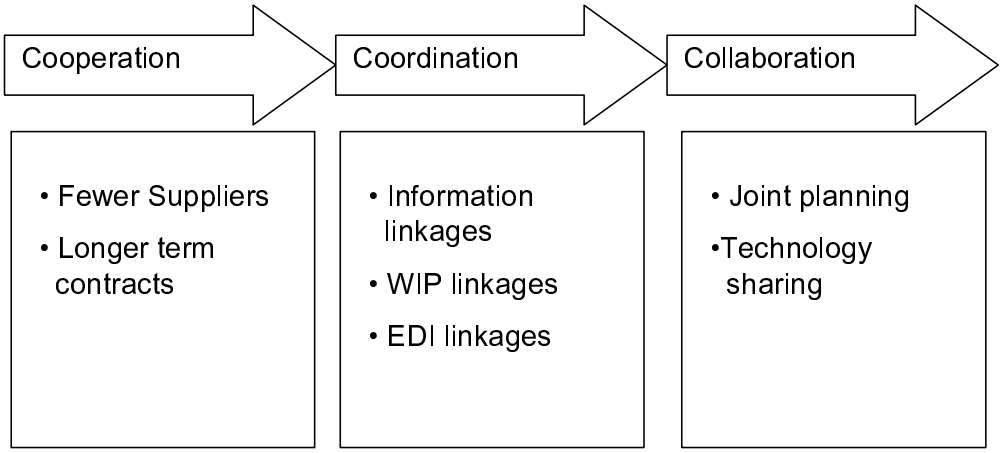


Figure 2.26: Various modes of interactions among trading partners (Source: Spekman et al. (1998))

Spekman *et al* (1998) argue that 'cooperation' is the threshold level of interaction where firms exchange essential information and engage some suppliers/customers in longer-term contracts. The next level of intensity is 'coordination' where specified workflow and information are exchanged in a manner that supports seamless linkages between and among trading parties. The final stage is 'collaboration' where by partners engage in joint planning and processes beyond levels that reach in less intense trading relationships. Collaboration requires high levels of trust, commitment, and information sharing based upon partners who share a common vision of the future. An organisation may work at any of these three levels of trust and commitment with other trading partner to facilitate SCM, and may modify its selection after monitoring the interaction to observe change in the effecting factors. These various modes of interactions are in fact, limiting the magnitude of knowledge that can be shared with a specific trading partner. KM in this context would be helpful to provide detailed guidelines as to what sort of knowledge is appropriate to share in a certain mode of interaction. A supply chain exhibiting such characteristics can be termed as a Learning Chain.

The literature on SCM indicates that there are variable levels of alignment in different industry sectors. For example Michaels (1999) suggests that in the UK, by the closing decade of the 20th century at least, the supply chain for aircraft components had patchy levels of coherence in their ability to exchange knowledge and develop lean production and drive out waste. In a more current paper, Childerhouse *et al.* (2003) indicate that at least at the first tier of component suppliers in the automotive SC, substantial gains are being made in tuning productivity and information flows for the automotive industry however, they identify

continuing barriers relating to technology, cultural and financial barriers that need to be addressed to realise the potential for SC to effectively align their knowledge transfers. They do indicate recent advances in ICT that is enhancing knowledge and information transfer such as adoption of groupware, linked computer aided design (CAD) information and the ubiquitous use of email and the Internet. They also indicate that what they call "product champions" are helping to propagate good and best practice in SCM through knowledge transfer.

The construction industry appears to be in a nascent stage of SCM using e-commerce tools such as the UK and Australian versions of the INCITE procurement and information exchange system for conducting e-business (Peansupap 2004; Taylor 2004). Thus while it appears to be normal and expected that some parts of the SC will be more advanced than others the longer-term aim should be to raise all members to a common higher level of SC integration of knowledge and information transfer to squeeze out waste and create greater value for SC members and additional value to customers. This said, Cox (1999) argues that the aim of firm in general is to appropriate as much value that can be derived from a SC as possible even at the expense of the customer and other SC members. His salutary and often contested proposition is that successful SCM helps to elevate a SC's group competitive advantage to such an extent that it drives out other SCs or individual firms from the market thus creating itself an oligarchic niche and which point it is free to move from a customer delight delivery aim to determining itself what the customer will tolerate in terms of value delivery by satisfying them The SC then appropriates excess value. Further, the dominant members of the SC can appropriate value at the expense of weaker SC members (Cox 1999, p171). This is a somewhat profit-only-centred proposition, however, Cox's argument is strongly argued with organisations like Microsoft and UK supermarket chains cited as already holding this market position.

KM Proliferation in the Supply Chain

For supply chains to act as a learning chain would require that KM initiative is to be taken throughout. Each trading partner has to adopt a knowledge advantage framework described above. In this regard, a concrete effort from a certain trading partner who holds a vantage point is required. Maqsood et *al*. (2002) consider 'Power Management' being an important component of SCM where by a trading partner holding a vantage position is able to create a supply chain and monitor and control the performance of a supply chain. Depending upon

how the supply chains have been created in the first place, either by a contractor or client, one has to take control to synchronize downstream or upstream chain activities. The party assuming power (e.g. contractor) needs to take responsibility for establishing knowledge leadership in whole supply chain on a similar basis, as it would take for its own organisation. Based on this knowledge leadership throughout the supply chain, it needs to ensure that other components (ICT enabling infrastructure and People Infrastructure) to achieve knowledge advantage are appropriately addressed (see Figure 2.15). It should ensure that each trading partner takes an internal assessment of their knowledge processes according to K-adv framework and help them to establish achievable targets to reach up on the scale of K-adv framework. Help should be provided to adopt same ICT infrastructure across the chain. Supply chain members are to be considered part of the people capital and should be rewarded for their trust and commitment.

2.11.2 KM and Human Resource Management (HRM)

HRM for a long time is associated with handling of people's intelligence. If KM is being considered as a human related issue, it cannot be separated from HRM. Here lies an opportunity for KM to assist and compliment existing HRM practices and provide a framework where it may be possible to quantify how people's intellect and knowledge is best developed and leveraged to the benefit of the organisation.

Egbu (2001) and Olomolaiye and Egbu (2004) have placed great emphasis on pursuing this stream of research. Potential research in this realm includes the re-evaluation of HRM as a more active and strategic enabler of building organisational competencies, of developing reward systems to more effectively facilitate knowledge exchange and embedding knowledge and competence within organisations provides fertile ground for KM research. While HRM has a wide scope of literature relating to KM, much of this has been adequately discussed in this chapter relating to the establishment of a supportive management environment for knowledge generation and transfer. Lessons learned from project histories and ongoing knowledge capture for example, can be re-used as training and development and simulation exercises.

2.12 Link between KM, Organisational Learning and Innovation

Based on the literature discussed and review in this chapter, a conceptual model is proposed in Figure 2.27 that interlinks KM, organisational learning and innovation.

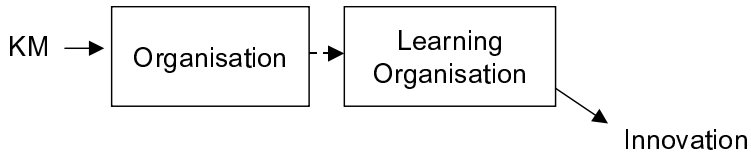


Figure 2.27: Link b/w KM, Learning Organization and Innovation

It has been discussed in section 2.9 that KM initiative will cause people in the organisations and hence organisation as a whole to learn as it carries out its processes of capturing, sharing, transferring of knowledge. This continuous cycle of learning will help achieve the organisations a vision of being considered as a "Learning Organisation' where only change is constant. Such an organization will be continually challenging their output and outcomes resulting in continual change and innovation. Hence innovation is linked to the output of a learning organisation. This can help such organisations to improve their capabilities and successful maintain their competitive advantage.

This sets the basis for the defining a model show in Figure 2.27. This simple model provides a conceptual foundation of this research and thesis. The next chapter actually details what happens inside the organisation and how organisational learning is achieved through KM and how innovation becomes the routine out put of the learning organisation.

2.13 Summary

This chapter confirms that the construction industry is a vital element of the economy and has a significant impact on the efficiency and productivity of other industries. Construction industry innovation aims to increase productivity and improve project delivery outcomes. The construction industry by its very nature has a highly complex structure and is often termed as being old fashioned or traditional. The culture of the industry tends to resists new innovations unless they are tested and trialled in other industries and proved to be successful. There is a growing interest in KM in the construction industry due to its successful application in

pharmaceutical, electronics and manufacturing projects. Construction organisations can innovate, reduce project time, and improve quality and customer satisfaction through effective KM. Successful KM initiatives establish a knowledge-sharing environment /culture and provide effective leadership to overcome any learning barriers. Thus it was important to explain the meaning of KM and how organisations can consider knowledge as a resource and a valuable intangible asset providing the means to improve business performance and customer satisfaction.

Knowledge is a complex, messy and problematic concept to understand. A typology of knowledge either being 'tacit' or 'explicit' is generally considered a useful starting point. The exchange of knowledge from tacit to explicit from individuals to groups and entire organizations forms a large part of the body of current KM research. Therefore, it is vital to understanding this knowledge conversion process its pivotal role in producing innovation. Limitations to knowledge transfer must also be understood and so this chapter noted a main knowledge characteristic recognized in the literature, 'stickiness'. Knowledge stickiness poses considerable problems for organisations wishing to maximise the conversion of tacit knowledge in people's heads into explicit knowledge that has been codified and organizationally embedded. To make this process effective and achievable, various types of knowledge transfers were discussed in the chapter—serial, near, far, strategic, and expert.
However, tacit knowledge can be misleading and this perspective is poorly understood and considered in the literature. This chapter provides a section on this issue, considering it as hidden or 'dark' side of tacit knowledge. Factors that eventually govern human decision-making that influence tacit knowledge construction, use and reuse were discussed from a cognitive and psychological perspective. These include: perceptions and recognition; cognitive styles; biases and heuristics in judgment; functional fixedness and mental set; mental models; and variations in learning styles. These factors are associated with gut feeling and intuition. A vital KM implication of this is that to ensure that tacit knowledge is bias free and effective, the context in which the knowledge gets constructed in the human mind should also be captured and this capturing should be done as soon as possible.

The chapter mapped three KM dimensions to help us better understand the essence of KM: Categorical Dimensions; IC Dimension; and Socially Constructed Dimension. Categorical Dimension considers knowledge as an entity that can be categorized and is usually criticised for being so linear and mechanistic. IC Dimension views KM as something related to the management of IC that comprises of human capital and structure capital (customer capital and

organisation capital). The third dimension Socially Constructed Dimension is usually considered more probably a true representation of what KM is and should be. This dimension identify that KM is a social issue and knowledge construction and transfer is more effective through building social network ties, and COPs. This inturn provide a mechanism for the development of 'Social Capital' that could eventually be converted into 'IC'. Issues of 'Trust' and 'Commitment' are central to this dimension. Thus the intangible value of KM was established.

While this chapter established the potential value of KM it noted that KM practice has resulted in numerous failures. KM took off in 80s as a technological initiative with a view of transferring knowledge of humans to machines. Consistent failure of such initiatives forced KM researchers view the philosophy through a different lens and learn from experience of failed initiatives. This produced a total shift in current KM research to now being considered as much as 90% human activities and only 10% technology. The human factor is now becoming dominant and with it issues such as culture, leadership, rewards systems and change management programs becoming the major part of any KM initiative. So it was important to stress the limitations of a technology-centric view of KM.

The major thrust of this thesis is that organisational learning and KM are linked. The underlying philosophies of both streams of research are in agreement with each other. Both strive to reduce mistakes and learn from the past, both focuses on organisational factors to deliver the best outcome. It has been argued in this chapter that KM initiatives can cause organisations to learn and eventually help to achieve their vision and status as being a "Learning Organisation". KM has a strong and definitive role to play, especially in the project based construction industry where project based learning poses big problems. This may be achieved through one such integrated KM initiative—by efficiently capturing knowledge from past projects, developing project repositories and establishing a culture of knowledge sharing.

KM also supports the innovation stream of research in many different ways. Innovation may occur whenever tacit knowledge is converted into explicit knowledge resulting in process or product improvement. A further essential KM initiative discussed in this chapter involves adoption of innovation and its diffusion within an organisation. KM provides a solid platform for this sort of activities because sound KM initiatives rely upon establishing a basic atmosphere of collaboration, trust and sharing within the organisation. Hence KM has a role

to play in deciding what sort of innovation is to be adopted and then diffusing it with in the organisation to produce productive innovation.

Two emerging directions of KM research were also identified where KM has a strong role to play. First, this chapter highlighted how the philosophy of SCM and KM is enmeshed through fundamental factors of 'trust' and 'commitment'. The argument advanced is that both information and knowledge move upstream and downstream in the supply chain. A second direction of KM research is linked to HRM and how HRM practices can be re-evaluated. Two specific aspects were highlighted in this chapter: first, to provide a more active and strategic enabler of building organisational competencies; and second, to develop reward systems to more effectively facilitate knowledge exchange and embedding knowledge and competence within organisations.

Finally, this chapter demonstrated the link between KM, organisational learning and innovation. This forms the basis for discussing the conceptual model developed in the next chapter to explain how KM initiatives may trigger innovation.

Chapter 3
Research Method and Design

The aim of this chapter is to describe the research method and design that is used in executing this research project. The chapter starts by explaining the philosophy of the research and then provides an understanding of the two competing research paradigms i.-e. Positivism and Social Constructivism. This is followed by a discussion on research approaches and strategies in these two paradigms. A case for adopting interpretative paradigm for this research is then made through reasoning that dominant positivistic paradigm of research in the construction industry is still yet to produce any noticeable changes in the construction industry and its culture, it is therefore becoming incumbent to use an alternative paradigm of research. The argument is supported by Seymour and Rooke (1995) paper on the culture of the research and the culture of the industry. The next sections provide the understanding and the working details of the two qualitative research methodologies chosen for this research (the Grounded Theory Methodology and Soft Systems Methodology (SSM)). The last section describes the Research Design for this research which is divided into two phases with grounded theory employment constituting the phase 1 of the research and SSM utilisation forms the phase 2 of the research.

3.1 Understanding the Philosophy of Research

Fellows and Liu (2003, p4) describe research as a careful search and investigation and term it as a 'voyage of discovery'. The purpose of research is to contribute to the existing body of knowledge and to facilitate the learning process. It is an organised, data-based, critical investigation into a specific problem (Sekaran 2000).

Research is always based on assumptions that are philosophically grounded and relate to a researcher's view or perception of 'reality'. The aim of research is to discover truth and construct reality. Two terms 'ontology' and 'epistemology' are extensively used in research to describe the nature and characteristics of philosophical assumptions. Ontology is the science of being and existence (Easterby-Smith *et al.* 2002). It is the way researchers perceive and understand the nature of 'real world'. This could be from the perspective of an individual, an organisation or an industry. Epistemology is the theory of knowledge and a critical examination of assumptions of what is valid and what is the scope of that validity (Easterby-

Smith *et al.* 2002; Holden 2002). Research undertaken in the natural science context has a different perspective and position on the nature of research philosophy from that of the social science context. These different perspectives have given rise to two different streams of research with different notions, priorities and *modus-operandi*- the 'positivism' and 'social constructivism'. These are discussed in the next section.

3.2 Positivism and Social Constructivism Paradigms

A paradigm is a theoretical framework which includes a system by which people view events (Fellows and Liu 2003). It provides an approach to questioning and discovery. In the domain of the research, 'positivism' and 'social constructivism' can be safely termed as paradigms. The research methods literature also provides different labels to these paradigms. Rationalist, Normative and Quantitative terms are often used to describe the 'Positivism Paradigm' and the Social Constructivism paradigm is often termed as being Interpretivism and Qualitative paradigms.

The Positivism Paradigm's main principle is separation of the researcher (subject) and the research object. This strict separation is intended as necessary to get impartial results. Positivists believe that the world is concrete and external. Therefore, exploration can only be based upon observed and captured facts using direct data or information (Easterby-Smith *et al.* 2002). Any subjective influence exerted by the researcher is regarded as a disturbance that must be minimized through standardization of the elicitation process. The premise of this separation is that it facilitates coherence of the research process through hypotheses testing. Hypotheses are the means of connecting two disjunct parts of the research process and the research activity involves attempting to refute them (Fensel 1991).

The main underlying theme of the 'Social constructionist' Paradigm is that the world is not objective and exterior and the real world is determined by people rather than by objective and external observable facts (Easterby-Smith *et al.* 2002). Truth and reality are social constructs rather than existing independently 'out there' (Fellows and Liu 2003). Miles and Huberman (1994) while explaining the main purpose of 'Social constructivist' or the Interpretivism paradigm, state that in this paradigm, the researcher's primary role is to gain an holistic overview of the context under study. The main task of this sort of research is to explicate the ways people in particular settings come to understand account for, take action and otherwise manage their day to day situations. Researchers belonging to this school of thought posit that

human discourse and actions cannot be analysed using natural and physical science methods. Human activity could be seen as "text", as a collection of symbols expressing layers of meaning. The unveiling of these layers to get a deep understanding of a certain process is the objective of the Interpretative Paradigm. However, researchers are not detached from their objects of study because they have their own understandings, convictions, and conceptual orientations. They are affected by what they hear or what they observe in the field in noticeable ways. An interview, which is common research instrument, does not simply involve gathering information by one party. It is a "co-elaborated act" on part of both the parties (Fensel 1991). Most analysis is done with words in this sort of research. Words can be assembled, sub-clustered, or broken into semiotic segments and organized to permit researchers to contrast, compare, analyse and bestow patterns upon them (Patton 1990). In contrast to normative methods (that requires a representative sample to verify the significance of the hypothesis statistically) qualitative researchers don't intend to explore representative samples. Rather they claim that the human-related things they wish to explore are present in one form or other in every individual (Fensel 1991).

There are many arguments among the followers of these paradigms. Rationalists claim that there is no such thing as qualitative data. Everything is distinctively measurable, either 1 or 0, black or white. Interpretive paradigm researchers counter this view by arguing that all data are basically qualitative and so they attach meaning to raw experience, words or numbers (Miles and Huberman 1994). The normative paradigm relies mostly on testing an hypothesis. Fensel (1991) argues that no definitive answer is given when confirming hypotheses and that theory is built from refuting the negative or alternative hypothesis—thus limiting conditions that constrain the hypothesis. Such arguments and counter arguments between researchers supporting these paradigms are quite common and have been continuing for a long time. The purpose of these arguments is to justify dominance of one paradigm over another in a struggle for supremacy of 'strong' or well-supported theories over weakly supported ones. To resolve the issue, Patton (1990) proposes two paradigms may become integrated through an approach of 'Triangulation'. This is to ensure that a certain paradigm is being used for the purpose it is best suited to. Most often qualitative research is exploratory and comes up with various deeper and often unexpected insights. This may help in the development and refinement of a hypothesis that can be verified by a positivist approach to develop its significance or cause effect relationship (Miles and Huberman 1994).

3.3 Research Approach and Strategies

A general model of the research process for basic and applied research with positivistic influence is provided by Sekaran (2000) as shown in Figure 3.1. This is represented as an eight-stage process that is iterative in nature. The model is based upon the hypothetico-deductive mode of research, which depends upon the development of hypotheses for testing (Stage 5). If the subsequent investigation and analysis substantiates all the hypotheses, then the research questions will be fully answered. If the hypotheses are not fully substantiated, the further studies can be undertaken to investigate the reasons.

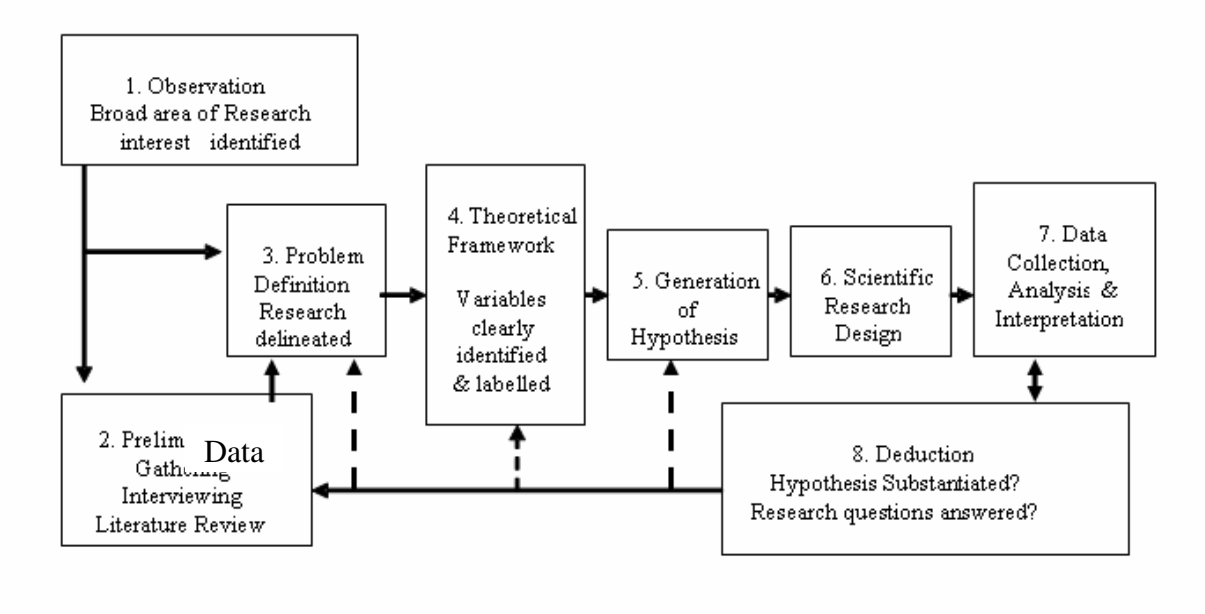


Figure 3.1: The research process for basic and applied research in Positivism paradigm (Adapted from Sekaran, (2000, p54) and Finegan (2001))

Various research approaches or strategies that are more commonly used in Positivistic Paradigm are shown in Table 3.1 as follows:

Table 3.1 Various research approaches and strategies (Adapted from Galliers (1992, p144-59) and Yin (1994, p3-9))

Research Approach	**Research Questions**	**Key Features**
1. Laboratory Experiments	How, why	Identification of the precise relationships between chosen variables in a designed laboratory situation. Uses quantitative analysis and allows intensive study of a small number of variables.
2. Field Experiments	How, why	Extension of laboratory experiments into real-life situations. However, it is often difficult to find organisations prepared to be experimented upon.
3. Archival Analysis	Who, what, where, how many / much	Based upon the quantitative and qualitative analysis of archival records to describe the incidence or prevalence of a phenomenon, or to be predictive about certain outcomes.
4. Forecasting Future Research	What, how much	Providing insights into likely future events or impacts, these studies use techniques that include regression analysis, time series analysis, or the delphi method and change analysis. They attempt to deal with the impact of change, but must deal with complexity and changing relationships between variables under study.
5. Simulation, game/role playing	What, how	Used to study situations that are otherwise difficult to analyse by simulating the behaviour of the system by the generation or introduction of random variables.
6. Surveys	Who, what, where, how many, how much	Questionnaires, interviews and observation are used to obtain data on the practices, situations or views of a sample of a particular population. Surveys allow large numbers of variables to be analysed quantitatively, but do not provide insight into underlying causes.

The social constructivism or interpretive approach is inductive, and is not consistent with hypothesis development, testing and deductive reasoning. The theory building is at the heart of the process as shown in Figure 3.2.

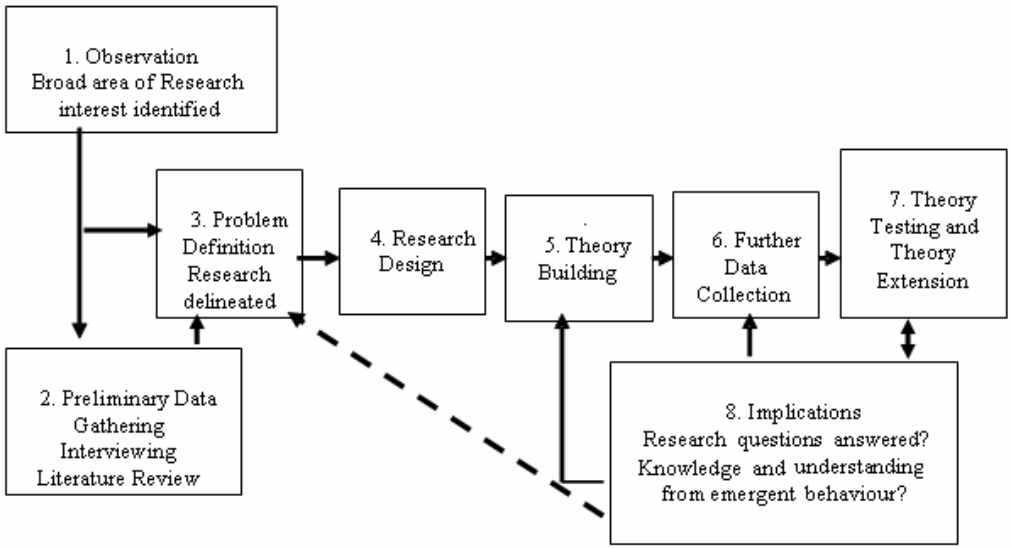


Figure 3.2: The research process-interpretive approach
(Adapted from Sekaran (2000, p54) and Galliers (1992, p61) and Finegan (2001))

Various approaches or strategies that usually fall in this interpretive paradigm are collated below in Table 3.2.

Table 3.2: Various approaches in Interpretive Paradigm (Adapted from Galliers (1992, p144-59) and Yin (1994, p3-9))

Research Approach	**Research Questions**	**Key Features**
Case Study	How, why	Case studies can either be explanatory, exploratory, or descriptive, in all cases focusing on contemporary phenomenon in real-life settings. They allow the capture and analysis of many variables, but are generally restricted to a defined event or organisation, making generalisation difficult.
Archival Analysis	Who, what, where, how many / much	Based upon the quantitative and qualitative analysis of archival records to describe the incidence or prevalence of a phenomenon, or to be predictive about certain outcomes.
History	How, why	Explanatory studies that deal with operational links over time.
Subjective Argumentative	What	A creative, free-flowing, unstructured approach to theory building that is based upon opinion and speculation. A subjective approach that places considerable emphasis upon the perspective of the researcher, its objective is the creation of new ideas and insights
Action Research	What to do, how, why	This is applied research where there is an attempt to obtain results and benefits of practical value to groups with whom the researcher is allied, while at the same time maintaining a holistic perspective and adding to theoretical knowledge. The underlying philosophy is that the presence of the researcher will change the situation under investigation.
Grounded Theory	What	A structured approach to forming and eliciting theory grounded in data.

Descriptive, Interpretive	What, how, why	Based upon the philosophy that phenomena are the essence of experience, this form of research seeks to represent reality using an in-depth self-validating process in which presuppositions are continually questioned, and the understanding of the phenomena under study is refined. The approach allows the development of cumulative knowledge by incorporating the thorough review of the literature and past research as well as the current investigation. This encourages additional insight, and well as ensuring that subsequent research builds on past endeavours.

Patton (1990) and Miles and Huberman (1994) provide another classification of qualitative research approaches based on what is the purpose of the study. These are show in Table 3.3.

Table 3.3: Classification based on the purpose of the study (Source: Patton (1990) and Miles and Huberman (1994))

Ethnography	deals with the culture of a group of people
Phenomenology	deals with what is the structure and essence of experience of this phenomenon for these people
Heuristics	deals with what is my experience of this phenomenon and the essential experience of, to others who also experience this phenomenon intensely
Ethnomethodology	deals with how people make sense of their everyday activities so as to behave in socially acceptable ways
Symbolic Interactionism	deals with what common set of symbols and understandings have emerged to give meaning to people's interactions.
Ecological psychology	deals with how do individuals attempt to accomplish their goals through specific behaviours in specific environments
Systems theory	deals with how and why does this system function as a whole?
Chaos theory	deals with what is the underlying order, if any, of disorderly phenomenon
Hermeneutics	deals with what are conditions under which a human act took place or a product was produced that makes it possible to interpret its meaning.

It is possible to combine the research approaches mentioned in Table 3.2 and Table 3.3. For example, it is possible to conduct a case study approach to study the culture of some group of people or culture of the organisation which is referred to as 'ethnography'. The grounded theory approach can be combined with 'Ethnomethodology' to form a theory that would explain how people make sense of their everyday activities so as to behave in socially acceptable ways.

3.4 Culture of the Construction Industry and Culture of the Research

Construction research witnessed a heated debate about a decade ago covered by Construction Management and Economics Journal in 1995 and Journal of Construction Procurement in 1997. This started with a landmark paper by Seymour and Rook titled as 'Culture of the Industry and Culture of the Research' in 1995.

Seymour and Rooke (1995) argue that the rationalist approach is dominant in the industry and a lot of research in this normative paradigm has been conducted but noticeable improvement has not been felt yet. Seymour and Rooke (1995) also attribute this to the culture of the industry consisting of various participants collaborating in different capacities to overcome the fragmented nature of the industry. This leads them to explore and understand human related factors involved in better collaboration and improvement of the project delivery process and to also develop an understanding of various phenomena (such as when some things that are expected to work do not). Quantitative research offers procedures and mechanisms in the form of models, tools and techniques to improve predictability and analytical process improvement but why any construction project procedure is not applicable or not able to produce promised benefits can only be explored by 'understanding' the phenomenon following an 'interpretative approach'. Seymour and Rooke (1995) state that ''If the researchers have to play a role in changing the culture of industry, then the culture of research must change also". Ofori (1993) endorses this idea by arguing that key research approach changes are necessary for bridging the gap between research and practice.

Harriss (1998) counter argues that adopting the interpretative paradigm approach may involve rejecting theory and generalization. However, one can argue that the nature of the construction industry (with huge variability and diversity) doesn't demand generalisation and a *'one size fits all'* approach. This suggests that there is a need to seek different explanations for each individual organisation depending on its position in the supply chain and role in the industry. Perhaps a good approach is to aim for generating best practice as it emerges out of 'best in class' organisations and leave other organisations in the industry to follow this practice after modifying it according to their own circumstances.

From the research point of view, Wing *et al.*(1998) provide a balanced argument by stating that whatever choice of approach is adopted, it is important that the problem and associated key concepts are clearly defined and that the methods used, underlying assumptions and limitations are transparent and defensible. This points out to the fact that the problem should be appropriately identified to select the corresponding paradigm for its solution.

3.5 Selecting the Interpretive Paradigm for this study

The discussion and research direction provided by Seymour and Rooke (1995) becomes the principal basis for this research. The objectives of the study are consistent with the approaches expressed in Table 3.2 & 3.3 and position this research firmly in the Interpretive Paradigm. This research has not aimed for generalization at this point in time, as ICT innovation and KM initiative is not being under taken industry-wide. Instead of embarking upon the quantitative investigations of factors (or success factors) and determinants for the whole industry through a quantitative analysis (using predominantly survey techniques), it is considered more prudent to focus on the best-in-class organisations (obviously less in number) that are undertaking these initiatives and carry out in-depth exploration with an aim of generating best practice for other organisations in the construction industry to follow.

The problem of low response rate in returning questionnaires (a popular means of conducting quantitative research) in the construction industry is becoming of real concern to construction researchers. Liu and Fellows (2003) note that most postal questionnaires yield a low response rate of 25-35% and with this rate it is not always possible to test hypotheses statistically or provide conclusive results. This deficiency in quantitative research also reduces enthusiasm in carrying out research with positivistic undertones and reinforces the decision of undertaking an interpretative research approach.

Creswell (1994) identifies a qualitative approach to research as the most appropriate when the objective of the research is to develop new theory, technique or process. The aim of the research reported upon in this PhD study is to investigate the role of KM in enhancing learning and innovation. This research objective makes this research predominantly 'demonstrative', where demonstrating that KM produces learning and innovation is the primary objective. Action research then becomes the most appropriate choice in this scenario. The first step in this study is to map the present circumstances of the organisation. Grounded theory provides an efficient means of generating theory (grounded in data) eliciting the present situation as it occurs 'out there' in reality. For this reason grounded theory becomes the natural choice as a means of carrying out the research. As a next step, a stimulus (or intervention) needs to be employed in line with the action research philosophy to improve the present situations. This research has made the case that a KM initiative or tool, if effectively employed can act as such a stimulus and would cause this improvement. The Soft Systems Methodology (SSM) is chosen for this purpose as it exhibits all the qualities and

characteristics that one may expect from a KM tool as detailed later in this section. SSM encompasses a dual nature, it facilitates a KM activity as perceived, plus it carries out a research process to satisfy the research thesis by acting as meta-action research technique.

Another factor providing impetus to selecting grounded theory approach and SSM is that both of these have a history of successful and meaningful use of more than 30 years in other fields of research even though construction industry researchers have rarely explored this approach. These research methods, however, specifically suit the purpose of this research and their employment also contributes towards body of knowledge related to their use and significance in the construction context. The next section provides a basic understanding of grounded theory and SSM.

3.6 Understanding Grounded Theory

The grounded theory approach was first presented by two sociologists, Barney G. Glaser and Anslem L. Strauss in 1967 when they were researching in the field of 'nursing' (Glaser and Strauss 1967). Later on, the founders of this approach worked independently to form two different approaches which are termed as the Straussian Approach and the Glaserian Approach (Hunter *et al.* 2005). The Glaserian approach is detailed in Glaser and Strauss (1967), Glaser (1978) and Glaser (1992) where as the Straussian approach can be found in Strauss (1987) and, Strauss and Corbin (1990). Both approaches advocate that theory derived should be grounded in data. Instead of trying to deliberately finding out something, the theory should just emerge by itself from the data.

The debate over various differences among these approaches has become a part of the literature. It is therefore necessary for any one aiming to use grounded theory to first understand the two approaches and then clearly state what approach they want to adopt. Differences lie in the process of theory generation with different emphasis on induction, deduction and verification, the form the theory should take, and use of the literature (Heath and Cowley 2004; Hunter *et al.* 2005). Glaser (1992) is cited by Heath and Cowley (2004) as considering Straussian approach as being no longer grounded theory but 'full conceptual description'.

Heath and Cowley (2004) illustrate the differences between two approaches in Figure 3.3 & 3.4. Induction is a key process in Glaserian Approach, with a researcher moving from the data

to empirical generalisation and on to theory. Glaser considers deduction and verification as the servants of the emergence (Glaser and Strauss 1967). However, the Straussian Approach claims that in the original development of grounded theory, inductive aspects were overplayed (Strauss and Corbin 1990) and deduction and verifications must be made before a new data set is considered. Glaser (1992) has criticised the Straussian approach because the deductive emphasises asking various questions and speculations about what might be rather than what exists in the data (Heath and Cowley 2004). Another difference is that Glaser has argued against hypothesising while Straussian approach considers it acceptable to form the hypothesis before the start of the research. This leads to the debate on position of the 'literature' in the grounded theory. Glaser and Strauss both acknowledged that the researcher cannot enter the field free from ideas but differs considerably the role they see for the literature (Heath and Cowley 2004).

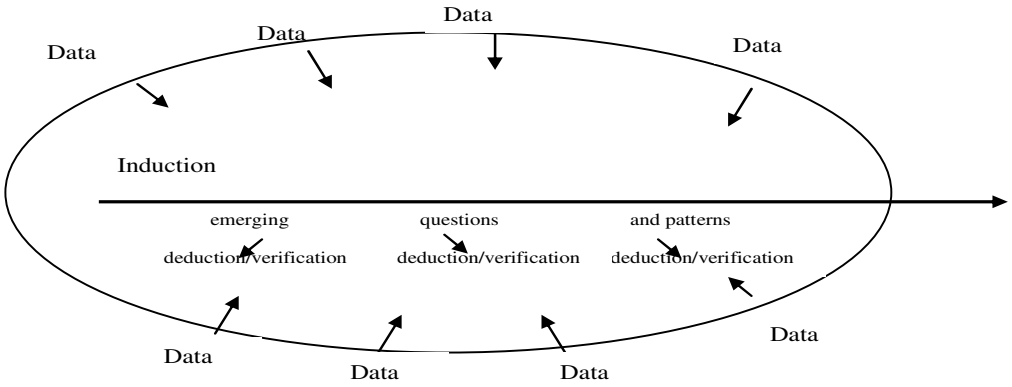


Figure 3.3: Glaser (1978, 1992) place of induction, deduction and verification in grounded theory analysis (Source: Heath and Cowley (2004))

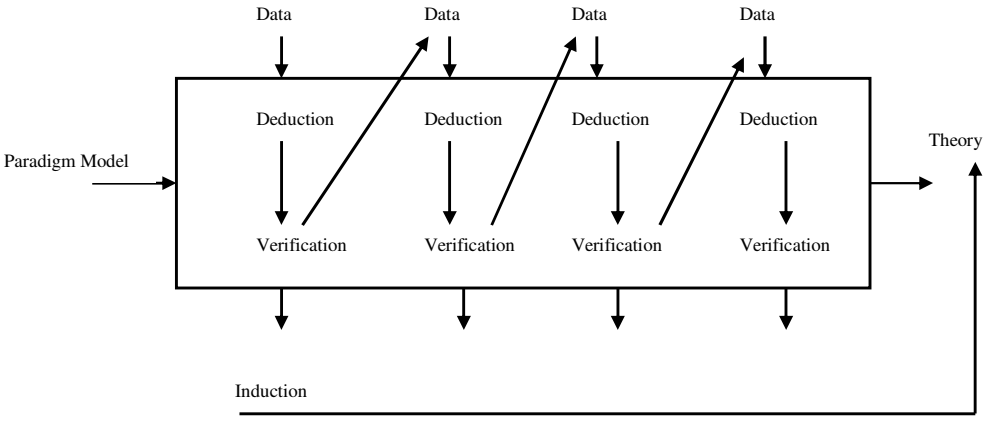


Figure 3.4: Strauss (1987), Strauss and Corbin (1990) place of induction, deduction and verification in grounded theory analysis.

Glaser (1978) and Locke (2001) argue that a researcher should approach the research problem with minimal or almost no prior models or constructs in mind. The literature should be considered and incorporated only when it becomes relevant to the course of the research as it unfolds. If there is a prior understanding, it should only be based on the general problem area. More focussed reading should be done when theory is sufficiently developed (Heath and Cowley 2004). At that stage the literature can also be used as additional data (Dick 2005). Glaser's belief is to use the literature to gain an overall picture of the research problem and to subsequently confirm any developed theory (Hunter *et al.* 2005). Strauss (1987) strikes a different note by mentioning that both past experiences and understandings may be used to stimulate theoretical sensitively and generate hypotheses and a research question can be established to identify the phenomenon to be studied and what is known about the subject (Heath and Cowley 2004; Hunter *et al.* 2005).

Locke (2001) notes that grounded theory has undergone adaptations, one being to approach the problem with existing theory in mind to narrow and direct the analysis. This adaptation occurs because researchers using a grounded theory methodology encountered an enormous amount of data that was very hard to sift through and make any sense of without due reference to the literature. Locke (2001) quoted the research of Harris and Sutton (1986) and Eisenhardt and Bourgeois (1988) who started their research activity with several different constructs in minds that emerged from the literature. Martin and Turner (1986) also indicated that "Preconceptions" cannot be totally abandoned, and they stressed the need to approach the data with a fair mind rather than locked into data in already established categories.

The distinctive differences between the two approaches present an extremely intellectual challenge for the researcher while selecting a research approach. Hunter et al, (2005) while acknowledging this complexity state that grounded theory is very diverse in its application and can be modified and applied to suit the nature of the research problem and the particular style of the investigator. On a similar note, Heath and Cowley (2004) quote Glaser (1998) who suggests that researchers should stop talking about grounded theory and get on doing with it. Qualitative analysis is a cognitive process and each individual has a different cognitive style and this in turn profoundly effects how the research is carried out (Heath and Cowley 2004).

3.6.1 Selecting Grounded Theory Approach for This Research

The doctoral research program reported upon in this thesis emanated from a research project with varying objectives. The researcher entered the project stage with his aim of carrying out a doctoral study while data collection was already proceeding on a related research project (CRC CI funded research project on improving KM and ICT diffusion). Having been familiar with the CRC CI project's area of research and with the basic objectives of that research in mind, this researcher embarked on a data collection procedure that linked into that CRC CI research project. In this way, this PhD research project's data collection stage was synchronised with the CRC CI research project to deliver synergy between the two research projects. At the first phase of the doctoral research, the aim was to understand the present circumstances regarding the use of an innovation (i.e. ICT) in two partner organizations that are leading best- in-class Australian Construction Contractors companies. The second aim was to demonstrate the use of KM in establishing a path from a present position to an improved position. Hence, the Glaserian approach became the preferred choice for this research for the first phase of the research as this approach advocates minimum reading of the literature. The researcher then read the literature only as theory emerged and the literature was helpful in making sense of what was being observed to generate theory.

Two key literature resources Locke (2001) and Dick (2005) were used to guide the adopted research approach along with the original monograph of Glaser and Strauss (1967). Locke (2001) summarises the main steps involved in grounded theory as follows:

1. Comparing incidents applicable to each category
2. Integrating categories and their properties
3. Delimiting the theory
4. Writing the Theory

In Step 1, the aim of the researcher is to assign a common meaning to multiple data observations. Data incidents that have been collected from observations, interviews and/or archival material for this purpose, are analysed and categorised with a view to understanding a particular substantiative problem. Naming, Comparing and Memoing are research activities that take place in this step. Through Naming researchers attempt to conceptualize and develop abstract meaning from the observations or incidents in their data sets. Comparing, as Locke (2001) observes, occurs in 'tandem' with naming and aids the act of creating conceptual

categories in two ways; firstly by helping to develop a common name of category for multiple observations or incidents in the data set and secondly by supporting the act of naming conceptual categories by helping researchers to sharpen and clarify what is in the data. Memoing is an act of writing field notes on an idea that has come in the mind of the researcher while he is engaged in the process of data collection. This helps researcher efforts to name what is expressed in the data incidents, helping to articulate and draft conceptual categories.

In Step 2, that Locke (2001) considers a second form of analytic activity; the researcher shifts attention and aims to fully develop and provide an organisation framework for the drafted conceptual categories. This is done in order to arrange the categories so that they begin to add up to a conceptual 'whole' and be turned into a complete picture so that a theoretical framework emerges. Various earlier forms of conceptual elements are compared in order to clarify the relationships between the categories and their properties.

Step 3 involves 'delimiting the theory' and entails bringing the analysis elements together with the aim to settle on the theoretical component frameworks and to clarify the story that this framework is telling about the phenomenon or social situation under study. The 'Theoretical Saturation' is achieved in this step when a state occurs where any subsequent data incidents do not provide any significant new information to inform the emerging theory.

Step 4 is aimed at writing a theory by collating all the categories that have been formed with the conceptual framework (or model) to explain and facilitate readers' understanding of the studied phenomenon.

Dick (1995) described a very useful framework, as illustrated in Figure 3.5, for gathering the data while conducting the grounded theory mode of research that was adopted for data collection in this PhD research.

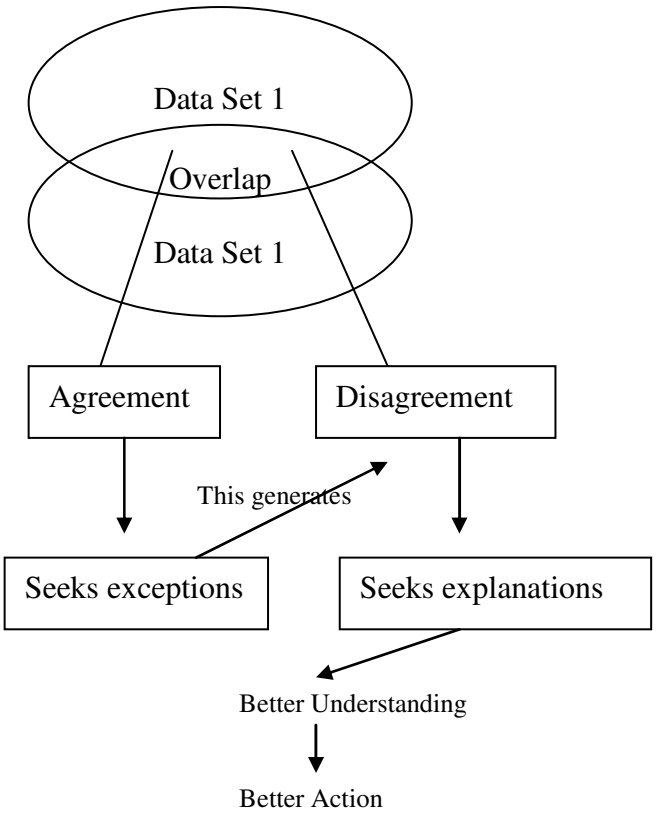


Figure 3.5: Underpinning framework of Grounded theory used in this research (Adapted from: Dick (2005))

3.7 Understanding Soft Systems Methodology (SSM)

Action Research is considered as being research carried out with a view to improve a certain situation or process by a team of professional action researchers and the members of organisation or community seeking that improvement (Greenwood and Levin 1998). Action research is building/testing theory within the context of solving an immediate practical problem in a real setting. It thus combines theory and practice, researchers and practitioners, and intervention and reflection. Collaboration with practitioners and their learning is vital. Both, the researcher and the practitioner emerge with enhanced learning.

It is possible to conduct action research from a systems perspective—considering a situation or process as a system that provides some form of transformation. By taking this perspective it becomes possible to incorporate all possible influencing variables and conditions that may have an effect in one way or other on the situation under study.

The traditional systems approach to problem solving is generally based on a reductionism technique in which problems are solved through fragmentation—one stage at a time. This technique is appropriate in complex and highly structured situations that can be well defined, particularly in terms of inputs and outputs. However, complex and poorly defined systems often conceal interesting hidden sub-text issues that are difficult to readily unearth. Understanding these contextual issues requires a pathway by which a joint exercise of sensemaking is embarked upon to fully understand the situation, environment and dynamics. The term 'wicked problems' is generally used to describe complex and poorly structured systems. The concept of wicked problems originated in the work of Rittel and Webber (1984) that examined societal problems that planners face. Becker (2002) defines problems as being wicked in the sense that they are very difficult to solve. Wicked problems typically have a dense web of inter-related factors, making it very difficult to understand how one decision will impact decisions in other areas. This class of problem often exists in dynamic and uncertain environments that generate significant risk. Furthermore, Becker (2002) observes that conflict arises from wicked problems where there are competing claims, especially where 'good outcomes' are traded off against 'bad outcomes' within the same value system. Figure 3.6 provides an overview of the nature of wicked problems.

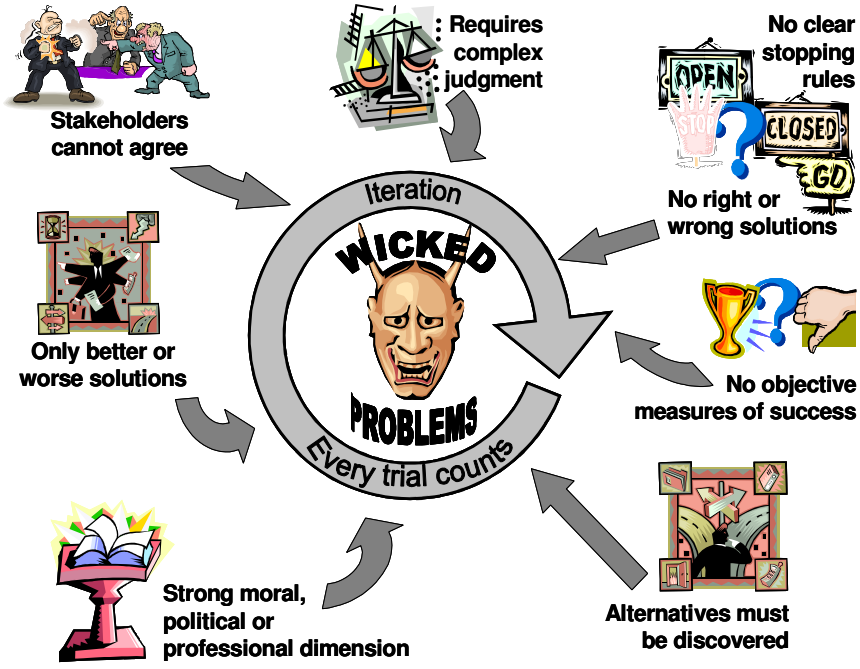


Figure 3.6: The Nature of Wicked Problems

(Adapted from Rittel and Webber (1984) and Maqsood et al. (2003b))

Wicked problems can take many forms and exist in a wide variety of settings. Gustafsson (2002) describes the design and management of the physical setting for organisational change as a complex process that is a wicked problem. Similarly, Savage *et al.* (1991) give as an

example the challenge of establishing a socially responsible and effective organisation within a turbulent global economy. Lang (2001b) states that knowledge work deals with wicked problems, especially where the 'problem space' is continually changing and complex judgments are required. Other wicked problems are the typical challenges commonly faced in software design, government and social policy formulation, and strategic planning in organisations (Buckingham Shum 1997). Furthermore, the presence of multiple stakeholders complicates situations and exacerbates the wicked problems. The response to wicked problems, suggested by Gustafsson (2002) is to adopt a holist open systems approach that recognises that all the parts are inter-related and can affect each other. Lang (2001a) recommends that wicked problems should be addressed through a process of discussion, debate and deliberation among team members, leading to compromise and the reconciliation of different viewpoints and perspectives. Bryson *et al.* (2002) recommend that stakeholder analysis is particularly useful for turning wicked problems into problems that can be solved, and are worth considering.

Barry and Fourie McIntosh (2001) recommend that Soft Systems Methodology (SSM), which incorporates systems thinking and systems concepts, is an approach that provides the opportunity for incremental improvement that is needed to address wicked problems. In particular, SSM offers a framework to involve all the stakeholders in a continual learning cycle. It offers an empirically based theoretical foundation for thinking about, analysing, and responding to wicked problems.

Soft systems thinking seeks to explore the 'wicked' and 'messy' problematic situations that arise in human activity. However, rather than reducing the complexity of the 'mess' so that it can be modelled mathematically (hard systems), soft systems strive to learn from different perceptions that exist in the minds of different people involved in the situation (Andrews 2000). This interpretive approach is strongly influenced by Vickers' (1968 ,p59,176) description of the importance of appreciative systems in dealing with human complexity. Checkland (1999) and Checkland and Scholes (1990) have attempted to transform these ideas from systems theory into a practical methodology that is called Soft Systems Methodology (SSM). Checkland's premise is that systems analysts need to apply their craft to problems of complexity that are not well defined, and that SSM attempts to understand the wicked and fuzzy world of complex organisations. This is achieved with the core paradigm of learning (Checkland 1999, p258).

Soft Systems Methodology (SSM) may be used to analyse any problem or situation, but it is most appropriate where the problem "cannot be formulated as a search for an efficient means of achieving a defined end; a problem in which ends, goals, purposes are themselves problematic" (Checkland 1999, p316) Soft Systems Methodology, in its idealised form, is described as a logical sequence of seven steps (Checkland 1999 ,p162-183). These are illustrated in Figure 3.7.

It is most important to note that the sequence is not imposed upon the practitioner; a study can commence at any stage, with iteration and backtracking as essential components. SSM encourages investigators to view organisations from a cultural perspective. Therefore the component parts that are human beings determine the essential characteristics of organisations. These "people-components" can attribute meaning to their situation and define their own purpose for the organisation.

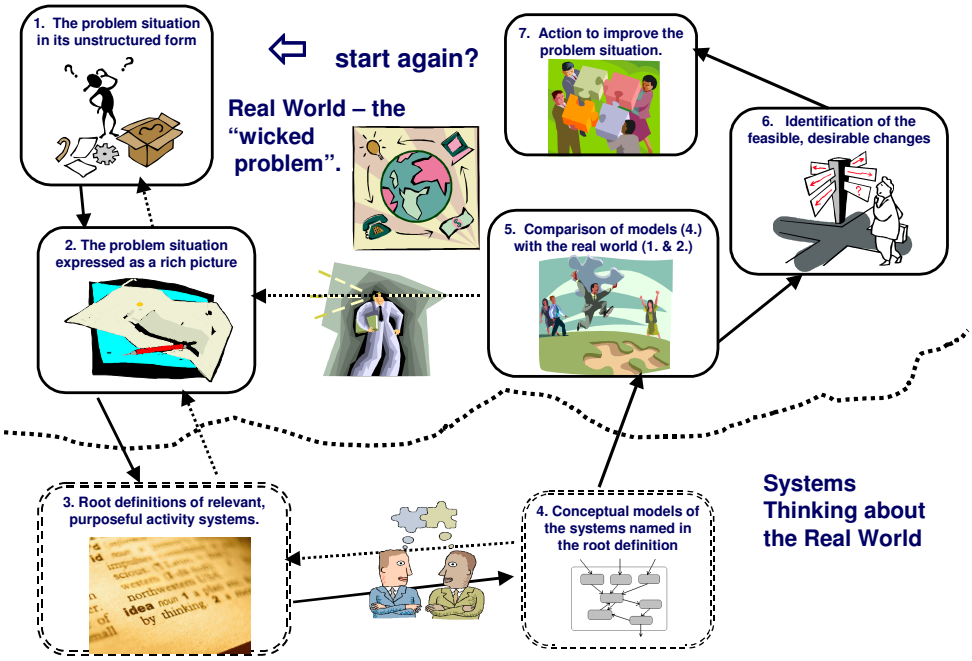


Figure 3.7: Summary of SSM as a seven-stage process
(Adapted from Checkland (1999, p163) and Checkland & Scholes (1990, p28))

In Stage 1 the situation or problem is identified in an unstructured form as a problematic situation. In Stage 2 the problem is expressed where knowledge must be unearthed. In SSM the usual techniques used to interview as many participants in the situation as is practicable who can explicate their tacit knowledge about the situation. This is made explicit through rich pictures. These are interesting and at first sight deceivingly child-like because of their

interpretation of a situation. This format however, conceals a sophisticated attempt to inclusively garner impressions and interpretations of experiences, feelings, and manifestations of driving and inhibiting forces that create the situation dynamic. These are the illustration of stories that help in the sensemaking process (Weick 1995).

Rich picture represents a connective human communication channel that expresses the situation through an elicitation process from interviews and possible surveys where respondents are encouraged to express their unease in graphic means. The idea is to unearth sub-textual information and knowledge rather than to stick to factual or 'hard' data because those interviewed generally have valid tacit knowledge to offer that is difficult to explicate in more conventional means. The underlying simplicity and human connection provides a powerful voice in explaining the situation.

Stage 3 comprises the interpretation of the rich picture into a root definition to take the rich picture and offer a more systemic and formulaic summary. A Root Definition is tested in Stage 4 against a group of elements known by the mnemonic CATWOE that defines a checklist for:

- **C**ustomer (beneficiary or victims of the situation),
- **A**ctors (those directly affecting the situation),
- **T**ransformation process (what is happening in terms of inputs being transformed into outcomes in this situation),
- **W**eltanschauung (worldview of participants – the underlying narrative that addresses the question "why bother with this situation of endeavour?"),
- **O**wner (the entity most affected by the particular situation), and
- **E**nvironment (what lies outside the situation).

The Root Definition is the chosen system expressed in statements, which incorporate the points of view that make the activities and performance of the systems meaningful, so the CATWOE provides the analyst with a framework for ensuring that all points of view and interest are considered in the knowledge elicitation process. It should be a concise description of a human activity system that captures a particular view of it as a transformation process
Stage 4 involves developing an account of what must be done to achieve the transformation described in the Root Definition. This is generally illustrated as an activity model and uses whatever techniques may be available. 'Hard' system tools may include flow charts, simulations, animation, and statistical or mathematical models. Stage 5 can reveal many

interesting questions to be addressed, assumptions to be re-visited and dysfunctional behaviours/actions to be remedied by comparing what is perceived to be the way things happen including subtext and the full picture with the conceptual model. This stage provides the reality check for Stage 4 and challenges owners of the situation, to rethink and re-analyse underlying assumptions to reach a more creative and fulfilling outcome.

Stage 6 involves formulating specific recommendations and implementation plans. This may trigger organisational structural changes, procedures changes and/or organisational culture change. Action is taken in Stage 7 to make changes and/or restart the process using feedback loops to test and monitor changes. SSM is both a reflective learning process and an action learning approach to problem resolution (Schön 1983; Argyris and Schön 1996).

Studies in knowledge elicitation have focussed upon the need to use systemic and psychological foundations to develop models of human knowledge representation, acquisition and processing (Gaines and Shaw 1984, 1985; Shaw 1985; Shaw and Gaines 1986; 1999) . This research supports the argument offered by Checkland (1999) that the standard formal logic of the accepted reductionist or mathematical systems theory may be inappropriate for knowledge elicitation, and that SSM provides a more suitable theoretical framework. While builders of expert systems in the late 1980s and early 1990s generally adopted prototyping as the preferred model of system development, there was strong evidence of limited success in adopting this approach because human factors and poorly defined complexity issues confounded acceptable definition of how knowledge experts actually address problems (Stowell and West 1989).

The principal failing of previous attempts to capture knowledge in expert systems (an early manifestation of the study of KM) was the appreciation of context, the validity of a wide range of perspectives of the described situation and the whole concept of reality as independent truth. SSM addresses these problems through its inherent acceptance of multiple realities experiences by different people with different worldviews and experiences that have formed the lens in which they perceive any given situation. SSM is claimed to be a more holistic and valid approach to viewing problematic situations that need addressing because it has the potential to unearth causal issues through its rigorous pursuit of a range of views of the situation.

3.7.1 Use of SSM in the Construction Industry

Industries with entrenched traditional structures, including the building, construction and engineering industries, are under particular pressure to review their working practices. In this context, Elliman and Orange (2000) recommend SSM as an approach to facilitate effective change and to improve work practice. In particular, SSM is able to stimulate debate and capture the vision for the future of participants. They observe that a soft systems approach allows the exploitation of individual and socially constructed group knowledge and experience. Green (1999) also identifies wicked problems in the building and construction industries and suggests that the potential of SSM lies in the early stages of a project to assist stakeholders to achieve a common understanding of the problem situation. Cushman *et al.* (2002, p3) observe that "Construction is ultimately a very complex, multi-disciplinary activity and there is a need to integrate the kind of design and management processes in terms of skill and the knowledge that people bring." To achieve this, Cushman *et al.* (2002) have used SSM's rich pictures and root definitions to identify responsible actors, key transformations, and the knowledge resources that are appropriate to the needs of a construction company. Venters *et al.* (2002) further describes how SSM can be used to develop conceptual models that identify patterns in knowledge activities. Such patterns can be used to provide a basis for technical design and organisational and social intervention. SSM has been also usefully employed in conducting value analysis exercises in the construction industry (Green 1996).

3.8 Research Design

The research was divided into two phases in line with the objectives of the study (see section 1.3) as shown in Figure 3.8. The first phase strove to understand the present circumstances of the organisations in which they attempted to adopt and diffuse an innovation such as ICT (specific knowledge chosen as an example in this research) and made use of knowledge that is available within its boundaries or elsewhere. A grounded theory method of research was used in this phase to elicit the theory and build a construct. This phase of the research is discussed in detail in Chapter 4. An improvement in the scenario obtained through the construct was the next objective of the research and hence Phase 2 of the research addressed this aspect and is described in Chapter 5. In this phase SSM, was used as a KM tool for improving a process recommended by the case study organisation which considered this process as complex and extremely important. This allowed a particularly challenging process to be studied to propose useful and vital improvements. The next step was to integrate and collate all the findings to produce discussion and hence conclusion.

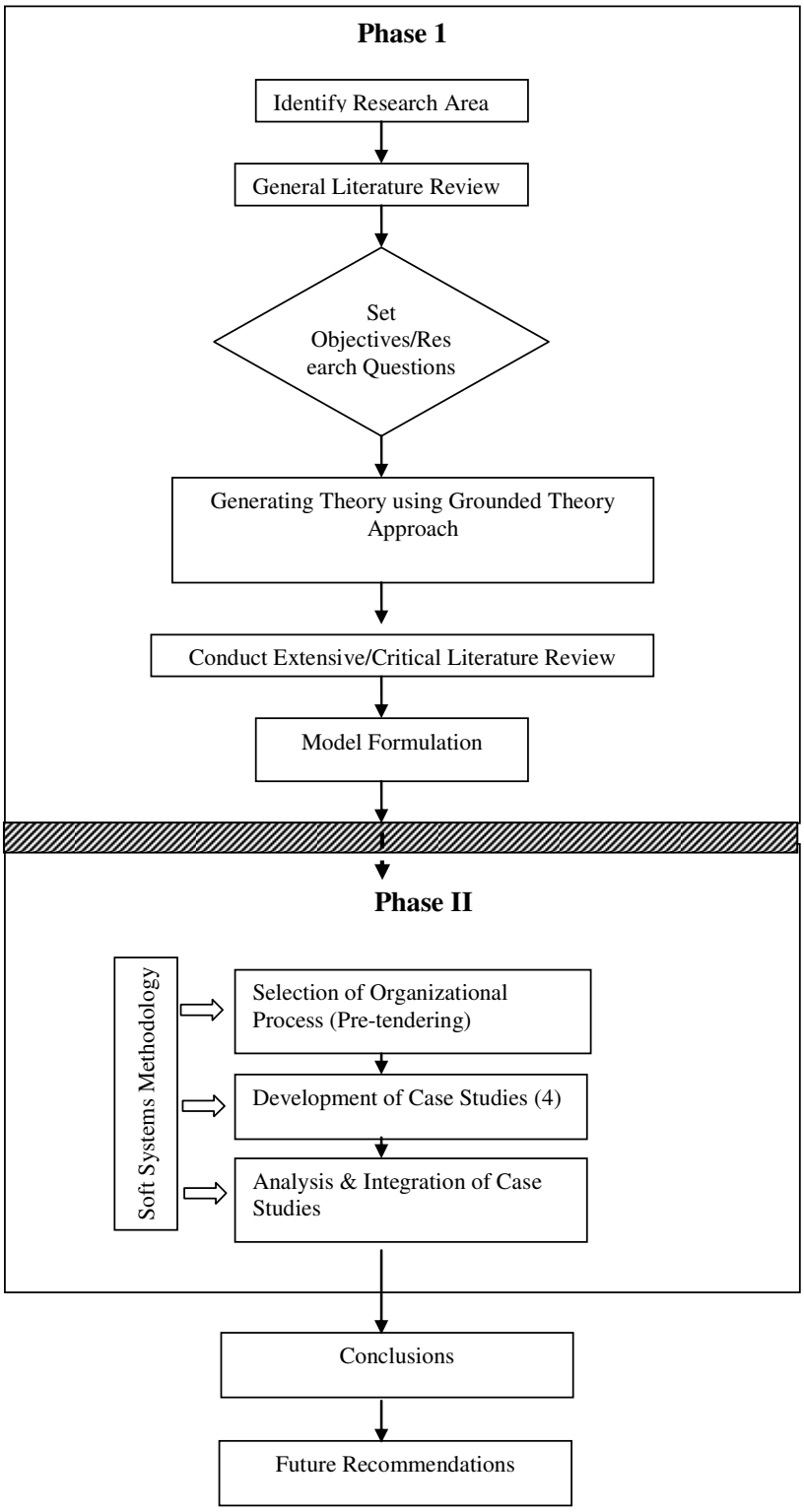


Figure 3.8: Research methodology adopted for this research

3.9 Research Participants

Research Participants are classified on the basis of the Phases. While using grounded theory in Phase 1, the aim is to achieve the state of theoretical saturation after which no further data adds any important information. It was ascertained by interviewing sixteen personnel from the two leading Australian Construction Organisations (eight each). This study was carried out from October 2002 to May 2003. As this doctoral study forms part of the research project, most of the interviews in this phase was conducted by a team of three researchers, where one took the notes and other two engaged the participants in the interview. Table 3.4 explains the number of participants involved in each phase, their roles in the organisation and the number of the interviews done.

Table 3.4: Number of the participants and their role along with the number of the interviews conducted in Phase 1 (Grounded Theory)

No. of Organisations Involved	**No. of Participants**	**No of Interviews Conducted**	**Participants and their role in the Organisation**
2	16 (8 from each organisation)	16	Senior managers (4) Project Managers (4) Site Engineers (4) Foremen (4)

In Phase 2, only one organisation was selected in order to demonstrate the use of SSM as a KM tool on a specific chosen business process of the organisation. Eight participants were involved in this phase and were interviewed several times depending upon the iterations of the SSM. Details on these iterations are presented in chapter 5. This part of the study was carried out from August 2003 to July 2005. In this phase a team of two researchers, one with extensive experience in applying SSM, conducted interviews. Again, one researcher took notes and the other engaged the participants in the interview. The number of participants involved in each phase, their roles in the organisation and the number of the interviews done are illustrated in Table 3.5

Table 3.5: Number of the participants and their role along with the number of the interviews conducted in Phase 2 (SSM)

SSM Iteration	No. of Participants	No of Interviews Conducted	Mode of Interview	Participants and their role in the Organisation
1	6	6	Face to Face	Business Manager, Estimating Manager, Engineering Manager, Design Managers (3)
2	3	1	Focus Group	Business Manager, Engineering Manager, Design Manager
3	3	3	Face to Face	Engineering Manager, Design Manager (2)
4	4	4	Face to Face	Estimating Manager, Operations Manager, Engineering Manager,
5	2	2	Face to Face	Design Managers (2)

**** Only one organisation was involved in Phase 2***

In Phase 2, the Knowledge Manager of the organisation was extensively involved in each and every cycle of the research. This is because the Knowledge Manager was carrying out a very prominent role in the execution of this research as a key industry representative in the CRC in Construction Innovation (as explained in Chapter 1) and was also acting as the facilitator and advisor for this research and research candidate.

3.10 Summary

This chapter has highlighted the research method and design that is employed in conducting this research. It begins with describing the basic philosophy of research that is in terms of 'ontology' and 'epistemology' and a critical examination of assumptions of what is valid and what is the scope of that validity.

Positivism and Social Constructivism which are the two competing research paradigms are discussed followed by a discussion on the research approaches and strategies in these two paradigms. It is argued, supported by the work of (Seymour and Rooke 1995), that using positivistic undertones to undertake construction research has not resulted in many noticeable benefits for the construction industry or its culture. Therefore, it is important to test and try alternative research paradigms provided that it meets the study's objectives.

The predominant nature and main objective of the research undertaken in this PhD study is demonstrative through highlighting the role of KM in producing innovation and learning. This research objective sits comfortably within a Social Constructivism Paradigm and hence is adopted for the present research. The most suitable research approaches from within this paradigm are found to be the Grounded theory methodology and SSM. The use of these approaches then divides the research in two different phases. Phase 1 entails the use of the grounded theory methodology to map the present circumstances of the two organisations when they adopt and diffuse ICT innovation and deal with both internal and external knowledge. Phase 2 seeks improvement in the situation modelled in Phase 1 through the use of SSM. Only one organisation is selected for this demonstrative purpose. The detail employment of the grounded theory methodology is presented in chapter 4 whereas the utilisation of SSM is discussed further in chapter 5.

Finally, this chapter justifies the selection and rationale of the appropriate research paradigm for the study.

Chapter 4
Use of Grounded Theory

This chapter presents the details on the use of grounded theory in the Phase 1 of the research that involved two best-in-class Australian Construction Contractor Organisations. It begins with the overview of these organisations and what sort of ICT they employ. It then explains the selection of the research participants and phenomenon that is studied using grounded theory. After this, the next section highlights the nature of interview questions that were used for probing purpose to instigate the discussion.

The next section deals with the actual conduct of the grounded theory process. It describes, through using an example, how interviews were coded into the various categories that formed collectively a grounded theory of ICT innovation adoption and diffusion and the use of the knowledge with in the organisations. The last section visually presents this theory in a form of a model for easy understanding and visualisation of the theory elicited. This model is then extended to include two more stages exhibiting improvement. The perceived transformation from one stage to other is then demonstrated by the use of SSM in the next chapter.

4.1 Grounded Theory Application

It is important to make important decisions about the selection of the organisations and their numbers, nature and number of participants to be interviewed, phenomenon to be studied and questions that are to be used for probing the participants, before actually embarking on the use of grounded theory approach. These are discussed below.

4.1.1. Organisations Selection and their Background

Two best-in-class Australian construction contracting organisations were selected. The qualitative nature of this research permits fewer organisations to be studied where the objective is to develop an understanding of how these leading organisations operate and handle issues so that a best practice process can be drafted. Both of these organisations are collaborating with the CRC CI as industry partners and are devoting resources to help carry out the research with a view of benefiting from the findings.

Overview of the Organisation A

Organisation A has experience in various types of construction projects such as buildings, civil infrastructure and telecommunication projects. The head office is located in Victoria, Australia from where it interacts with several regional offices. This organisation has adopted an electronic document management system as their ICT system. It is basically an Intranet application based on a *Lotus Notes* environment, which has databases and communication modules and the system was implemented over a 5-6 years span. This part of the ICT system features three main modules, a tender pack, a project pack and a project history facility. The purpose of the tender pack is to create tender specification documents with only authorized staff and clients having access to the tender pack. The project pack assists in managing project documents and correspondence during project construction phase. The last module, project history, is aimed to store completed construction information for future use. This ICT system runs on a central database server, in which all the information is created, accessed and stored through each module's user-interface. Users are connected through three different types of connections: local area network (LAN), which is used in the main office; a wide area network (WAN), which is used in regional offices and some construction sites; and a dialup connection for remote construction sites. Staff from all levels (senior level to foremen level) in the organisation are required to use this system for correspondence.

Overview of the Organisation B

Organisation B is a major international construction contractor with a strong global presence and in Australia and is considered as one of the largest construction contractors. It has several business units, which are engaged in various construction related activities such as design engineering, construction and project management. The present research focussed on the regional office based in Victoria, Australia. This organisation has adopted Web-based document management systems as their ICT system. The main objective is to enhance communication and coordination among construction project teams. The company liaises with number of trading partners (client, architects, consultants) to use this ICT system to assist them to work productively with their trading partners by rapidly exchanging information. The ICT system has various modules maintaining data bases such as a to-do list, a calendar, a document control register, multimedia/images, correspondence, RFI, general file transfer and contact details. All the information is stored in a central database server that is then accessed through an Internet connection. For this reason Internet Service Providers (ISPs) play a very

important role in linking users to the ICT system that can then access the World Wide Web (WWW). Workstations are linked to the network through a rental wide area network (WAN) in the main office, whereas on construction sites different types of connections like Asymmetric Digital Subscriber Line (ADSL), Internet service digital network (ISDN) or modem are used to connect the organisation via the ISP. The use of ICT is mandatory and employees from senior level to field level are required to use the system.

4.1.2 Participants Selection

Grounded theory doesn't impose any limit on the number of people to be interviewed in the research process. Rather, it aims to achieve theoretical saturation—a state after which no more data makes any useful contribution. The use of ICT is mandatory in both the organisations at all levels ranging from senior level down to foreman. Hence, the research design involved interviewing people from all levels to generating the theory. The detail of the participants is illustrated in Table 3.4.

4.1.3 Phenomenon Explored in the Study Using the Grounded theory Approach

The main objective of this part of the research is to map out a current scenario in a leading construction organisation that can highlight how a particular innovation is adopted and knowledge related to it is diffused with in the organisation. This exposes the issues involved and the nature of the knowledge link between the organisation and the external world (mainly knowledge sources). ICT as an innovation is selected for the purpose of the study for two main reasons:

1. ICT is a modem technology and is being adopted as an innovation by all industries for improving their work processes.
2. ICT is a KM enabler.

The term ICT refers to the electronic document management system in organisation A which is based on *Lotus Notes* and Web-based document management systems that used HTTP protocol for organisation B.

4.1.4 Pre-conceptualisation Propositions

It was explained in chapter 3, while discussing the grounded theory approach, that pre-conceptualisation cannot totally be abandoned. Following the Glaserian approach, a minimal reading of the literature was conducted to develop an initial basic and broad understanding of

the research area. This provided the researcher with core KM concepts and the role of ICT as a KM enabler. This was found to be of help when the interviews were started and as the process of theory building gained pace. Pre-conceptualisation propositions took the following form:

1. Construction organisations have issues with their ICT adoption and use.
2. The purpose of ICT is to help with communications in their day-to-day processes.
3. Organisations don't have KM initiatives up and running and ICT is not being effectively used as a KM enabler.
4. The culture of the organisation and industry as a whole has some role in restricting the organisation-wide use of ICT.
5. Organisations don't have good interaction with external knowledge sources.

The researcher embarked on the process of developing a theory from data obtained from the organisations based upon the above mentioned raw propositions. These pre-conceptualisations also help the researcher develop the interview questions to be asked for the purpose of initiating and probing discussion points.

4.1.5 Interview Questions

Using grounded theory, a researcher has to initially 'go with the flow'. This means that specific questions are avoided in the initial interviews, instead favouring asking general open-ended questions. The researcher is seeking to understand what is going on there in the organisation, what is the situation, and how is the person managing that situation (Dick, 2005). The purpose is to let the participants speak as much as they can without breaking their momentum. Intervention is only made if they digress too far from the situation they are discussing. An example of the notes taken in the phase 1 of the study is presented in Appendix. In this research, the following questions were asked (in random order depending upon the situation and ongoing discussion) in initial interviews:

1. What is your experience of using ICT?
2. Why ICT is necessary? What is it used for?
3. What are the advantages and disadvantages of using ICT?
4. How the knowledge about ICT is usually shared in the organisation?
5. Apart from ICT, generally how is knowledge usually accessed or shared in the organisation?

As it will be explained later, the first six interviews (out of total sixteen) set the basis for developing emergent categories and the outline of the theory. The rest of the ten interviews then authenticated the categories already emerged and assisted in developed the theory. In the later ten interviews, grounded theory then allowed the use of specific questions so as to strengthen the emerging categories (Dick, 2005). The following questions were additionally asked, when it was deemed feasible, in the later ten interviews.

1. Do you think culture of the organisation has an effect on the adoption of any new innovation or technology like ICT and its use?
2. Do you feel the need for any internal knowledge bank?
3. Do you write down your experiences for your own use?
4. Any advantage of bringing academia and practice closer?
5. Do you think sharing knowledge is a useful endeavour?
6. Do you feel there is knowledge loss/leak is happening in the organisation?

4.1.6 Building Grounded Theory

It was explained in Chapter 3 that carrying out grounded theory entails, as stated by Locke (2001) and Glaser and Strauss (1967), the following:

1. Comparing incidents applicable to each category
2. Integrating categories and their properties
3. Delimiting the theory
4. Writing the Theory

The first step in undertaking grounded theory relies on coding the interview data set, comparing the data sets as they are coded and writing memos. For coding, each sentence recorded in the interview notes is examined and given a representative name for easy understanding and subsequent categorising. After the first interview is coded, the second interview is coded with the first interview in mind (Dick, 2005). Subsequently, the remaining interviews are coded with emerging theory in mind. This is the basic notion of the concept of ‘constant comparison’ highlighted in Glaser and Strauss (1967). Initially a data set is compared against the data set; later data set is compared to the theory. As this research progressed, it was found that the first six interviews set the basis for an emergent theory so the rest of the ten interviews were coded with the theory in mind. Also at this stage, specific

questions were asked to clarify the issues that were helpful in forming the theory. Memos were made throughout the interviews about any theoretical ideas that came in the mind of the researcher and helped develop relationship between the categories. Table 4.1 a and Table 4.1 b provide an example of coded interview with memos written during this interview and this is followed by Table 4.2 that shows the emerging categories as various coded data sets were put together after the first six interviews.

Table 4.1a: An example of a coded interview, participant is a Project Manager with Organisation A

Interview Notes	**Coding**
■ Databases created in lotus Notes	ICT Type
■ Good for having statistics of the project.	Advantage of ICT
■ Help Desk is responsive and good.	Helpdesk Response
■ Developed a Mentoring program but not really kicked off. It didn't work.	Failed Initiative
■ Great tool for communication but doesn't help really in decision-making.	Limitation in ICT
■ He is teaching new guys by himself showing them real use.	Knowledge Sharing
■ Personal contact is important when getting the help, whether coming through help desk or colleague, peer or mentor.	Personal Contact in Help
■ This is just tool, if its not working you should not think that my work is finished or hampered and I cannot do anything.	Feeling about ICT
■ It is hard to make it together so if they can find common place and time to meet, they can share the experience	Nature of the Job/industry
■ It would be good if subcontractor use the same system. No question can be asked about the training and long-term commitment thing.	Same system to be used by all
■ There is general training not specific to work. You get general training and then you figure out what suites your needs.	Training Style
■ Positive feelings are important to use. Systems must be so that it gives u positive feelings so that it	Positive Feelings about

can be used.	the System
▪ His team is the only where supervisor/foreman use this tool and his appreciation is a sort of reward for them.	Reward
▪ When project is finished the knowledge is not captured.	Loss of knowledge
▪ He keeps personal diaries, have an option in lotus notes where he can put the experiences. No point in making the mistake again as done in the past.	Use of Personal Diaries
▪ Have Vision. Young Manager. Wants to know more of leadership stuff.	Learning Desire

Table 4.1 b: Memos regarding the above Interview

Memo 1: A failed initiative in starting a mentoring approach could be because of the culture of the organisation. Even if it is failed he is still taking approach himself by teaching new guys about the ICT system and hence transferring his knowledge of ICT use to them

Memo 2: There is no capturing of knowledge at the end of the project which may indicate that organisational knowledge repositories are not being developed

Memo 3: He believes that there is no point in making the mistake again as it was done in the past so he keeps his personal diaries using an option in the ICT system

Memo 4: The young manager has a lot of energy and enthusiasm for becoming a good project manager by exercising strong leadership and is very willing to know more theory about it which indicates his desire to be in touch with academia or external knowledge source to obtain more knowledge regarding leadership.

Table 4.2: Emerging categories forming a theory from first six interviews

Categories	***Coded Data Sets***
Segregation between People, Process and Technology	Advantages of ICT, Helpdesk Response, Limitations in ICT, Same system to be used by all subcontractors, Feelings about ICT, Training Style, Reward, Reliability of ICT, Functionality of ICT, Double Work with ICT, Lack of Basic IT knowledge, Self motivation,
Culture	Failed Initiative, Knowledge Sharing, Personal Contact in Help, Nature of the Job/industry, Resisting Change, Generation Gap
Link with External Knowledge Sources (Push Vs Pull)	Learning Desire, Use of Internet for searching info/knowledge, Academia for Basic Concepts, Complex Research
External environment	Competition, Industry wide adoption, Productivity
A gap between research and practice	Difference between research and practice, Research implementation in practice
Feedback to external sources of innovation	Participation in Research Projects
Existing Knowledge in the organisation & Internal Knowledge Bank	Using ICT in improving work processes, Work methods, Explicit Knowledge, Knowledge in Heads, Loss of knowledge, Use of Personal Diaries,

Once the categories shown in Table 4.2 are formed the rest of the ten interviews then authenticated these categories. At this stage, along with open-ended questions, specific questions mentioned in the section 4.1.5 were also asked to develop further understanding of the emerging categories and hence forming the theory. This is in accordance with step 3 of the grounded theory procedure 'delimiting the theory'.

4.1.7 The Grounded Theory of ICT Innovation and Knowledge Use

The last step of the grounded theory process is to present the theory. Dick (2005) explains that theory is basically the presentation of the categories and memos in a structured way highlighting a relationship among them in order to produce a coherent argument.

The basic objective of presenting this theory is to study the innovation from a KM point of view in order to understand how and why a certain new knowledge (innovation) is adopted by the organisation and what are the steps taken to diffuse this new knowledge within the organisation. The innovation studied in this research is ICT innovation and the theory below highlights various important issues helpful in understanding the adoption and diffusion of it from KM point of view.

Existing Knowledge in the Organisation & Internal Knowledge Bank

Both organisations have a body of existing knowledge, based on what the role of the organisation is in the whole construction delivery process and the position of these organisations in their supply chain. In this case, the organisations studied were the construction contracting organisations, so most of their knowledge was related to processes, tools and techniques involved in procuring the project, constructing it and then delivering it—using appropriate project management knowledge to fulfill project objectives of cost, time, quality and safety. The ICT innovation is adopted to support the business processes by enhancing the communications among project team participants both within the organisation and outside it. It also acts as the repositories of data and information that can be accessed by the team members promptly to help make decisions efficiently. Overall, the use of ICT is being seen to increase the productivity of the organisation and making it more competitive and sustainable.

Explicit knowledge forms the main part of the internal knowledge bank which contains work methods, policies and procedures and access is available to all the people based on their responsibilities. Most people mentioned that they have their knowledge in their heads, only a few mentioned that they use diaries to write down their own experience to help them in future. Sharing this tacit knowledge is not an issue for some interviewees as they believe when they share their knowledge, they will also get some knowledge back in exchange, however for others, it is the matter of loosing their individual competitive edge. Most knowledge

accumulating from a particular project is tacit and remains restricted to those people involved in that project. No strong efforts are being made to make this tacit knowledge explicit for others to use and share. This causes knowledge loss when an employee leaves the organisation and takes all the knowledge with him/her.

External Environment

The adoption of any innovation is dependent on the external environment, conditions and constraints. Any new innovation is adopted to enable an organisation to remain competitive or sustainable. ICT innovation is also adopted for the same reasons, as indicated by several participants. The time for its adoption is ripe, in both private and public sectors as most industries in Australia are embracing this technology. However, ICT is not being adopted or used primarily as a KM enabler. Many industries are undertaking KM initiatives but the construction industry is still considering its move to employ this philosophy. However, the organisations under study have KM related activities going on in their organisations yet there is still a dearth of understanding of real and clear KM philosophies.

Segregation between People, Process and Technology

Organisational activities were dependent on the interaction of three elements—people, process and technology. People use various processes and technologies to carry out their organisational duties. Among the many processes and technologies used, this research was focused upon newly adopted ICT technology which could serve as a common platform to strengthen the effective delivery of these processes. It was discovered that ICT was not effectively integrated with people for carrying out their routine processes and the data suggested that there appeared to be a high level of segregation existing between people, technology itself and the processes in which it is used. Because of this segregation, each element has its own individual area of influence which means that each part is acting independently of other related parts—that is people doing things manually when ICT could have served them more effectively, or not following/having guidelines and procedures to undertake a process or group of tasks. Participants provided various reasons for this segregation and these are explained as follows:

- Training provided for ICT use is not very effective. Training provided is very general and not specific to any particular management role. People later learn how to use ICT when they practice it through ‘hit and miss’ this, according to one participant, should

never be the case. He advocated the proper training covering both general and specific aspects of introduced ICT applications.

- The Help Desk facility is responsive when it is located in the same building but on construction sites this is often not efficient.
- ICT has limitations for some of the staff and doesn't have enough functionality that gave rise to negative perceptions about the technology resulting in its under-use.
- Some staff (e.g. foremen) lack basic IT skills so if they are not given basic IT training they are unable to full realise the advantages of ICT.
- Reliability of ICT is a big issue. There is a low level of trust in system so people have to duplicate ('*double dipping'*) their efforts, which means they use ICT to send the communication but later on, also fax the document to ensure its safe and confirmed delivery. This has increased the workload of the staff.
- For some staff such as foreman, filling information first on paper and then transforming it in electronic format using ICT doesn't make any sense as it has increased their workload, so their tendency is to just do the paperwork and leave out the ICT use.
- People are not self motivated to keep using the ICT. The motivation level has dropped after ICT is not able to come up to the expectations.

Culture of the Organisations

The culture of the organisation is reported to affect in a way that it restricts the flow of innovative knowledge from the external world to within the organisation (Peansupap, 2004). The same is the case with the adoption of ICT and its diffusion. Among the factors mentioned that cause non-use of ICT, the culture of the organisation also has a very important role in causing the non-use of ICT. Resistance to change appears to be the biggest factor influencing this. Some participants mentioned that they didn't grow up with the computers so it is very hard for them to start adopting the use of ICT. There is no leadership and reward strategy to resolve this problem. Many participants blame the nature of their tough job (lengthy work hours) and nature of the industry as a whole, that bar them from spending time in learning new technology. It is this cultural barrier that the academic world has to overcome when trying to push new knowledge into organisations such as these.

Link with External Knowledge Sources (Push Vs Pull)

There is a weak link between both organisations with their external world so that seeking knowledge from outside the organisation was found to be vague. There are no specific mechanisms inside both organisations that would pull the knowledge from outside and bring it inside the organisation. External knowledge potential sources (such as research centers and universities) could push knowledge within the boundaries of the organisations as well as provide a mechanism to transfer knowledge from outside the organisation to within its boundaries and from within the boundaries to the external environment. These organisations seem to realize this fact and have started participating in various research projects with academia through CRC CI initiatives by becoming industry partners and extending all the support and interaction with the CRC CI that may be necessary to carry out the productive research.

A Gap between Research and Practice

Various participants consider research doesn't have any significant immediate implementation. According to them, research mostly produces complex and hard to formalize solutions instead of producing easy succinct solutions. For this reason many participants consider research and practice move in opposite unconnected directions. This indicates a gap that currently exists between research and its actual practice (application).

Feedback to External Sources of Innovation

There remains very weak feedback on organisational practices reported to researchers at universities. This indicates minimal interaction between the industry and researchers 'worlds'. Such feedback is considered an important part of the research process as it provides details of the effect of innovation for further refinement and new developments. This feedback happens only when researchers, while carrying out research, approach practitioners and take their feedback through questionnaires or interviews. There is less tendency on the part of the practitioners themselves to provide feedback to the researchers about the work processes they carry out and improvements that they think are required to produce improved productivity.

4.1.8 The use of Literature

The Glaser's approach is to restrict the detailed reading of the literature until a theory starts to emerge. In this research, a detailed literature review was also carried out once the theory

started to take shape. The review of literature is presented in detail in Chapter 2. While literature supports the elicited theory in all aspects, in grounded theory the position of literature holds the same status as data with no special privilege being accorded to it. Literature is used to add further categories to those that emerge from the data in extending the theory. In this part of the research, it is found that the literature doesn't add any new category and facilitates only increased understandings of existing categories; hence no modification to the theory is required after considering the literature. Table 4.3 presents selected literature (as an example) supporting the emerged categories.

Table 4.3: Literature supporting the emerged categories

Categories	**Supporting Literature**
Segregation between People, Process and Technology	(Davis *et al.* 1989; Murphy *et al.* 1989; Igbaria *et al.* 1996; Newman and Sabherwal 1996; Akins and Griffin 1999; Lederer *et al.* 2000)
Culture	As discussed in section 2.6.2
Link with External Knowledge Sources (Push Vs Pull)	(Cohen and Levinthal 1990; Bresnen and Marshall 2001; Gann 2001; dos Santos *et al.* 2002)
A gap between research and practice	(Cohen and Levinthal 1990; Bresnen and Marshall 2001; Gann 2001; dos Santos *et al.* 2002)
Feedback to external sources of innovation	(Cohen and Levinthal 1990; Bresnen and Marshall 2001; Gann 2001; dos Santos *et al.* 2002)

4.1.9 Achieving the State of Theoretical Saturation in Grounded Theory

In grounded theory, the size of the sample is not decided before the study begins. The process of data collections continues unless no new data emerges (Locke, 2001; Glaser and Strauss, 1967). Morse (1995) notes that there are no published guidelines or tests of adequacy for estimating the sample size required to reach saturation. Morse (1994) produces a 'rule of thumb' recommending approximately thirty to fifty interviews for grounded theory studies. However, Morse (2000) cited in Robson (2002) argues that to reach the saturation state, the

sample size depends on several factors; the scope of the study, the nature of the topic, quality of the data, study design and research technique. Most recently, Guest et *al.* (2006) has carried out an interesting study to determine the number of interviews that would be required to reach a saturation state. Their study involves sixty in-depth interviews with women in two West African countries. During their analysis of data, the authors systematically document the degree of data saturation over the course of thematic analysis. They found that within the first twelve interviews saturation occurred and main themes were present in as early as six interviews.

The phenomenon noted in this doctoral research was no different than Guest et *al.* (2006) study. The categories emerged completely in the first six interviews. The rest of the ten interviews only added to the existing categories and did not contribute to the development of any new category. In fact, the last two interviews basically mirrored what was already known and documented. At this stage, it was felt that saturation state had occurred and author decided to stop the process of data collection. It can be argued that the early occurrence of the saturation state might be because of the nature of the research and phenomenon under study. This research was trying to map the current circumstances in the organisation regarding ICT and Knowledge use. The adoption of ICT technology by the organisations was just recent and riddled with various issues. The perception of the respondents about these issues was not highly variable and this might have led to the emergence of all the categories in relatively shorter number of interviews.

4.1.10 Formulating the Model

The above theory highlighted various categories that are interrelated. This relationship becomes more clear and vivid when presented in graphical form. Figure 4.1 shows the theory in form of model for easy understanding and visualisation.

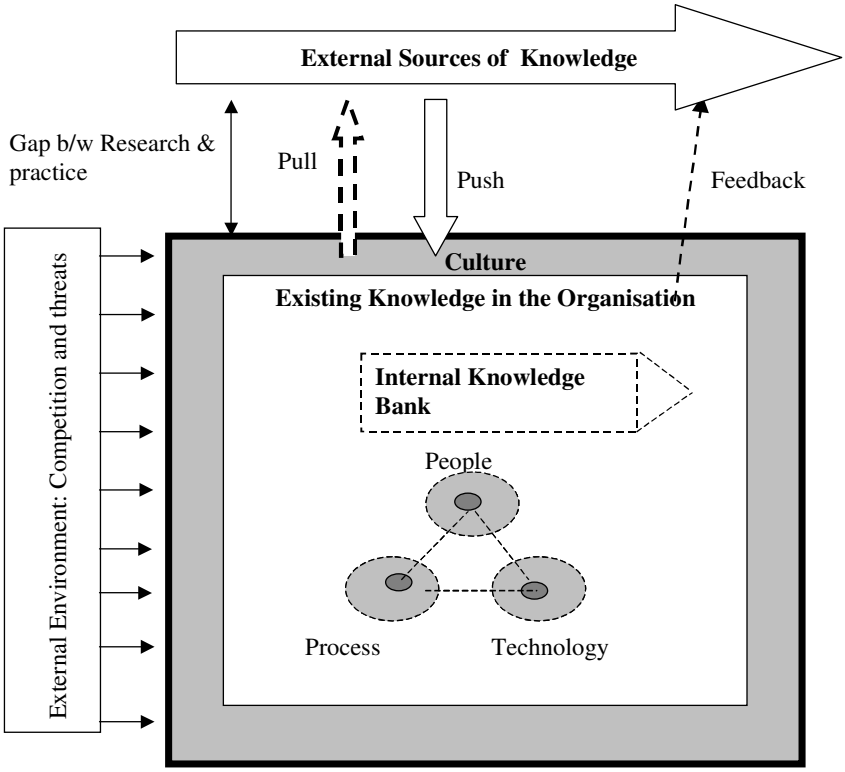


Figure 4.1: Construct developed from the theory

The core category of the theory 'segregation between people, process and technology' is shown dotted, and linked in triangular fashion. Dotted links shows segregation. These three components always exist in the form of a triangle where one is dependent on two others. Small circles around these components represent the 'area of influences', which intends to show for example, people don't follow the proper process and technology to carry out the work, hence they bypass both of these. The triangle of people, process and technology is set in the existing knowledge of the organisation under which it operates and it contains an inadequate internal knowledge bank. Culture is depicted by a thick boundary line indicating the resistance it offers to the flow of knowledge from the external world into the organisation. The interface with external sources of innovations such as the 'academic world' or a research centre is visualised as operating under two forces; push forces depicted by thick arrows and pull forces arising from the organisation by dotted arrows. These show either virtually none, or a weak pull force from the organisation relating to a desire for obtaining knowledge external to it. Weak 'Feedback' from the organisation to the external sources of knowledge is

shown as a dotted arrow. The distance between organisation and external knowledge sources (research) highlights the gap that exists between research and its practical implementation.

4.1.11 Validity and Reliability of the Proposed Theory and Model

The term 'validity' in qualitative research is potentially confusing and issues that surround it are controversial and many (Weber 1990; Winter 2000). It is not a single, fixed or universal concept, but rather a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies and projects (Winter 2000). In quantitative research there are standardised or accepted tests that would decide the research is valid or not. In qualitative research there are no such standardised tests and often the nature of the investigation is determined and adapted by the research itself (Winter 2000). Validity relates to the 'accuracy'. It is affected by the researcher's perception of validity in the study and his/her choice of paradigm assumption (Creswell and Miller 2000). The generalisability of the qualitative research is limited but it does provide an indication about the quality of a research increasing the validity or trustworthiness of the research (Golafshani 2003). In quantitative research generalisability is achieved through large sample sizes but in qualitative research the notion of generalisability presents that research has the potential of application in diverse situations.

Reliability or consistency mirrors replicability and ensures that researchers are measuring what they intend to measure (Winter 2000). The basic reliability issue concerns a measurement method's ability to produce the same research result over and over again. In qualitative research, this shows reliability has no relevance, as it is impossible to differentiate between researcher and the method (Stenbacka 2001). This makes the concept of reliability even misleading in qualitative research. If a qualitative study is discussed with reliability as criterion, the consequence is rather that that study is no good (Stenbacka 2001).

Stenbacka (2001) indicates that a good quality in qualitative research is achieved through description of the whole process and enabling conditional intersubjectivity. In grounded theory, the process of the conducting the grounded theory is a validations in itself. It doesn't require any additional validation approach. However, Glaser and Strauss (1967) indicate that a good theory should satisfy four highly interdependent properties. There are listed below:

1. It should closely 'fit' the area in which it will be used.

2. It must be readily 'understandable' by laymen working with this area so they can make sense of it and apply the theory themselves when required.
3. It must be sufficiently 'general' to be applicable to a multitude of diverse situations with in the area studied.
4. It must allow the user 'control' so that the application of the grounded theory becomes the worth trying.

The theory discussed in this chapter complies with these four points as discussed below:

1. Fit: The theory is closely related with the area of innovation adoption and diffusion from KM point of view and this is the area in which it can be efficiently used.
2. Understanding: The theory is readily understandable. It has been tested at various occasions by showing the model and explaining the theory to the participants in the phase 2 of the research. This was done to ensure that participants understand phase 1 of the research and why they should be involved in phase 2 of the research. The participants indicated many times that the model and theory was very useful in helping them understand the whole research situation.
3. General: The theory takes into account ICT innovation but it is argued to still be valid for innovation in general. Even though, this theory emerged from two leading Australian construction organisations, it presents a strong case for the whole industry to consider its present ICT diffusion state being not very different to generic innovation adoption and its diffusion. Hence this theory may be useful across a wide range of organisations in a construction industry supply chain.
4. Control: The theory provides sufficient control to the one who wants to apply it and makes sense of the situation regarding adoption and diffusion issues of innovation from a KM point of view. The users can readily apply the model to the situation in their organisations and develop good sense of understanding. They don't even have to apply the full theory to the situation. In fact they can select certain part of this theory and apply it on the situation/circumstances they are faced with hence giving them control over the theoretical components of the theory presented.

4.2 Extending the Model

The first phase of this research dealt with the mapping of the present situation in the studied construction organisations. This is achieved as discussed above by the use of grounded theory methodology that was manifested through forming theory and building a construct from this

theory. The second phase of this research is related to improvements that can be triggered in the present situation by using a KM initiative. The model in Figure 4.1 highlights various areas that can be further improved upon. This led to the extension of this model in Figure 4.2 to incorporate two other stages showing transformation of the organisation over time as KM initiatives assist in more closely linking people, processes and technology. It is postulated that organisational KM initiatives have the capacity to improve innovation. Such improvement will produce changes that would be reflected in improved organisational practices conforming to the Senge (1990) vision of a learning organisation i.e. organisations that are continually expanding their capacity to create their future through knowledge of how to improve their performance and processes.

Figure 4.2 indicates how a weak integration between people, process and technology transforms over time into stronger and more meaningful integration. Organisation's culture becomes less of a barrier to this integration. Stronger integration indicates effective utilisation of knowledge and increased absorptive capacity of the organisation (Cohen and Levinthal 1990). This would facilitate and give birth to pulling forces within the organisation that could be exerted over external sources of innovations to bring knowledge inside the organisation and immediately absorb it, thus making it a routine process for the organisational. As this transformation gathers pace, external sources of innovation such as academic institutions and research centres tend not to push so much of the new knowledge inside organisation boundaries at this stage, rather there is a greater flow of knowledge back and forth between the external knowledge sources and the organisation. The organisation improves and streamlines its processes and routines after it has undergone change and experienced learning. People change their attitudes and become motivated under strong leadership to learn, adopt and utilise the knowledge available. The area of influence grows as shown by growing circular rings and segregation of these reduces as shown by thinner cultural boundary lines. This is the state where people are learning and trying to adopt whatever knowledge is officially deemed to be useful. KM initiatives extensively include development of an internal knowledge bank or more commonly know as "Organisational Memory". In the construction industry "Project histories" are considered an appropriate word to use to reflect this concept because of the project nature of construction industry. Weak existence of an internal knowledge bank is then rectified through KM transforming these into more useful and user-friendly knowledge repositories. The purpose of the knowledge bank is to contain useful knowledge obtained from previous projects that would allow the organisation to not reinvent

the wheel thus saving time and costs as well as enhancing productivity. The knowledge bank would also contain the results of utilizing new knowledge that external innovation sources can tap into to get feedback. The stronger feedback mechanisms enable research communities to see the effect of innovation, refine it and produce more innovations. The gap that appears to exist between academia and practice can then be considered bridged.

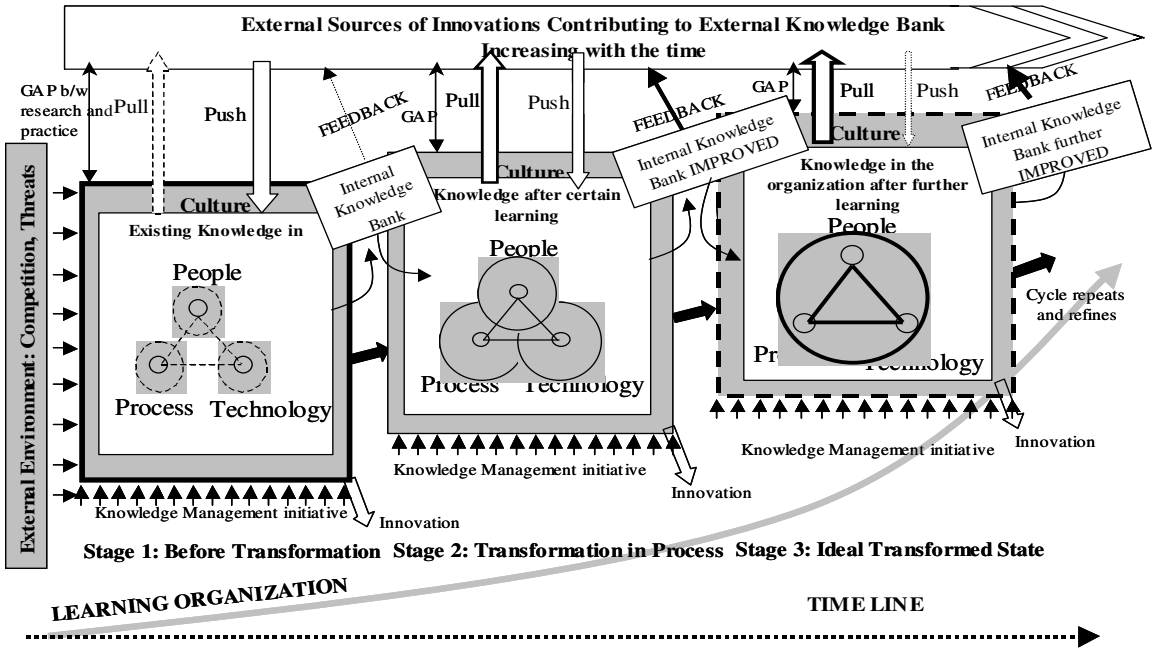


Figure 4.2: Organisational learning and transformation through KM

Chapter 5 illustrates how this transformation may be achieved.

4.3 Summary

This chapter has presented details on the use of grounded theory in the Phase 1 of the research. It starts by providing provides an overview of the two best-in-class Australian Construction Contractor Organisations that were involved in the study. The basic objective of this part of the research is to: (1) map out the present scenario in leading construction organisations that can shed light on how a particular innovation is adopted; (2) understand how knowledge related to that innovation is diffused within those organisations; (3) understand what are the issues involved and what sort of the knowledge link exists between the organisation and the external world (mainly knowledge sources). ICT as an innovation is selected for the purpose of the study. According to the guidelines of conducting grounded theory, the literature was only broadly read initially to develop a general understanding of the research area. The interviews comprised the main source of data for developing the grounded

theory. It was found out that first six interviews set the basis for emerging categories and the later ten interviews only authenticated and supported the emerged categories. The main categories that emerged from the interview data are:

- Existing Knowledge in the Organisation & Internal Knowledge Bank
- External Environment
- Segregation between People, Process and Technology
- Culture of the Organisation
- Link with External Knowledge Sources (Push Vs Pull)
- A Gap between Research and Practice
- Feedback to External Sources of Innovation

These categories are presented both in the form of the theory and the model. The theory is considered both reliable and credible as it complies with Glaser and Strauss (1967) criteria of Fit, Understanding, Generality and Control.

It is postulated that KM initiatives help transform the organisations towards being learning innovative organisations as shown in the model. This is depicted by the extension of the Figure 4.1 model to incorporate two other stages. The aim of Chapter 5 is to discuss how this transformation can take place through KM initiatives and demonstrates this using a soft systems methodology approach.

Finally, this chapter has endeavoured to provide details of Phase 1 of the research design that was manifested by the formation of a theory and developing a model as well as building a construct through the use of grounded theory.

Chapter 5
Using SSM as a KM tool

The aim of this chapter is to describe phase 2 of the research in detail. The chapter begins with providing a case for using SSM as a KM tool to achieve the transformation mentioned in Chapter 4. It then provides details on how the organisation and the business process, which is used in the study, was selected. The next section describes the use of SSM in investigating this business process. In line with the model envisioned in Chapter 4, the rest of the chapter describes four additional cases carried out again by using SSM to study the people and technology components of the selected business process.

5.1 SSM as a KM Tool

A basic understanding of SSM is provided in Chapter 3. Capitalising on that, it can be concluded that SSM helps:

- Achieve the systems and holistic view of the situation under consideration;
- Obtain the worldviews of various participants involved in the situation;
- Know the conflicting perspectives and issues within the system;
- Involve the participants when looking for the solution to the issues raised thus giving them the control over the situation;
- Involve all participants in cycle of action and learning; and
- Develop relevant system rather than a right system.

The above-mentioned characteristics of SSM share similarities with basic KM process components, such as knowledge elicitation & capture, creation, sharing, dissemination, etc. This forms the basis of establishing a plausible claim of treating and considering SSM as a KM tool. The next sections shed more light on the validity of this claim by results from a series of experiments demonstrating how SSM was used as a KM tool on a selected business process to achieve integration of people, technology and process that otherwise remains highly segregated.

5.2 Selection of the Organisation and Business Process

Organisation A was selected for carrying out this experimental part of the research primarily because of its willingness to be involved in this project through the help of its knowledge manager, who greatly assisted in organising the necessary resources and staff involved in this research. He collaborated with the researcher to decide upon an appropriate process to study and arrange likely participant willing and keen to participate.

The decision of selecting a business process was based on the following guiding factors in line with SSM philosophy:

1. It should be an important process, crucial for the business;
2. It should be a tacit-rich process that relies heavily on the experience of the people involved; and
3. It should at present be a poorly structured, poorly defined, and complex informal process.

The process of "Pre-tendering" fits the above-mentioned specification. It is the process by which this organisation makes an early decision to continue, or not, to further pursue an interest in a specific project. The pre-tendering process is not documented in any explicit form; rather it depends on the team that informally undertakes it to follow an ad hoc approach to doing what needs to be done to gather sufficient knowledge about the project to make the appropriate proceed-to-tender decision. It is a process that is embedded in the organisation's customary routine. Knowledge for carrying out this process resides mainly in a tacit form in the heads of the people. It involves making a decision whether or not to make a large financial commitment (frequently in excess of $100,000) to tender for major projects that could vary from several tens of $million to $billion plus in project value. With typical tender competition of 3-5 companies for such projects, this process is strategic and operationally important for the profitability and sustainability of the organisation. Any improvement in deployment of knowledge in this process may make a significant difference in winning tenders at acceptable profit margins. It also could conserve management energy to concentrate on the most 'winnable' or strategic projects thus enabling the organisation to make the most of its opportunity cost of its skilled staff engaged in this business process.

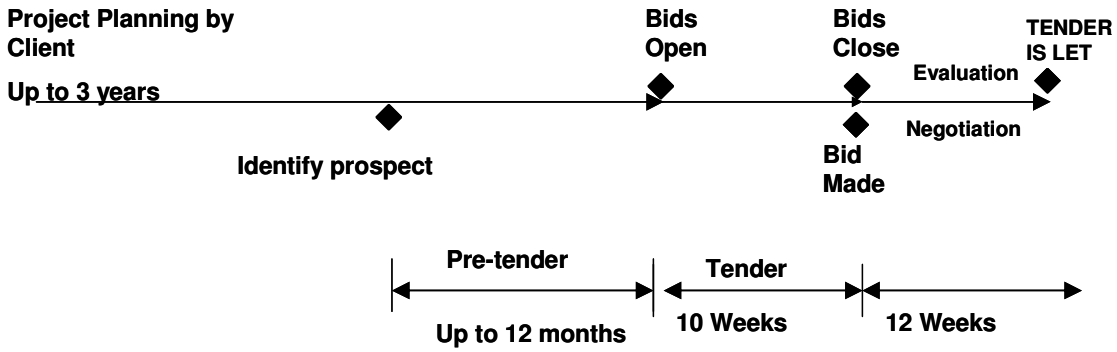


Figure 5.1: Pre-tendering process illustrated

The pre-tendering process in Organisation A is illustrated in Figure 5.1. The pre-tendering process may be initiated up to 12 months in advance from the date when bids are invited. This depends upon how early a particular prospect can be identified. Public sector clients normally start planning a project much in advance—in some cases this could be up to 3 years. A good networking and relation with clients may help organisations to identify a prospect early and provide ample time for the organisation to consider committing resources to it once tenders are invited.

5.3 Investigating Pre-tendering Process Using SSM

The employment of SSM on the process of pre-tendering entail the seven-stage process illustrated in Figure 3.7-(See section 3.7).

Stage 1: Unstructured Interviews

In the first stage SSM requires conducting unstructured interviews with people involved in the process. Six people, as illustrated in Table 3.5, were involved at this stage. The interviewees were asked informal, unstructured questions about their involvement in the pre-tendering process based upon their experience and expectations. They were asked to talk about their role and the important tasks that they have performed in the past. It was observed that some participants found it difficult to focus on the answers. This difficulty is normal and can occur when people try to verbalise their tacit thoughts. Therefore an important task of the interviewer was to keep the discussion within the topic and context of the study. Two researchers, of whom one was experienced in the deployment of SSM, were involved in this stage. Interview notes were taken by one of the researchers and other kept the participants engaged in the interview.

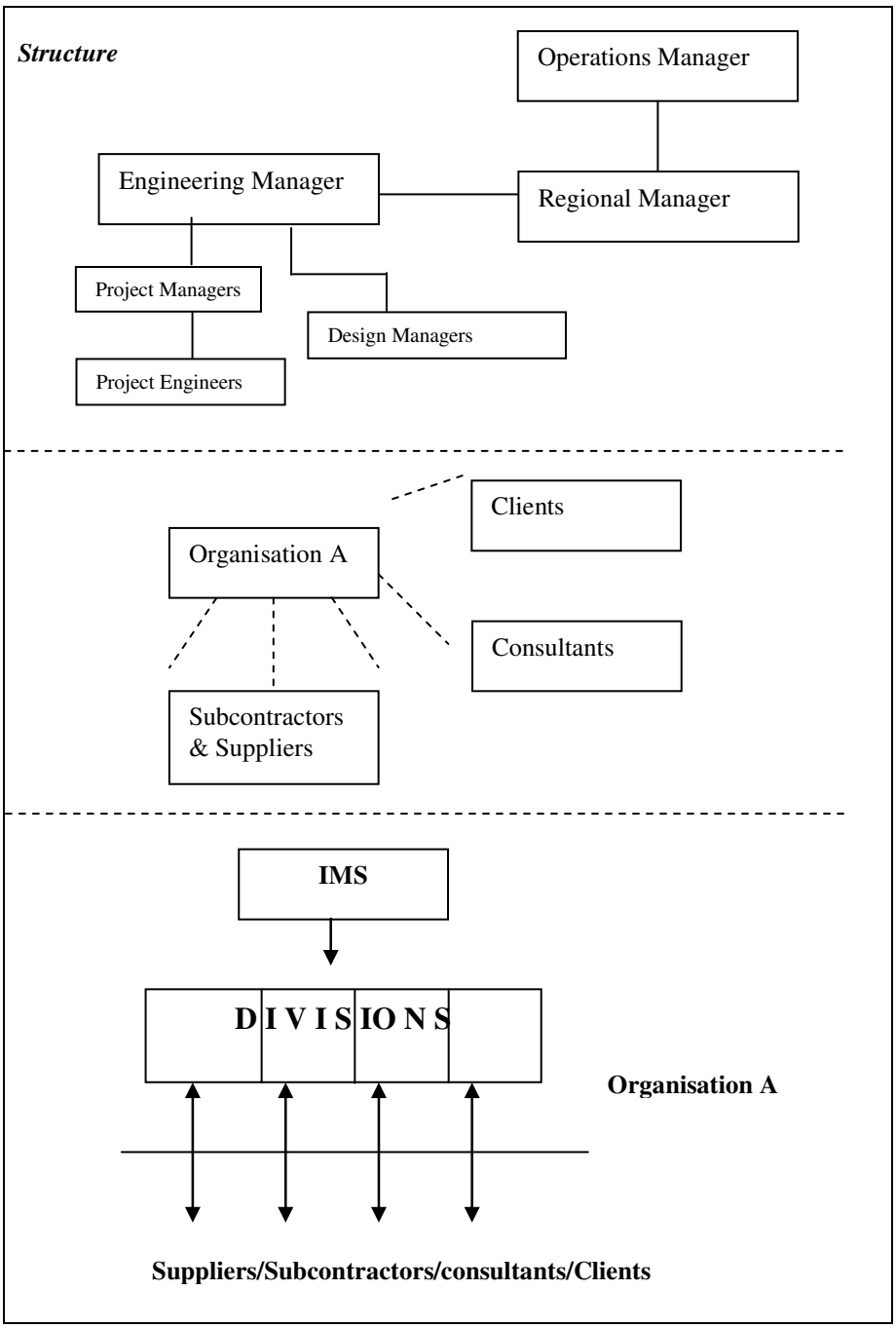
Stage 2: Developing a Rich Picture

The next stage requires giving a structure to the problematic situation through the use of rich pictures. The objective of this was to learn about the structures, processes, perceptions and beliefs associated with the case study situation. Iterations are very common in the development of a rich picture, where analysts draw the rich picture and show it to the participants for comments and corrections. This is iterated until consensus of the participants is achieved on the true representation of the situation portrayed in the rich picture. The rich picture for this case was developed in two iterations. In the first iteration, two researchers worked together on the interview notes (see sample presented in Appendix) and categorized the notes based on the structures, processes, perceptions and beliefs as shown in the Table 5.1. This categorization helps the development of the rich picture. The purpose of the rich picture is to portray all the key players involved in the process and present a structured view by putting the factors affecting the process into context. Drawing rich pictures is a creative skill conventionally done on a big chart sheet moving from left to the right. Stick-like figures represents the people involved and other drawings symbols are used to depict the resources (e.g. computers). The dialogues and perceptions are attached to these stick figures as obtained from the interview notes. Arrows depict relationships developed between people, resources and processes. Where there is an issue or conflict, it is shown by a storm cloud.

Once an initial version of the rich picture was developed, it was shown to the participants in a focus group setting and their opinions were sought on the accuracy of the situation depicted in the rich picture. A second version was then developed after taking into account all feedback obtained through the focus group. The rich picture was then developed using MS Power Point to serve as a basis for the further study.

Table 5.1: Structures, Processes, Perceptions and Beliefs elicited in interviews

Processes/Procedures   • Networking with industry   • Attending Seminars   • Talking to colleagues   • Working with consultants   • Using the IMS to manage correspondence   • Make approximate estimates   • Produce Preliminary design   • Use personal expert knowledge   • Find things on internet   • Validate using past experiences   • Gather intelligence from suppliers   • Pursue and compare other options
Beliefs/ Values/ Perceptions   • Specific consultants have skills to help ensure project success   • Must be able to use conceptual knowledge to find ways to improve productivity   • Always need a signed hard copy of drawings   • IMS is just means to an ends   • IMS can be very beneficial and provides a controlled way of organising data. It is a good way of keeping track of consultants   • Client is not replacing engineering knowledge-big skill gap developing   • Cannot get constructive feedback from Client   • IMS helps to fight contractor claims   • Soft copy and signed hardcopy must be same versions   • I need more opportunities to attend knowledge gathering activities   • Trying to get consultants to change the way they think is waste of time. Better to completely change the system   • Need to know the key person in the consultant company who can produce winning designs   • What wins the project is “how good the design is”   • We need more time   • I hate novated consultants, they are very difficult to manage   • On big projects, design managers should be on site but this never happens   • Design manager should flag design issues   • Construction foreman often the key to successful project, they can spot a problem before it becomes a critical   • A minor design detail can make a major contribution to productivity   • Documentation coming from building developers is often poor, they expect the builders to do it   • Initially IMS is difficult to understand but when the benefits are understood then systems becomes attractive and beneficial to use fully.



In the SSM investigation undertaken upon the process of pre-tendering, producing a rich picture provided a structure to an informal process. This made it possible to target knowledge assets involved in the process, which were subsequently investigated in line with the 'people' component of the model presented in the Chapter 4. Participants involved in the study highly regarded the use of rich pictures as these allowed them to make sense through use of this explicit knowledge about the process where previously only tacit knowledge existed in their heads. Once they saw themselves represented, sitting in the rich picture and performing various roles, they immediately started giving feedback as to what extent their roles were truly portrayed. This illustrates the power of rich pictures in making implicit knowledge explicit and codifying and socialising it. The rich picture is shown in Figure 5.2.

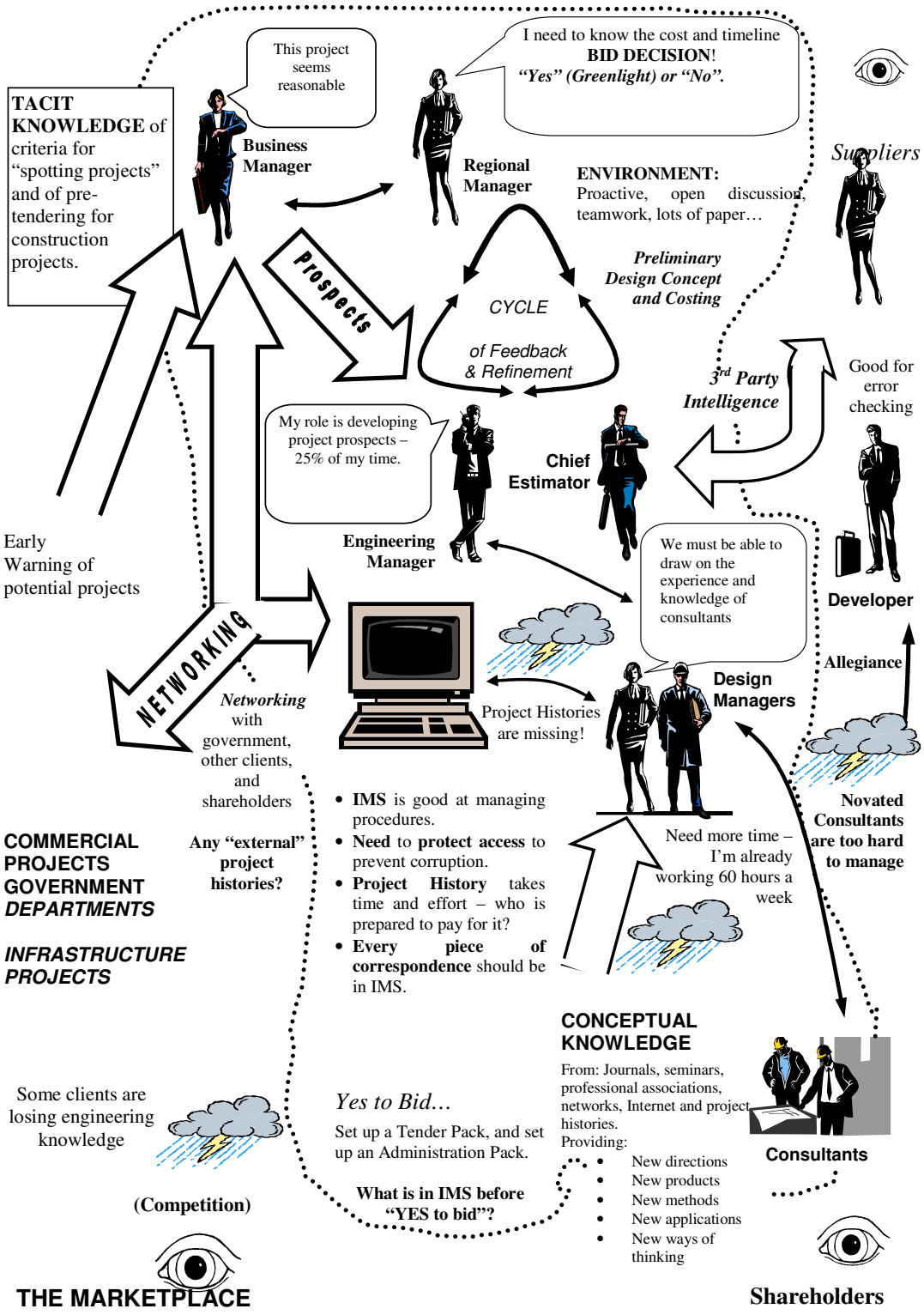


Figure 5.2: Rich picture of pre-tendering process

Stage 3&4: Developing Root Definition, CATWOE and Conceptual Model

In this part the SSM analyst develops the ideal solution to the problem under study by clearly defining the purpose of the system by establishing a precise wording for the system defined by the Root Definition. It is then tested against the CATWOE (Customer, Actors, Transformation, Weltanschauung, Owner, Environment). This ensures that the Root Definition is complete, precise and concise. Using the understanding gained from the definition of the situation in this form, the analyst then becomes confident in proposing a conceptual model that details an ideal situation.

Figure 5.3 illustrates a Root Definition, CATWOE and conceptual model.

ROOT DEFINITION –

Pre-Tendering
A system owned by the pre-contracts team, who together with the Chief Estimator and the Design Managers, takes prospective projects from the Business Manager, together with knowledge, processes and technology, and prepares preliminary understanding of the project and cost estimates.
This is used to assist the Regional Manager in assessing the feasibility of making a tender bid. This must be undertaken within short timeframes and with expert assistance from consultants. This is taking place in a very competitive environment where the "fit" to business objectives and corporate goals, cost and the timeline are all important.

Customer: Regional Manager (RM)
Actors: Engineering Manager, Chief Estimator, Design Manager, Pre-Contracts team, Business Manager.
Transformation: Knowledge, processes and technology together with details of prospective projects, are used to prepare an understanding of the project and a cost estimate for assessing the feasibility of a tender bid.
Weltanschauung (why Bother?): To assess the feasibility of making a tender bid, we (RM) need a good understanding of the project – does it fit our corporate objectives - and cost and timeline details.
Owner: Pre-Contracts Team
Environment: Competitive, quality, cost and time critical, community and corporate goals.

CONCEPTUAL MODEL – Pre-tendering

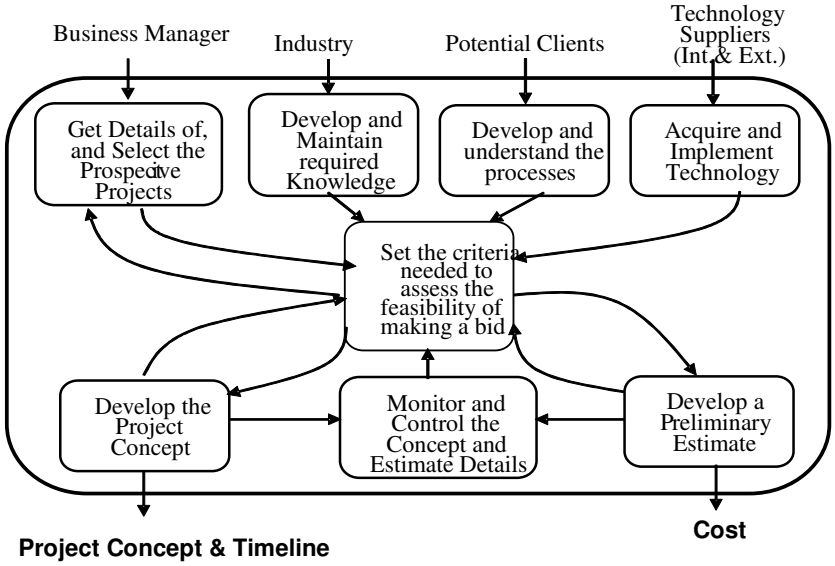


Figure 5.3: Root Definition, CATWOE and Conceptual Model of Pre-tendering Process.

Stage 5

In Stage 5, participants were interviewed with the structured questions that have emerged from the key activities described in the conceptual model in Figure 5.3. Participants were asked the following questions for each activity highlighted in the conceptual model:

a) Do you undertake the described activity?
b) How is this activity accomplished?
c) Define your measure of performance for undertaking this activity.
d) Describe any improvements that could be made to the way this activity is undertaken.
e) How are you likely to undertake this activity in the future?
f) Do you think this is an important activity?

The discussion that was generated in this stage is presented in Table 5.2

Table 5.2: Discussion on the activities of the conceptual model-Pre-tendering process

Activity	**Discussion**
Current Projects: Get details of and select prospective projects	This activity is being undertaken within the organisation and business manager is mainly responsible for it. However, there is a need to improve the process through which early spotting of the projects become possible.
Develop and maintain required knowledge about the Industry and its projects	This activity is not formally done but is considered very important because knowledge about the structure of the industry, and what sort of projects have been done, or what may be done in future, gives the organisation an ability to upgrade its knowledge in order to compete for the projects.
Develop the process for understanding and networking with clients	This activity is not formally done in the organisation. It was considered important because it is believed in the industry most of the work comes through networking and contacts. An early knowledge of a particular prospect means better preparation and decision making for its selection. Therefore a formalized process that dictates how to network with a particular client is very important and should be developed.
Acquire and implement technology from technology suppliers when the project demands that.	Certain projects would demand the use of new technology or technology that the organisation is not familiar with or has used before. This activity is therefore important to be able to acquire and implement technology from technology suppliers whenever there is a need. This would require a good knowledge of technology suppliers and existing technologies they provide.
Set the criteria needed to assess the feasibility of making a bid	This activity is considered very important as there is no specific criteria in the organisation used to judge the strategic aim of winning a potential project, or whether it is feasible or not to tender for it. This activity is mostly taken using tacit knowledge about criteria (such as profitability, competition, risk, availability of resource, financial capacity) but not being able to explicitly quantify knowledge about determining the suitability of the business prospect.
Develop Preliminary Estimate to obtain the cost of the project, Develop the Project Concept, Monitor and Control the Project	These activities are undertaken in the organisation, mainly with the help of consultants, suppliers and subcontractors that the organisation has previously worked with before and who they have trust and confidence in. These third parties play a great role

Concept and Estimate Details	in the pre-tendering process and hence it is very important to build good relations with trusted trading partners.

Stage 6

Stage 6 deals with the development of list of actions based on the discussion generated in Stage 5 that should be taken in order to improve the situation or process under study. The list of actions compiled below are considered by the analysts as being promising to improve the process when acted upon, is provided below:

1. Improve the understanding about clients, their businesses, roles and projects they may invite tenders for;
2. Enhance networking skills of the staff liaising with clients and to develop a guideline to undertake successful networking through socialising with them;
3. Establish decision criteria that quantitatively assesses a particular prospect in order to assess its feasibility of converting that prospect into a tender bid; and
4. Maintain and enhance relations with trading partners such as consultants, suppliers and subcontractors to obtain the best quoted prices and develop a quick and reliable preliminary estimate of the project expected time and cost.

Stage 7

This is concerned with implementing actions and monitoring changes (improvements and unintended problems). This requires a considerable amount of time, well beyond the time limit available for completing the doctoral study. It was also beyond the scope of the research to actually implement the actions and study any changes.

The next two sections of this chapter investigate the technology and people components respectively using same methodology (SSM) following same stage-by-stage process. However, it should be noted, they are presented in an abbreviated and more readable descriptive form to maintain the readers' interest and avoid monotony.

5.4 Investigating the Technology Component Associated with Pre-tendering Process Using SSM- Project Histories

From the study of the process of "pre-tendering", it distinctly emerges that the pre-tendering team places a very high value on the use of an ICT component referred to as "Project histories". Nevertheless, the effective use of project histories has been plagued by various issues that restrict the team's effective use of them. This led to further investigation of the issues associated with the utilisation of these project histories. The research team conducted an in-depth interview with one of the initial participants (the Engineering Manager, who possessed an avid interest in the development and use of the project histories). Interview results are represented in the rich picture illustrated in Figure 5.4. This rich picture forms the basis for developing the Root Definition, CATWOE, and Conceptual Model shown in Figure 5.5.

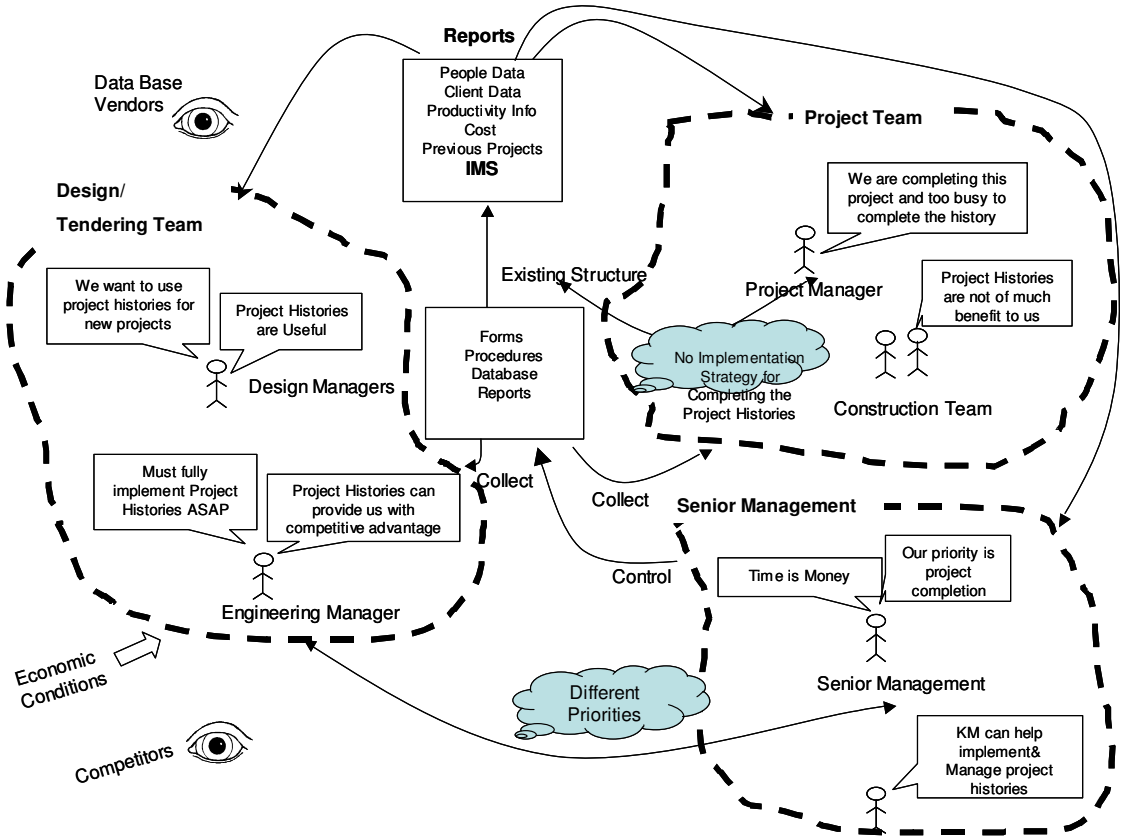


Figure 5.4: Rich Picture for project histories

In this organisation the project histories are intended to be the repositories/data bases that contain useful information and knowledge from previous projects. These should include information such as productivity rates on previous projects, cost and timelines, and client

details. These project histories are operated through a corporate ICT system referred to as IMS (Information Management System). As one of the leading contracting companies in Australia, this organisation's use of ICT has proliferated from the mid 1990's as part of its commitment to become a best-in-class organisation. IMS - as a communication tool - has become the general and most usual form of communication throughout the organisation. Organisation A has made significant efforts to successfully diffuse it within the organisation to the foreman level. As such, IMS is effectively utilized while the project is in progress, but it is rarely used to successfully and efficiently to develop and maintain a project history.

Developing a project history requires the management of a large volume of information generated while the project is being executed, and identification and classification of information that may be of use on future projects. It is often recommended that this kind of information should be gathered as part of a project debriefing process; however, experience shows that this is often not sufficient to provide and record useful information for future use. However, the lack of interest of the project team in participating in project debriefings further aggravates the problem of knowledge gathering and transfer. This results in very little knowledge being carried forward from current projects to be used in future projects. In practice, most knowledge transferred from one project to other remains tacit—often unspoken, and certainly not documented. As shown in the above rich picture (Figure 5.4), the success of project histories proliferation is very limited. A key factor in this is the support of senior management, and this PhD study emphasises that project histories need to be strategically aligned with a business process like KM.

The benefits of project histories were articulated as significant, and are very clear in the minds of the people who want to use them. However, users of project history have little influence over the project team members who are essentially responsible for the creation of project history information and knowledge, but have very different priorities. The value of adopting a KM philosophy is that it provides senior management with a rationale to support the creation and maintenance of repositories of project histories. These repositories will contain the lessons learnt and a rich contextual description of unique problem handling techniques devised by the project team. Future projects can then avoid re-inventing the wheel, thus saving time and resources. Highlighting a project history KM focus could provide a vigorous and convincing rationale for both senior management and project team to accept its value.

Root Definition – Project Histories A system owned by the Engineering Manager, who together with the Design Managers, seek data, information and knowledge from previous projects stored in project histories in order to prepare realistic preliminary understanding of the project and cost estimates for pre-tendering process and then for preparing the project bids.	**Customer:** Senior Management, Future Design Managers, Project Managers **Actors:** Engineering Manager, Design Managers, Project Managers, Construction Team **Transformation:** Knowledge, processes and technology together with details of past projects, are used to create and maintain a repository of a project histories that can be used when preparing a tender bid for a new project. **Weltanschauung (why bother?):** To assess the feasibility of making a tender bid, a good understanding of the project is required based upon previous organisation experience and knowledge. **Owner:** Engineering Manager **Environment:** Competitive, Quality, Cost and time critical, Community and Corporate Goals.

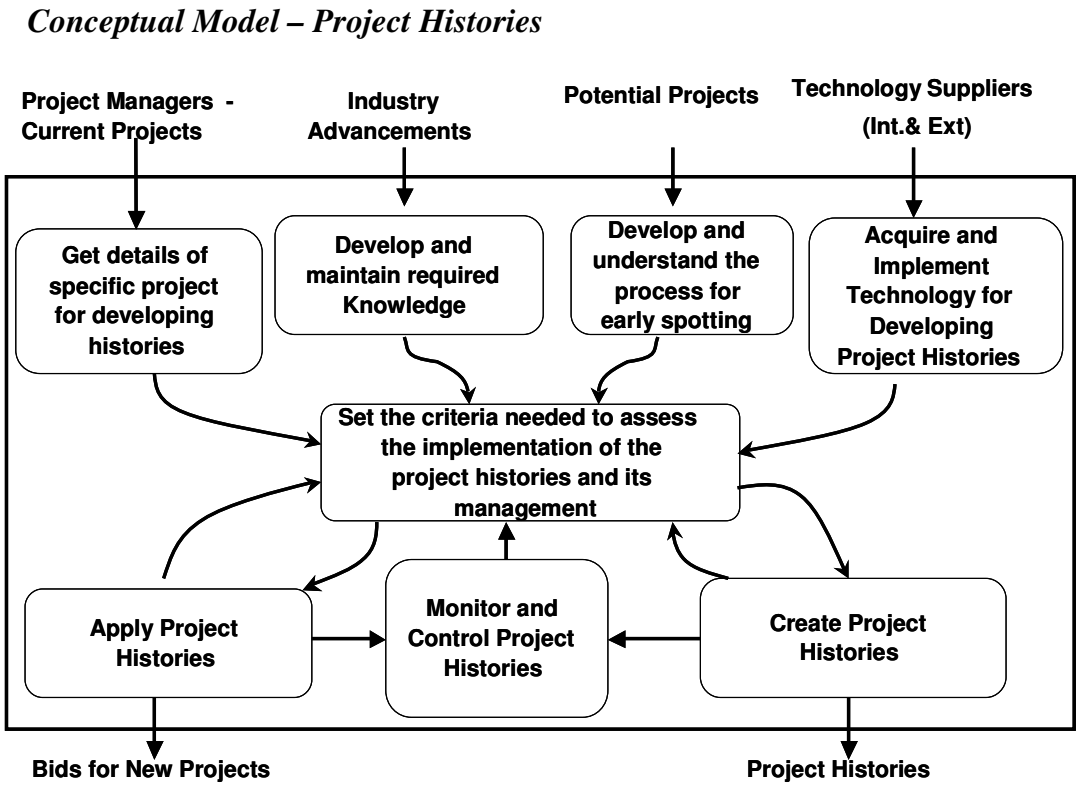


Figure 5.5: The Root Definition, CATWOE and Conceptual Model of Project Histories

In the next stage of this part of the research, participants were interviewed with a similar set of structured questions (previously described in Stage 5) that emerged from key activities described in the conceptual model. Table 5.3 summarises discussion that took place over activities conceptualised in the conceptual model.

Table 5.3: Discussion on the activities of the conceptual model

Activity	**Discussion**
Current Projects: Get details of specific projects for developing histories	This activity is not formally done. However it is considered a very important activity. A framework needs to be developed to decide what important information and knowledge needs to be captured from current projects. This would enable the organisation to utilize its resources in an optimal and efficient manner and use knowledge gained on subsequent projects. Ideally it needs to be done by the project managers but, due to various constraints as discussed earlier, it is more feasible to recruit staff in the KM department and let them liaise and work closely with project managers to gather knowledge and important information.
Industry Advancement: Develop and maintain required knowledge	This activity is not formally done in the organisation. It is an important activity, as it would help benchmark the organisation against the current industry best practices. If industry as a whole is embracing new modus operandi for its advancement, the organisation must be able to acquire, develop and maintain the required knowledge to remain competitive.
Potential Projects: Develop and understand the processes of early spotting of viable projects	This activity is not considered an important activity when dealing with the issue of project histories. So it can be safely ignored.
Technology Suppliers: Acquire and implement technology required for developing project histories	This activity is not being done in the organisation at all. However it is considered an important activity as it becomes very crucial to decide with technology to use for developing and maintaining project histories in the organisation. It will involve both hardware and software aspects of the technology. A proven technology should be sought. The organisation has developed a technology at its own to develop project histories but its efficiency is to be benchmarked against other technologies available in the market.
Implement project histories organisation-wide and set the criteria for assessing the implementation of project histories and its management	At the heart of all the activities lies this most important activity that demands the commitment from senior management. Currently there is no implementation strategy from the organisation at the corporate level. Along with this implementation commitment there is a need to develop a criteria that would assess the implementation strategy of project histories and its efficiency.
Monitor and control project histories	This is also considered to be a very important activity as once the process of developing and maintaining project histories is underway, it becomes essential to constantly monitor its performance and deals with the issue causing obstruction to its creation and efficient use. The KM function of the organisation should be able to take up this responsibility.

This information forms the basis of the comparison between the realities of the real world of developing and using project histories, and the "ideal" expressed by the conceptual model. This comparison – or gap analysis – provides the framework to focus on the issues and opportunities, examine assumptions, and better understand the dysfunctional behaviours/actions that need to be remedied. Stage 6 strives to identify the desirable and

feasible options for change and improvement in the process of creating and using project histories. Based on the previous discussion and insights gained from the previous stages, it is possible to assemble various options for improving the process of creating and using project histories. These options can be summarised as follows:

1. Senior management buy-in and development of a corporate-level implementation strategy at for the creation and use of project histories—appropriate leadership is required to bring this change;
2. Deciding on a framework to signify what is the important information and knowledge that should be captured or preserved from the current projects;
3. Deciding upon a user friendly and effective format of the project histories;
4. Deciding upon who should be gathering the required information and knowledge and who should be creating and developing project histories—this would involve investigating an option for staffing an organisational KM function to implement such responsibilities;
5. Investigating current technology available in the market to create and develop project histories and how their efficiencies could be compared with technology currently being used within the organisation; and
6. Once project histories become operational, monitoring and controlling their operation should become an embedded process. A KM organisational function should take up this responsibility.

5.5 Investigating People Component Associated With Pre-tendering Process

The investigation of the pre-tendering process highlighted various key personnel who were an integral part of the process. Three of these people agreed to take part in further research (owing to their eagerness, willingness and time availability). They were asked to provide examples from their previous work experience in order to elicit tacit knowledge residing in their heads that may have the potential to contribute towards the improvement of the pre-tendering process. Among various examples provided and quoted, are three that were selected (based on how well they can contribute towards the improvement of the pre-tendering process).

5.5.1 Participant 1: An Example of a Bridge Project

This case examines a commonly observed scenario while tendering, where multiple parties compete to bid on a specific project and the contract is awarded to the lowest bidder. It documents a tendering process on a bridge project where the bidder lost their bid by a very small margin. The unsuccessful bidder claimed that with a little more expense, the client would get a lot more value out of the design. The unsuccessful bidder claimed the bid with the lowest price was selected (but with inferior value) because the client disregarding best-value and hence adhering to competitive low-cost bidding.

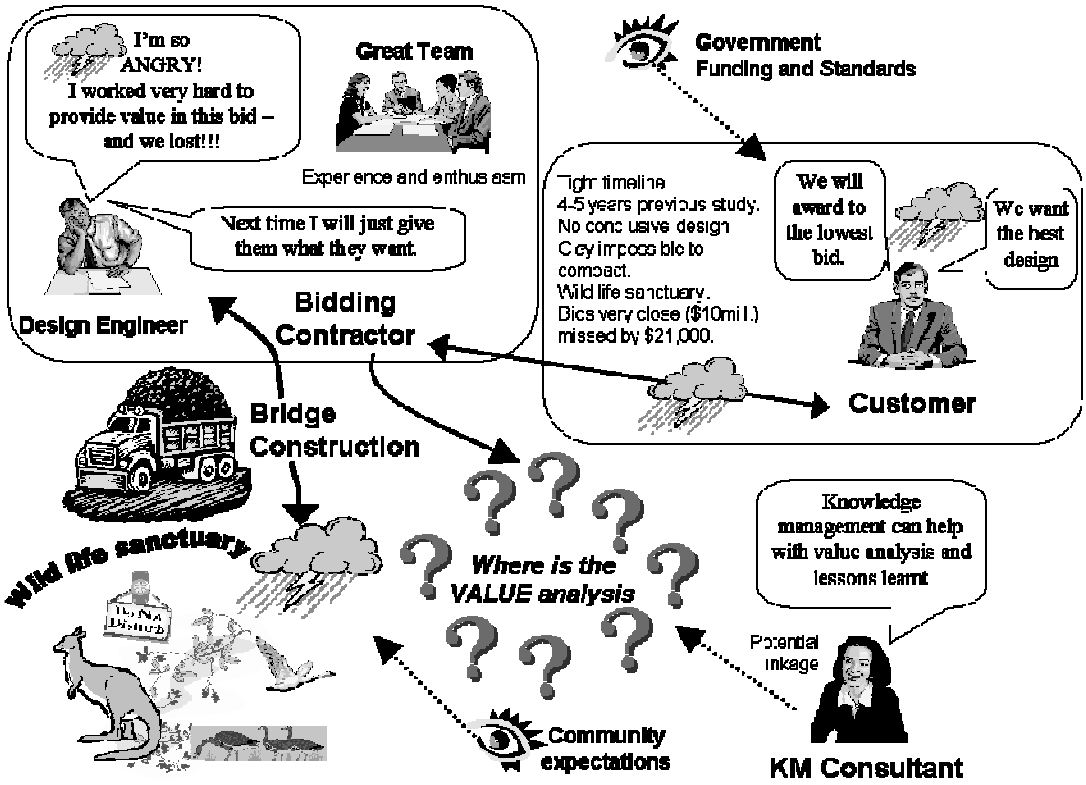


Figure 5.6: Rich Picture of the Bridge Project

The Rich Picture shown in Figure 5.6 illustrates the difficulty that the tendering team experienced throughout the tendering process due to the very short time available for bid preparing. The organisation then discovers that it had failed to be successful by a very small margin. In this case, the client had undertaken an investigation of the site in the previous 3 to 4 years, but had not completed a final design. It then became a task of the bidder to develop a realistic design in addition to the cost and time estimate that would form a bid—all within the short time span of 12 weeks. The routine method of bridge design and the routine typical construction method could not be used because of the nature of soil (clay) that was very

difficult to compact. Also, the presence of a wild life sanctuary in the vicinity of the bridge made the design and construction environmentally sensitive and subject to community interest. To achieve a suitable solution all the team worked strenuously to develop and submit a realistic design, cost and timeline bid. Much to the disgust of the bidding team and especially the design manager who led the team and was Participant 1, the bid was eventually lost. The case study also documents a changed worldview and a negative impact on the design manager who worked very hard on this project, failing to win the bid. He then promised himself not to work so hard to provide value while making a bid for future projects. His own words reflect a changed worldview - “Next time I will give them what they want”. This illustrates a negative transformation—that he would not be performing innovatively on future projects and would rather stick to a conventional approach. This reality goes against the wider worldview shared by other parts of the construction industry that looks forward to becoming innovative and modernised and to eliminate or substantially reduce notoriously low productivity levels.

The Root Definition, CATWOE and Conceptual Model is presented in Figure 5.7 as a case study of this problematic situation that uses SSM to generate a solution.

ROOT DEFINITION – Bridge Project A system owned by the Bidding Contractor, who together with the Design Engineer, use knowledge, skills and experience to prepare competitive bids for the design and construction of bridge projects. This is undertaken with the understanding that while the client wants a low price, there is also a desire to obtain the best value in a bid. These bids must also take into consideration the competitive market and community expectations for the design and construction of a major project.	**Customer:** The client and the community **Actors:** Bidding contractor, competitors, design engineer, design team, client. **Transformation:** To use knowledge, skills and experience to prepare competitive bids for the design and construction of bridge projects. **Weltanschauung (why Bother?):** While the client wants a low price, there is also a desire to obtain the best value in a bid. **Owner:** Bidding Contractor **Environment:** Competitive, quality, cost and time critical, and community expectations.

CONCEPTUAL MODEL – THE BRIDGE PROJECT

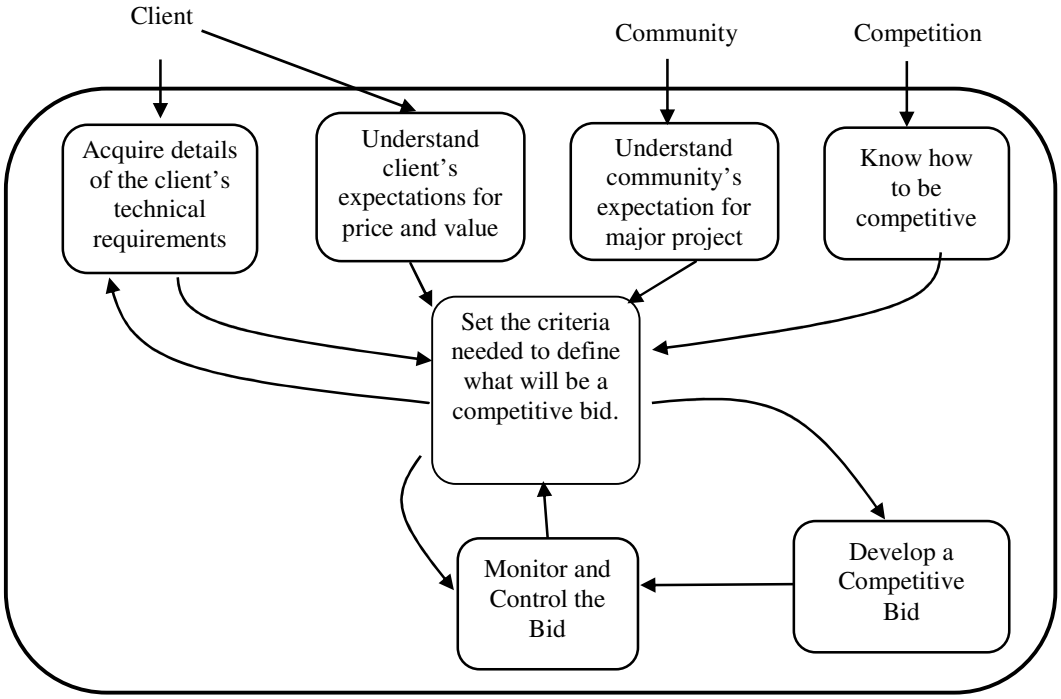


Figure 5.7: Root Definition, CATWOE and Conceptual Model of the Bridge Project.

Table 5.4: Discussion on the activities of the conceptual model

Activity	**Discussion**
Acquire details of the clients technical requirements	This activity is undertaken in the organisation and mainly relies on the technical requirements stated in the specifications but only when tenders are invited.
Understand clients expectations for price and value	This activity is not formally undertaken in the organisation and depends mainly on the person undertaking it. It is however a very important activity as it would ultimately decide the fate of tender. If the clients' expectation is only price then it is worth focussing only on price and not giving much attention to the value.
Understand community's expectations for major project	This activity is considered important as some projects may affect the community and their expectations and it is important to

	involve their representative during the construction process. It is therefore important to develop good liaising skills with the community.
Know how to be competitive	This activity is not formally done and is usually measured by noticing how many projects are being won. However there is need for explicit criteria that could define the competitiveness of the organisation and a way of understanding the organisation's competitive advantage.
Set the criteria needed to define what will be a competitive bid	This activity is considered very important, as it will decide winning or losing the bid. It is therefore considered important to develop criteria that can quantitatively rank chances of success of a particular bid. There are no such criteria so far, and so staff tacitly takes most of the decisions.
Develop a competitive Bid & Monitor and Control the Bid	Once criteria for a competitive bid is developed, a bid can be prepared based on that, which will stand more chance of success as compared to the other bids.

The above-mentioned scenario is primarily concerned with a tendering process but contains various implications for a pre-tendering process. The list of actions below would suggest that it is best to:

1. Know the clients expectations clearly, is it price or value?
2. Ascertain to what extent, community will be a part of the project and what could be the possible ensuing difficulties; and
3. Devise the criteria that will define the competitiveness for the organisation.

5.5.2 Participant 2: An Example of a Road Project

This case documents the process of tendering/bidding on a road project where it was required to construct the culverts to manage the flow of water. The rich picture in Figure 5.8 describes the problematic situation. Flood modelling was the basis for the selection of size and spacing of the culverts and this aspect was mostly covered in this case study. The design and construction method itself were routine in nature and was not investigated.

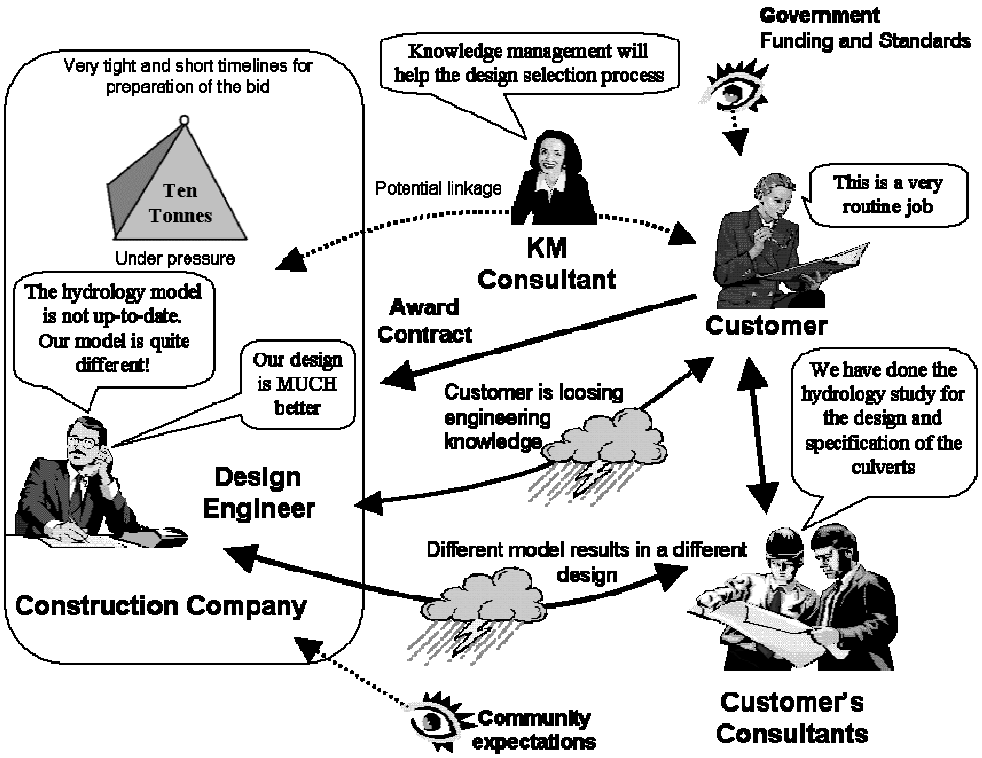


Figure 5.8: Rich Picture of the Road Project

In this case, the client carried out the hydrological study of the area almost five years ago, based on their subsequent flood modelling they allocated the space and sizing of the culverts and hence initiated a bid process. The organization under study was one of the bidders and didn't agree with the sizing and spacing of the culverts as specified by the client. The bidding organization carried out their own flood modelling and challenged the client's specification for culverts, based on the new model and the design properties derived from it. They completed their study under severe time pressure and were able to convince the client that their sizing and spacing was preferable and eventually produced significant cost savings on the whole project.

If this is modelled as a problematic situation, then proposing the solution using SSM requires developing Root Definition, CATWOE and Conceptual model as illustrated in Figure 5.9.

ROOT DEFINITION – ROAD PROJECT A system owned by the Construction Company, who together with the Design Engineer, use knowledge, skills and experience to prepare competitive designs that delivers the most appropriate solution for the project. This is undertaken where the client may be loosing engineering knowledge and the client's consultants have not provided the optimal design parameters. These bids must also take into consideration the competitive market and community expectations for the design and construction of a major project.	**Customer:** The client and the community **Actors:** Construction company, design engineer, client, client's consultants. **Transformation:** To use knowledge, skills and experience to prepare competitive designs that delivers the most appropriate solution for the project. **Weltanschauung (why Bother?):** the client may be loosing engineering knowledge and the client's consultants have not provided the optimal design parameters. **Owner:** Construction Company **Environment:** Competitive, quality, cost and time critical, and community expectations.

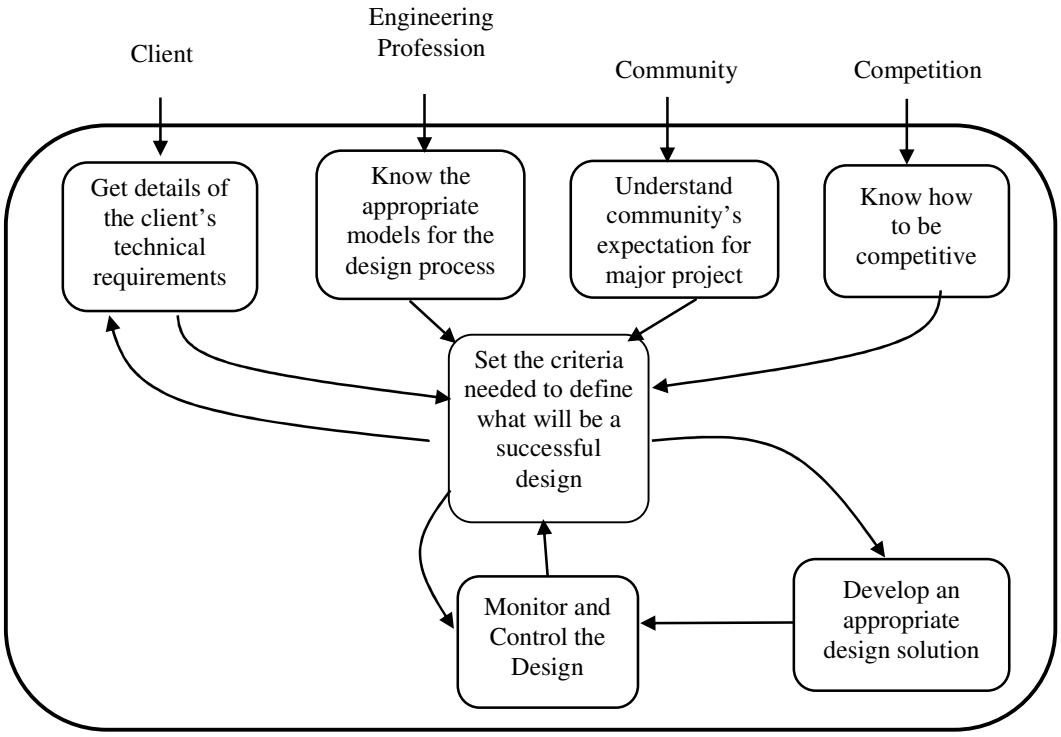


Figure 5.9: Root Definition, CATWOE and Conceptual Model of the Road Project.

Table 5.5: Discussion on the activities of the conceptual model

Activity	**Discussion**
Get details of the clients technical requirements	This activity is done in the organisation and mainly relies on the technical requirements stated in the specifications when tenders are invited. It is also important to question their technical requirements, as they may not be always correct, especially when clients are losing the engineering knowledge skills.
From the engineering profession, know the appropriate models for the design process	This activity is mostly taken in conjunction with consultants specialised in the field and have appropriate knowledge of the design process (hydrologic modelling).
Understand community's expectations for major project	This activity is considered important as some projects may affect the community and their expectations and it is important to involve their representative during the construction process. It is therefore important to develop good liaising skills with the community.
Know how to be competitive	This activity is not formally done and is usually measured by noticing how many projects are being won. However there is need for explicit criteria that could define the competitiveness of the organisation.
Set the criteria needed to define what will be a successful design	This activity is considered very important, as it will decide the winning or lost of the bid. It is therefore considered important to develop criteria that can quantitatively rank chances of success of a certain design.
Develop an appropriate design solution & Monitor and control the design	Once criteria for a successful design is developed, a design can be prepared based on that, which will stand more chance of acceptance as compared to the other bids.

The above-mentioned scenario is primarily concerned with a tendering process but contains various implications for a pre-tendering process. The list of actions below would suggest:

1. Learning to question the clients' technical requirements and always look for alternatives;
2. Ascertaining to what extent, the community will be a part of the project and what could be the possible difficulties; and
3. Devising through modelling, criteria that will define the successful design in case of flood.

5.5.3 Participant 3: Use of an Innovative Product in a Project

This case specifically describes the adoption and diffusion process of an innovative product called "BAMTEC" in the organisation under study (Visit http://www.bamtec.co.uk/startuk.html?index.html~main accessed 5 May, 2005). The technical nature of the product is immaterial to the execution of this case study. The most

important issue highlighted, is to know how the process behind the diffusion and adoption of such an innovation in the organisation actually happened, so that a better understanding of how it was adopted and diffused can be developed. Issues such as adoption of innovation and its diffusion are central to the core of KM. KM helps people identify innovations that have the potential to improve their productivity and it also provides a framework to adopt and diffuse that innovation throughout the organisation in order to reap benefits. The rich picture in Figure 5.10 illustrates the related processes.

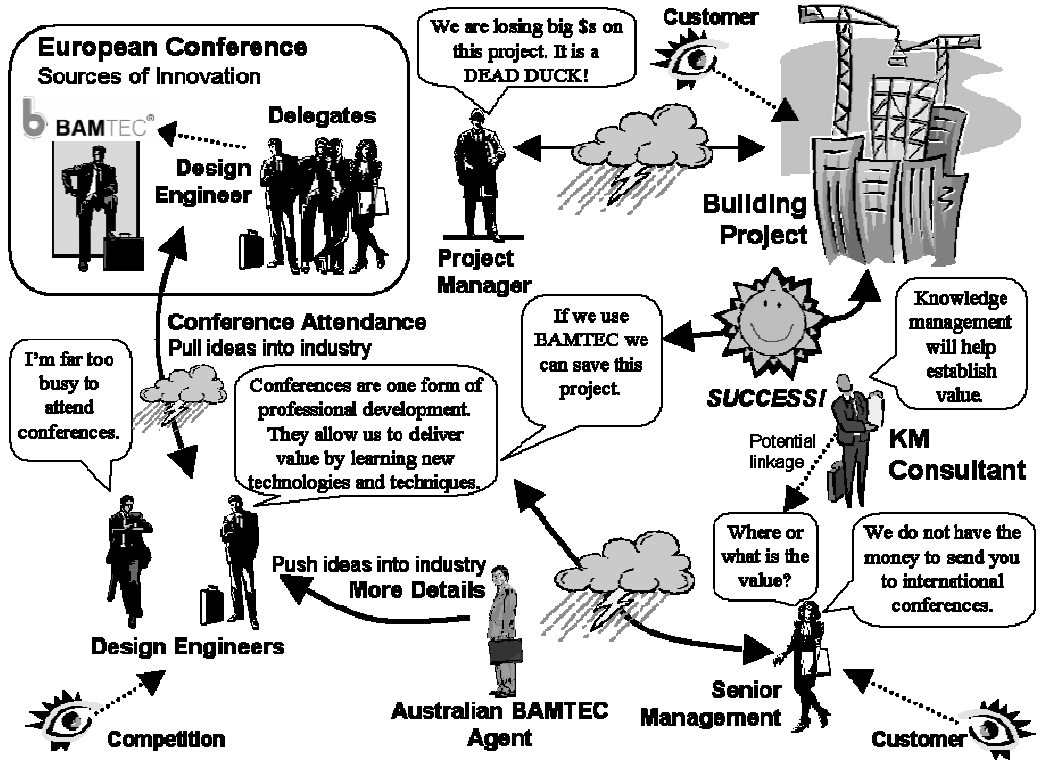


Figure 5.10: Rich Picture of the Bamtec Study

The innovative product under study was displayed at a European construction conference. This conference was attended by one of the design managers from the organisation. The rich picture documents the values and beliefs usually existing in the organisation. For some people, attending conferences is not particularly important but others take this seriously and expect that their organisation should fund them to attend such events on a regular basis. In this case, the design manager implemented the use of the BAMTEC product in a project that previously had been declared as a "dead duck". It was the sort of the project that was not only running over budget but also not returning any profit to the organisation. Implementing the BAMTEC product on the project - in the words of the design managers - "literally saved the project and pushed it towards a profitable outcome". The root definition, CATWOE and conceptual model shown in Figure 5.11 gives an explicit description of how a specific

innovation can be adopted and diffused and how it can be effectively utilized for the benefit of the organisation. This is in accordance with SSM stages 1-4.

ROOT DEFINITION – BAMTEC A system owned by the Design Engineers, who with the support of Senior Management are able to achieve professional development and learn new ideas and techniques by attending major, international conferences. This adoption of innovative building techniques can be the key to project success. However, Senior Management need to be convinced of the value of conference attendance, and many design engineers consider themselves to be too busy to attend conferences.	**Customer:** The building company, project managers, the clients and the community. **Actors:** Design engineer, senior management. **Transformation:** To achieve professional development and learn new ideas and techniques by attending major, international conferences. **Weltanschauung (why Bother?):** This adoption of innovative building techniques can be the key to project success. **Owner:** Design engineer **Environment:** Work pressure, cost and time critical, and community expectations.

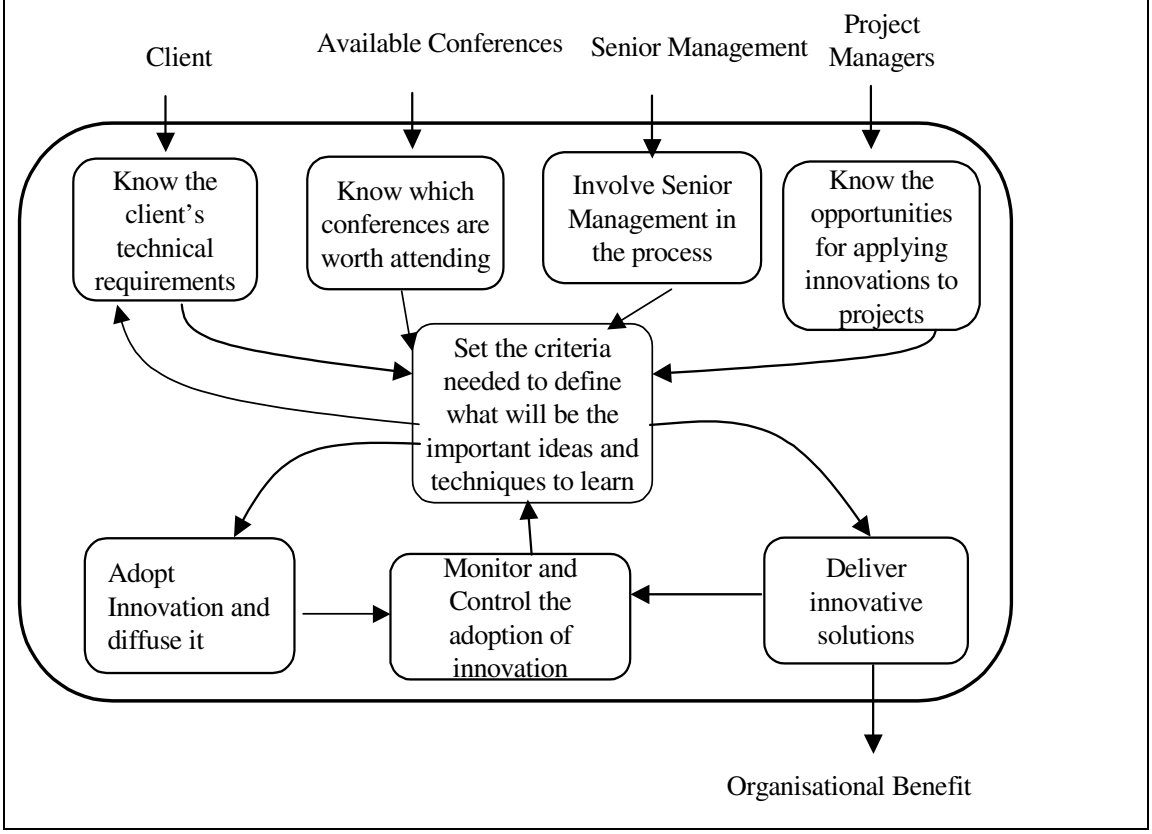


Figure 5.11: Root Definition, CATWOE & Conceptual Model of the BAMTEC study

Table 5.6: Discussion on the activities of the conceptual model

Activity	**Discussion**
Know the Client's technical Requirement	This activity is not formally undertaken. However it is considered a very important activity because this organisation is able to know how to do to better know the client's technical requirements—it must enhance its capabilities in terms of technology and skills. This sort of activity is done during the pre-tendering or tendering stage but deficiencies in the organisation are only resolved on a temporary basis and not on a permanent basis.
Know which conferences are worth attending	This activity is not being undertaken in the organisation at all. There are no resources dedicated to conduct this activity. However it is considered an important activity as it becomes crucial to decide which among many conferences are the ones that are promising and deliver good value to participants.
Involve Senior Management in the process	It is an important part of the whole process. Nothing can happen without senior management getting involved and recognising the importance of employees participating in conferences and also appreciating benefits that this knowledge may bring to the organisation. This would ensure that conference participation expenditure would be budgeted for employees.
Know the opportunities for applying innovations to projects	This activity is not formally undertaken at all. However it is very important as project managers are in better position to look for opportunities where any innovation can be applied. If this were systematically undertaken, it would ensure that innovation opportunities don't go unnoticed. Instead, organisations can develop an approach to procure skills and technologies related with that innovation and applying it to a project.
Set the criteria needed to define what will be the important ideas and techniques to learn	At the heart of all the activities lies this most important activity that would require the input from all the above-mentioned activities. A criteria is needed to be developed that could take into account the company's strategy and overall vision and then establish a plan incorporating important innovative ideas and techniques to be learnt and applied in the projects.
Adopt Innovation and Diffuse it with in the organisation	This activity is not formally undertaken but it is an important one because, once a new idea or technique is acquired by the organisation it is important to adopt that innovation and diffuse it organisation-wide. Organisation-wide commitment is needed to carryout this activity.
Monitor and Control the adoption and diffusion of innovation process and look for new innovations.	This is also considered a very important activity, as once the innovation becomes the part of work process; there is need for a process that may monitor and control the adoption and diffusion process to ensure best results are delivered.
Deliver innovative solutions	As a part of carrying out above-mentioned activities, organisation would be in a better position to deliver innovative solutions.
Decide who would be attending what conference	This activity is also a important as it will decide who will be able to attend the conference. It should match area of interests of the employees with available conferences. Senior management can use it as a reward to motivate employees. The organisation can then make sure that the person attending the conference effectively disseminates knowledge brought back to the

	organisation either through socialising with other employees or via other formal methods such as reporting on the conference. This activity was not initially considered in the conceptual model but participants mentioned the importance of this aspect.

Based on the discussion and insights gained from the previous SSM stages it is possible to assemble various options for improving the access to knowledge from external sources such as conferences. These can be summarised as follows:

1. Involve senior management and make them aware of the benefits that external knowledge may bring to the organisation in order for them to budget for people to attend conferences;
2. Decide a framework to decide what are the important ideas and techniques to learn from a client's point of view and also from an organisational point view that matches organisational strategy and vision;
3. Identify conferences or other external events that could be useful for disseminating knowledge considered helpful for the organisation;
4. Ask project managers to identify and report on innovation opportunities that may be able to be used while executing projects;
5. Devise selection criteria for rewarding employees by selecting deserving candidates for attending conferences; and
6. Arrange a seminar or socialising event where employees returning from a conference with particular knowledge could share and transfer it to other employees in the organisation. Also publish how new knowledge has contributed to improved performance at the personal and/or organisational level so that there is an explicit cause-and-effect link between being open to knowledge-pull and adopting an innovation.

5.6 Summary

This chapter described the fieldwork done in phase 2 of the research. The use of SSM is demonstrated as a KM tool to achieve the transformation mentioned in Chapter 4. A business process termed as pre-tendering in the Organisation A was selected for the study. It was selected because it was an informally executed process but had great strategic value for the organisation. SSM is highly suitable tool of analysis for such complex and poorly defined

processes. A complete SSM framework was applied on this process that resulted in various list of actions having the potential of improving the process.

In line with the model developed in Chapter 4, people and technology components of this process were also investigated. Again, SSM was utilised to carry out the investigation. The investigation of the technology component gave rise to carrying out a case study dealing with a very important component of ICT termed as 'project histories'. The people's component investigation gave birth to three case studies provided by three participants involved in the study. These case studies focussed on a bridge project, a road project and the use of an innovation in a construction project.

A list of actions is formed as a part of each case study carried out through SSM. This list of actions has the capability of dealing with issues hampering the effective integration of the three components, process, people and technology providing effective integration as was emphasised in the model presented in Chapter 4. The implications of carrying out the SSM studies are explained in detail in Chapter 6.

Chapter 6
Integrating People, Process and Technology

The objective of this chapter is to discuss how the use of SSM has contributed towards the integration of People, Process and Technology. The main contribution of SSM can be seen as achieving three components of KM. These are knowledge capture/elicitation, knowledge creation and knowledge sharing.

The first section describes various types of knowledge that was elicited when SSM was undertaken and how it is beneficial to the pre-tendering process. The next section describes various knowledge creating activities through carrying out a SSM study resulting in a list of KM actions. This section also discusses what strategy needs to be adopted in order to execute these actions. After this, the role of SSM as a KM tool in enhancing learning and facilitating a move towards becoming a learning organisation is discussed.

6.1 SSM Contribution towards Knowledge Capture and Elicitation

A large amount of knowledge in an organisation remains unnoticed and hidden in the form of organisational routines, processes and in the employees' heads. The SSM investigation presented in Chapter 5 demonstrates an example of knowledge capture and elicitation within a pre-tendering process. As a result of the investigation, many hidden facets of the pre-tendering process was unearthed causing the knowledge involved in a tacit rich process to become explicit and available to be effectively shared and used by others. Additionally, knowledge assets that are part of the process became noticeable and this made knowledge capture easy and robust.

The main contribution of adopting a SSM approach can be recognised as giving structure to an otherwise informal and unstructured pre-tendering process. It highlights the strategic importance of this process and presents it as a mission-critical business process that has great implications on organisations interests. This is delivered through developing 'rich pictures' which is an important element of the SSM approach. A rich picture of the pre-tendering process (validated by the participants) presents rich explicit pictorial knowledge of the structure of the process, together with values and beliefs of involved participants that highlights underlying issues involved. 'A picture is worth a thousands words', and a picture

such as a rich picture, assiduously drawn to provide a snap shot of the situation involving issues, beliefs, perceptions is worth more than a 'thousands words'. It is best understood and assimilated only when looked at. A conventional flow chart fails to provide the context and hence falls short of delivering the promise that a rich picture can deliver. The development of rich pictures strongly facilitated the research work. The participants, when they saw themselves represented in a situation portrayed through a rich picture, were in a far better position to discuss the issues and discuss their ideas than by example providing a narrative textual 'history'.

The knowledge elicitation stage of SSM (i.e. developing rich pictures) made it clear that the process of pre-tendering is not a simple one. It is a complex process that involves the vigorous interaction of people and technology. This led to the exploration of the 'People and Technology' interactive component of the pre-tendering process. It is in accordance with Process, People and Technology Triangle of the model presented in Chapter 4 showing interdependency and interrelation of these three components.

It is argued above that better understanding of the process is established when a rich picture is looked at and assimilated by the person (reader) based on his/her cognitive properties and worldview. Table 6.1 summarises the SSM investigations based on the model presented in Chapter 4 to demonstrate and illustrate how knowledge elicitation has increased understanding and is beneficial to the pre-tendering process.

Table 6.1: Knowledge elicited in SSM investigation

Model Component investigated by SSM	**Elicited Knowledge**	**Benefit to Pre-tendering process**
Process (Pre-tendering)	Networking with clients is extremely important.	Improving the networking process means early spotting of prospective projects
	Clients are losing engineering knowledge	This means there may be more work involved than initially thought in the project so be prepared
	Understanding clients and their business is essential	Improving the understanding of the clients will help develop the skills within the organisation to complete clients projects in far better way
	Relations with supply chain trading partners influences the pre-tendering process	Improving relations with supply chain partners such as consultants, suppliers and subcontractors will help in obtaining best quoted prices that will result in a quick and reliable preliminary estimate of the project's expected time and cost.

	Criteria for selecting or rejecting the prospect is missing	By developing the criteria it is possible to logically select and reject a prospect hence having a good rationale to support the decision made.
Technology (Project Histories)	Senior management support is needed for full diffusion and adoption of the technology within the organisation	It will help in developing a business case to convince senior management who may have different priorities for introducing IT systems and new processes
	It is important to have a framework to know what is the important information and knowledge that should be captured or preserved from current projects	It will help in capturing and preserving required information and knowledge, which will then be used in the pre-tendering process
	It is important to have a user friendly and effective format of the project histories	It will assist in effective use and search of project histories
	A continuous monitoring and control of project histories is very important and extra resources are required for this purpose	It will help in developing a case for KM function to take up this responsibility
People	It is important to know client expectations about price and value.	It will help in streamlining the pre-tendering process based on what clients actually want
	The community may play a role in some projects. It is important to know what sort of issues can occur in dealing with the community as an interested stakeholder	It will help in developing early strategies of dealing with the issues when community becomes part of the project
	It is essential to define competitiveness for the organisation and devise the criteria that will measure competitiveness for the organisation.	In the pre-tendering process, it will help in considering what sort of projects may add to the competitiveness of the organisation so that focus is maintained in winning those of strategic value
	It is essential that clients' technical requirements are questioned and other alternatives are sought	It will help during the pre-tendering process to think of the alternatives and adopt a more effective alternative when preparing the bid
	It is good to have access to external knowledge sources in order to acquire knowledge about new innovations and products	It will help in the pre-tendering process to know of innovative products that may improve productivity
	Conferences and external events are important for the dissemination of useful knowledge	By going to conferences and other external knowledge dissemination events it is possible, while carrying out pre-tendering process, to know of innovations that may provide various alternatives

6.2 SSM Contribution towards Knowledge Creation

The main objective of the SSM is to improve the process under study. A list of several actions is produced which has the potential, when acted upon, of achieving the perceived improvements in the process. The SSM investigations described in Chapter 5 produced various lists of actions under the category of Process, Technology and People. Undertaking these actions would require a particular strategy on the part of the organisation. Some actions will have an effect on culture (the way things are done) in the organisation and some would require generation of new knowledge and would require external interaction and collaboration with knowledge sources. Table 6.2 illustrates these actions and appropriate strategy that needs

to be considered in order to implement the action. Actions having an impact on the culture of the organisation would require internal change projects to handle that change. Some actions would require collaboration with external knowledge sources such as academia or other industry-academia collaborative initiatives to undertake projects to deliver and create the required knowledge. Some of the actions would require both internal change projects and external collaborative research projects.

Table 6.2: Knowledge creation in SSM investigation

Model Component investigated by SSM	**Proposed Action as a result of SSM Investigation**	**Impact upon**		**Appropriate Strategy**
		Culture	**External Knowledge Procurement**	
Process	Improve understanding about clients, their businesses, roles and projects they may invite tenders for.		✓	Collaboration with External Knowledge Sources
	Enhance networking skills of the staff liaising with clients and develop a guideline to undertake successful networking and socialising with them	✓	✓	Collaboration with External Knowledge Sources & internal change project
	Establish decision criteria that quantitatively assesses a particular prospect in order to assess its feasibility of converting that prospect into a tender bid		✓	Collaboration with External Knowledge Sources
	Maintain and enhance relations with trading partners such as consultants, suppliers and subcontractors to obtain the best quoted prices and develop a quick and reliable preliminary estimate of the project expected time and cost	✓		Internal Change Project
Technology	Obtain senior management buy-in and development of a corporate-level implementation strategy at for the creation and use of project histories—appropriate leadership is required to bring this change	✓		Internal Change Project
	Deciding on a framework to signify what is the important information and knowledge that should be captured or preserved from the current projects		✓	Collaboration with External Knowledge Sources
	Deciding upon a user friendly and effective format of the project histories		✓	Collaboration with External Knowledge Sources
	Deciding upon who should be gathering the required information and knowledge and who should be creating and developing project histories—this would involve investigating an option for staffing an organisational KM function to implement such responsibilities	✓	✓	Collaboration with External Knowledge Sources & Internal Change project

	Investigating current technology available in the market to create and develop project histories and how their efficiencies could be compared with technology currently being used within the organisation		✓	Collaboration with External Knowledge Sources
	Once project histories become operational, monitoring and controlling their operation should become an embedded process. A KM organisational function should take up this responsibility	✓	✓	Collaboration with External Knowledge Sources & Internal Change project
People	Know the clients expectations clearly, is it price or value?		✓	Collaboration with External Knowledge Sources
	Ascertain to what extent, community will be a part of the project and what could be the possible ensuing difficulties		✓	Collaboration with External Knowledge Sources
	Devise the criteria that will define the competitiveness for the organisation		✓	Collaboration with External Knowledge Sources
	Learning to question the clients' technical requirements and always looking for alternatives	✓		Internal Change Project
	Involve senior management and make them aware of the benefits that external knowledge may bring to the organisation in order for them to budget for people to attend conferences	✓		Internal Change Project
	Decide a framework to decide what are the important ideas and techniques to learn from a client's point of view and also from an organisational point view that matches organisational strategy and vision		✓	Collaboration with External Knowledge Sources
	Identify conferences or other external events that could be useful for disseminating knowledge considered helpful for the organisation;		✓	Collaboration with External Knowledge Sources
	Ask project managers to identify and report on innovation opportunities that may be able to be used while executing projects	✓		Internal Change Project
	Devise selection criteria for rewarding employees by selecting deserving candidates for attending conferences	✓	✓	Collaboration with External Knowledge Sources & Internal Change project
	Arrange a seminar or socialising event where employees returning from a conference with particular knowledge could share and transfer it to other employees in the organisation. Also publish how new knowledge has contributed to improved performance at the personal and/or organisational level so that there is an explicit cause-and-effect link between being open to knowledge-pull and adopting an innovation.	✓		Internal Change Project

6.3 SSM Contribution towards Knowledge Sharing

Another aspect where SSM has contributed is the sharing of knowledge among the participants involved in the research. During the development stage of rich pictures and its validation, participants understood each others role more clearly. The design managers appreciated the importance and value of the business manager's role in efficiently networking with clients to obtain knowledge of prospective projects. In the same way, business managers developed an enhanced understanding of the role of engineering managers and design managers in carrying out the pre-tendering process.

A SSM process, carried out with the pre-tendering team, can provide a knowledge repository for new team members and provides them with knowledge of how this process has been carried out by the earlier team. It also has training implications where SSM investigations can simulate a training module to demonstrate a certain process. A direct utilisation of SSM was realised during the research process when the pre-tendering team was disbanded. Two of the six participants moved to different organisations and the remaining four were deployed on different projects hence taking their knowledge of carrying out the pre-tendering process along with them. In this scenario, SSM investigation can be efficiently and robustly used to disseminate the knowledge as new team is formed.

6.4 Learning in the SSM and a Move towards a Learning Organisation under KM

Senge (1990) envisioned a learning organisation as one that is continually improving its capacity to learn and change owing to achieved learning. SSM provides a systematic way of achieving this aim. It is evident in the SSM investigation of the pre-tendering process that knowledge that is elicited and knowledge that is created in the form of list of actions, inadvertently causes learning and acts as a change agent for the organisation. Once these actions are implemented and the change process is on its way, new issues will emerge giving rise to different situations and problems. A new cycle of SSM investigation can then be initiated to elicit new knowledge and devising actions to handle the new situations. In this way, SSM has the capability of becoming an integral part of a continuous learning and change cycle within the organisation.

Deploying a SSM initiative in the organisation also delivers an essential KM initiative. It can be noted in Table 6.2 that actions proposed as a result of a SSM investigation impacts the culture of the organisation and requires collaboration with external knowledge sources to generate new knowledge. Its chances of success most likely increase when an organisation is undertaking a KM initiative. The model presented in Chapter 4 suggests that a KM initiative reduces the cultural resistivity of the organisation and develops strong 'pull forces' within the organisation under which increases its ability to access external knowledge and collaboration with external knowledge sources. It is therefore appropriate to consider SSM as a KM tool and it is suggested that it be used in organisations where KM initiatives are already being effectively deployed.

6.5 Summary

This chapter discussed the role of SSM in demonstrating integration of Process, People and Technology within the pre-tendering process. As a result of the SSM investigation, various types of the knowledge are elicited and captured in each category. The knowledge thus obtained develops a clearer understanding of the pre-tendering process and establishes it as an important strategic and mission-critical business process. The other contribution of SSM that can be realised is the generation of new knowledge in the form of a list of actions. Organisations need to have an appropriate strategy (or plan) in order to implement these actions. Some actions impact upon the culture of the organisation and trigger suitable internal change projects to accomplish the illustrated actions. Some of the other actions suggest that collaboration with external knowledge sources (e.g. Academia) should be considered to generate the required knowledge for the sake of the improvement of the pre-tendering process.

Lastly, it is emphasised, that a KM initiative in the organisation is a pre-requisite for the seamless and effective use of SSM. For this reason it is appropriate to consider SSM as a KM tool which has the capacity of providing a mechanism for efficient integration of Process, People and Technology.

Chapter 7
Conclusions and Recommendations

This chapter develops a conclusion to the thesis by discussing findings from Chapter 4, Chapter 5 and Chapter 6 in order to answer the questions posed and objectives set in Chapter 1. The Chapter starts by summarising the research findings related to the research questions. It then discusses the potential contribution that this study makes to both construction management theory and practice. Finally, the chapter ends with a discussion of recommendations arising from this study and recommendation for future research.

7.1 Main Research Findings

The main research premise was stated in Chapter 1 (Section 1.2) as:
The construction management literature discusses the importance of innovation as a means of improving productivity but it does not sufficiently describe mechanisms through which innovation can be embedded into the construction industry's operating culture. This may result in failure to innovate and/or tardy adoption and diffusion of innovation thus locking the industry into a status quo.

The core of this research addresses three main questions:

1. How does KM support innovation?
2. How is KM supported by the learning organisation concept?
3. Can it be demonstrated that KM has a role to play in enhancing innovation and learning in the construction organisations?

7.1.1 How Does KM Support Innovation?

This research question is predominantly answered through a rigorous cross disciplinary literature review as presented in Chapter 2 and specifically addressed in Section 2.10.

KM supports innovation in two ways. First, it helps organisations locate innovative knowledge in the outside world to pave a way to bring that knowledge inside the organisation and to effectively incorporate it into their work practices/processes. Second, KM supports innovation by helping organisations perform innovatively. This is done through KM processes

helping these organisations to initially obtain, assimilate and then use this external innovative knowledge. KM promotes and regulates the cycle of external innovation adoption and its diffusion—innovation performance results from this process

Innovative initiatives in project delivery methods such as privatisation, design/build, at-Risk construction management and seeking collaboration through innovative relationship management techniques such as joint risk management and partnering have been cited among several examples of innovations that have the capacity to boost the industry's productivity (Kumaraswamy *et al*. 2002). The related knowledge is developed external to the organisation, mainly by research centres/academia referred to as knowledge sources in this thesis sometimes in collaborations with industry but with the involvement of a few organisations. The whole industry will benefit only when such knowledge is adopted and used industry wide. KM facilitates this mechanism by helping organisations locate such innovative knowledge and then help these to diffuse it within themselves in order to benefit from it by making it part of the regular operation. Innovative initiatives cited above are example of new knowledge generally developed external to construction organisations by academia and collaborative research centres. This research has demonstrated the possible advantages that using KM can provide through collaboration with academic knowledge sources. The use of SSM in this thesis provided an example of how new knowledge can be generated, shared and used within an organisation through harvesting its own knowledge from its own experiences.

7.1.2 How is KM supported by the Learning Organisation Concept?

A learning organisation is generally referred to as an organisation that continually enhances its capacity to learn and adapt (Senge, 1990). The link between KM and the learning organisation concept is developed, again, through the cross-disciplinary literature review in Chapter 2, specifically in Section 2.9. Both these philosophies share the same vision of performance improvement through learning. It is important that relevant knowledge should be readily made available and used for continuous learning to occur. KM does this best through the creation/generation of knowledge and providing a mechanism for its effective dissemination and use to benefit organisations. Hence it becomes difficult to purposely provide distinctions between the KM and Learning Organisation concepts. They are invariably linked to each other. For this reason Cavaleri *et al* (2005) suggested that the simplest way to achieve the vision of a learning organisation is to integrate organisational learning processes with KM initiatives.

7.1.3 Can it be demonstrated that KM has a Role to Play in Enhancing Innovation and Learning in Construction Organisations?

The investigation of first two research questions predominantly through literature review, led to the development of theoretical model presented in Section 2.12 and Figure 2.27. This shows that KM is linked to both innovation and learning. KM initiatives in an organisation help it transform itself into a learning organisation. Thus, such organisations will always be far more likely to be more innovative than non-learning organisations.

The investigation of this research question, aimed to demonstrate any link between KM, innovation and being a learning organisation. This led to the development of the methodology described in Chapter 4. A grounded theory methodology was used to map the present circumstances, within two leading Australian Construction Contractor organisations, dealing with their knowledge and ICT use. The various categories that emerged in this research process were as follows and provided insights in the innovation behaviour of the organisations:

1. Segregation between People, Process and Technology
2. Culture
3. Link with External Knowledge Sources (Push Vs Pull)
4. External environment
5. A gap between research and practice
6. Feedback to external sources of innovation
7. Existing Knowledge in the organisation &Internal Knowledge Bank

These categories were represented in the form of the model shown in Figure 4.1 to facilitate understanding of their relationship with each other and to prompt further research.

The core category that emerged from this research cycle is ‘segregation between People, Process and Technology’. The implication of this is that people often bypass available knowledge of processes and technology to do their work, making limited use of knowledge existing within the organisation in form of explicit knowledge or tacit knowledge residing in people’s heads about organisational routines (processes). This has led to the development of a culture within the organisation that resists the flow of new externally generated knowledge being introduced to the organisation. It is debatable whether segregation between the three

components of people, process and technology has led to the formation of this culture or whether it is the culture itself (inherited from the construction industry) that is actually responsible for this segregation. Non-use of available internal knowledge, because of segregation and formation of a culture that resists the flow of new knowledge, contributes to a gap between current research and practice. These could be due to very little feedback emanating from construction organisations to researchers about knowledge they are using. Internal knowledge banks of the organisation studied in this research thesis were almost non-existent due to limited efforts being applied to develop and maintain such internal knowledge banks.

The second phase of the research assumes that the weaknesses identified in the earlier phase of the research can be rectified by the use of KM. This has led to the development of the model illustrated in Figure 4.2 which depicts KM initiatives in the organisations having the ability to dissolve cultural resistance through appropriately addressing vision, leadership and related soft factors and provide means for effective integration of the three components of people, process and technology. This ensures optimum use of the knowledge available with in the organisation. This optimum use of the knowledge would generate a further quest within the organisation to pull more externally available new knowledge within the organisation and readily adjust/change work processes to employ it. This would be reflected in some form of an innovative output from the organisation. When this cycle of knowledge procurement from the external world and knowledge deployment within the organisation becomes a regular phenomenon through deploying KM processes, it would provide the organisation with the ability to transform itself into a learning organisation (i.e. an organisation that readily changes its work practices in order to conform with the new knowledge externally obtained with a vision of continually improving its performance).

Figure 4.2 is reproduced as Figure 7.1 to reinforce the significance of this model as an important output of the thesis.

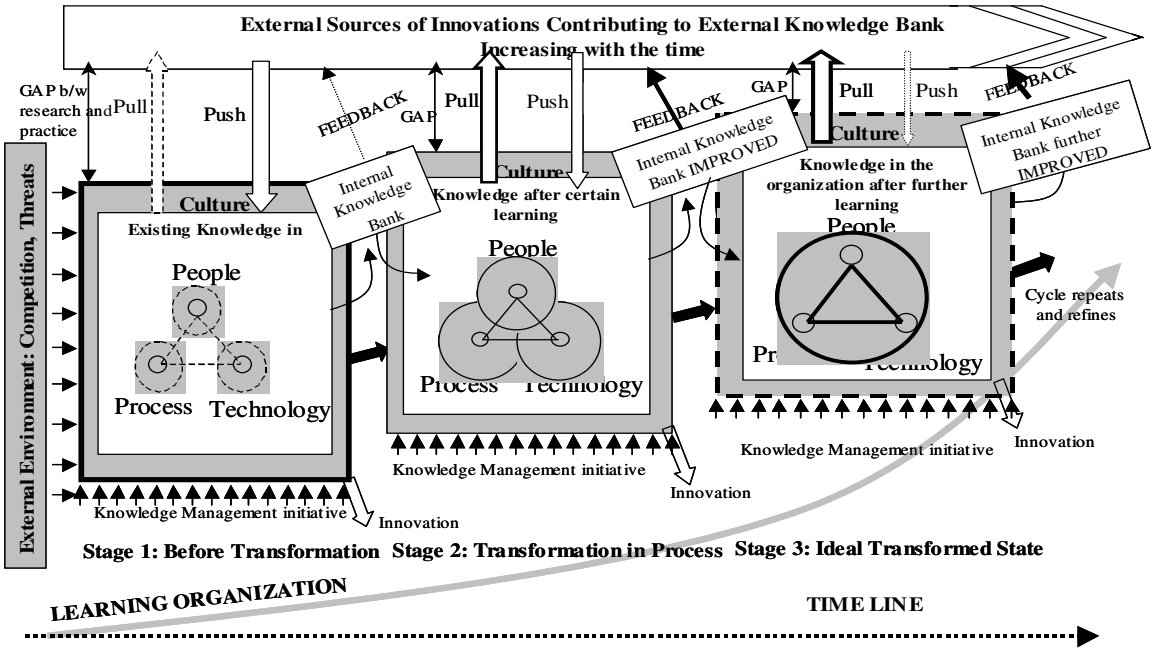


Figure 7.1: Organisational learning and transformation through KM

SSM was selected as a KM tool/technique for carrying out further research to demonstrate or to provide a 'proof of concept'. SSM may be viewed as a KM tool because it shares similar characteristics to that of KM, as highlighted in Section 5.1. One critical business process, pre-tendering, used by one leading Australian Construction Contractor organisation was selected to demonstrate how SSM could be used as a KM tool. The aim was to intervene and cause an improvement in this business process by using SSM as a KM tool. Each component of the people, process and technology triangle was investigated using a SSM approach. This led to the development of case studies in the following order:

1. Process: A case study of pre-tendering process identified people and technology being employed and issues influencing this business process. SSM investigation consists of developing a rich picture, Root Definition, CATWOE, and list of actions to improve the situation as discussed in detail in Section 5.3

2. People: It was possible from the pre-tendering case study to identify several knowledge assets (people) with relevant knowledge tacitly residing in their heads from working on previous projects. Access to this knowledge is important as this knowledge, in one way or other, has the capacity to improve the process of pre-tendering. This means that if knowledge apparently hidden in people's minds can be made explicit and available for sharing, it is possible through the use of that knowledge to improve the performance of the pre-tendering process. In the light of the thesis, this can be referred to as integrating people with the process. This led to the development of three SSM case studies presented in Section 5.5 and the list of

actions that were developed that could integrate people and process components thus improving the process of pre-tendering.

3. *Technology*: The case study of pre-tendering also highlighted the technology that was being used to carry out the process and is also riddled with issues and problems. So a separate case study was developed using SSM as presented in Section 5.4. The investigation revealed various problems and issues that inhibited it from being effectively integrated with the other two components of people and process. Again, a list of actions was developed that had the capacity of dealing with the problems encountered and could cause effective integration of technology with process and people.

SSM as a KM tool served three purposes:

1. Knowledge elicitation
2. Knowledge sharing
3. Knowledge creation.

It helped elicit knowledge useful for the improvement of the pre-tendering process as presented in Table 6.1. It also paved the way for further knowledge creating by facilitating the development of various lists of actions shown in Table 6.2. Some actions will have an impact on the culture of the organisation and would require internal change projects to accomodate that change. Other actions would require collaboration with external knowledge sources such as academia or other industry-academia collaborative initiatives to undertake projects to deliver and create the required knowledge. Further actions would require both internal change projects and external collaborative research projects. SSM also caused knowledge sharing among the participants as well as any other non-participants who through studying the investigation would get a good grasp of how this process has been done in the organisation. This kind of documented study can provide extremely useful information and explicit knowledge that can be transferred and shared when a team integrates new members as existing members leave.

7.2 Contribution of the Research

KM research is relatively new in the construction industry. This research has significantly added to the existing body of knowledge in the domain of KM by effectively linking KM with innovation and learning. This provides a strong case for employing KM in order to make

innovation a regular phenomenon within the construction industry and encouraging organisations to transform themselves into learning organisations. This case was developed through an extensive cross-disciplinary literature review and developing a detailed/validated model that exhibits the effect of KM on developing organisational learning to transforming an organisation into a learning organisation. This model provides a useful means of communicating and explaining to construction personnel, how KM can be of service to their organisation. This effect was confirmed, while undertaking the research, by research participants who indicated, on numerous occasions, that the model was extremely useful to them in enhancing their understanding of what KM could offer them.

The research has demonstrated in a practical way how SSM can be used for capturing, sharing and creating knowledge. Only one process was investigated in this thesis; however organisations can make use of the same method for other crucial processes. This could result in the development of knowledge repositories that can be used for training purposes for new staff and to also make them familiar with existing practices within the organisation.
The research has developed the realisation that people should be effectively integrated with processes they use and technology they employ to complete their job—KM is a way to facilitate this integration. This integration can be obtained through cultural change resulting from the implementation of KM initiatives. The research has endeavoured to bridge an identified gap between research and practice (academia and industry) by arguing that organisations need to effectively work in collaboration with knowledge sources (academia) and has also demonstrated how to further develop knowledge creation using SSM. The research also demonstrates how this collaboration should provide stronger effective feedback from industry partners relating to new knowledge they utilize or problems they face. The resulting collaborative effort could, and should, lead to the development of new knowledge that industry readily wants.

A PhD thesis is required to demonstrate mastery of research methodologies and selection of an appropriate approach for PhD research design. From a purely academic point of view, this research has added value by utilizing the qualitative methodologies of grounded theory and SSM to make sense of a complex business process. Qualitative research approaches are becoming increasingly popular in construction research and this research extend the experience of using these techniques by incorporating two qualitative methodologies that are proven in other fields and have been successfully used for over thirty years. This has generated a body of knowledge which other qualitative researches can refer to or capitalise

upon. This study, through explicating the research approach and how it was undertaken, provides other researchers with the benefits gained from this particular research innovation—using SSM as a KM tool for undertaking research.

Finally, a PhD thesis is expected to generate work of a publishable standard. This thesis work resulted in the publication of 1 book chapter, 3 journal Papers and 14 conference papers. One book chapter and one journal paper has been accepted for publication. One journal paper and a conference paper are currently under review.

7.3 Recommendations

As a result of conducting this research, the following recommendations can be made:
Construction organisations should adopt KM in order to become innovative and improve their productivity levels. The 'proof of concept' presented in this thesis should be able to provide a sufficient rationale for construction organisations to start adopting KM practices.

1. The construction industry needs to understand the difference between an IT (as a purely technology) initiative and a KM initiative (that relates more broadly to integrating technology such as IT as an enabler of KM, business processes and people), so that knowledge is viewed as a dynamic resource and an asset that can bring business benefits to organisations. This more fully KM-centred rather than IT-centred focus will collectively form a sound basis for a successful leap towards a 'knowledge economy'.
2. Construction organisations can follow the methodology of Grounded Theory and SSM as a KM tool as outlined in this thesis to map their business processes and chalk out paths for further improvements. This exercise will unearth knowledge of immense value generally hiding in peoples' heads and organisational routines. Rich pictures developed as a part of SSM study can be used by construction organisations for training new team members or for new staff induction purposes in order to give them a better appreciation of existing organisational processes hence contributing towards organisational learning.
3. Construction organisations need to realise that strong integration of people with the processes they work with and the technology they use is important to ensure optimum utilisation of knowledge available in the organisation. This integration could then create a further quest for knowledge that triggers organisations to externally procure

knowledge from outside sources. Organisations need to develop a supporting culture enable this. A KM focus will then inevitably emerge.

4. Construction organisations should leverage the impact of their collaboration with external knowledge sources such as research centres and universities, to work together for discovering solutions to practical problems they face. At the same time it is also immensely important for these organisations to provide increase feedback to the research bodies about the knowledge they obtain and then use. This will help external research bodies to further refine and fine-tune developed tools and techniques. KM needs to be at the heart of this endeavour. This can be further manifested in the development of COPs where practitioner and researcher will collaboratively work together forming a community of practice (COP) and feedback from practitioner would become instant.
5. An organisation's knowledge assets can be its defining and uniquely differentiating competitive advantage. It is important for construction organisations to improve the development and maintenance of their internal knowledge banks. Grounded theory and SSM unearths a great deal of knowledge. This knowledge should be appropriately indexed and stored for employees to quickly retrieve and put to use. At the same time, a mechanism needs to be put in place using KM tools and techniques to capture knowledge from previous and existing projects. This would lead to the development of project histories that needs to be made part of the internal knowledge bank and recognised as an important and valuable asset produced as a by-product of solving problems, interacting with project participants and experimenting with innovation or adaptations of well understood processes.
6. Construction organisations can use the techniques adopted in this research to enhance service, administrative and market innovations.

7.4 Recommendations for Future Research

Undertaking this research has opened many venues for further research initiatives which are presented below:

1. During this research it became evident that the two leading Australian construction organisations that participated in this research found it hard to distinguish between a KM initiative and an IT initiative. Knowledge Managers of the respective organisation, however, had a good understanding of KM and how it differed from an

IT initiative. But they faced a challenging task in changing the perception of influential people in the organisation that could champion and sustain KM initiatives. This forms the basis for a research initiative to investigate the perception of a broader range of organisations about the need for and value of KM through a quantitative study in order to devise strategies to improve KM in the industry.

2. The use of SSM as a useful KM tool has been demonstrated in the case studies to improve the process of pre-tendering. It is suggested that this approach should be extended towards other processes as well. For example, safety practices of a construction organisation can be improved through using SSM as a KM tool by helping people who carry out the safety management process, to integrate this process and the technology they use and at the same time try to obtain innovative knowledge of safety practices being generated/created outside its boundaries.
3. The SSM investigations can be put together in an electronic format manifest in the applications such as the digital dashboard application/ knowledge portal as presented in Walker *et al.* (2006). Through using this portal, it is possible for people to: connect their knowledge with other people; to link to information and knowledge about business processes; and to access KM support technology. This makes it easier to link people to improve their knowledge about what (people, processes and technology) resources are available to help them undertake their work more productively.

4. This research has focussed on two leading Australian construction organisations that are representative of the largest Australian construction organisations. However, small and medium size enterprises (SMEs) form the largest part of the supply chain working with these large organisations. As the supply chain management philosophy has gained increasing interest in the more recent construction industry literature, this would give rise to shifting the competitive focus from organisation vs. organisation to chain vs. chain. Also, from an innovation point of view, it is more productive that a whole supply chain work together to perform innovatively. This can be achieved when knowledge not just information is shared both upstream and downstream throughout the supply chain. There is room for an exciting research initiative regarding KM in supply chains with a view to creating learning chains.

5. The composition of KM being 90% a human issue and 10% a technical issue illuminates the fact that KM has a lot more to do with HRM than technology but this

area is relatively under-explored. This an area of research that could bring promising results by better integrating KM with HRM functions within the construction industry to develop an improved framework where it may be possible to quantify how people's intellect and knowledge is best developed and leveraged to the benefit of the organisation. Section 2.11.2 has introduced the importance of this.

6. As KM initiatives increase in the construction industry, quantitative studies can be undertaken to measure the significance (tangible; intangible; economic, environmental and social significance) of KM on innovation and learning.

7.5 Summary

This chapter provides a summary of research findings and put these together to answer the research questions identified in Chapter 1. KM links with innovation in two distinct ways. Firstly by helping organisations obtain external innovative knowledge and helping it absorb and incorporate this knowledge into the organisation. Secondly by helping organisations to capitalise on existing knowledge and new knowledge obtained from external sources to perform innovatively. This output is only possible when an organisation is committed to become a learning organisation through continually enhancing its capacity to perform innovatively. This research has put forward a model that shows a path to achieve this vision, by using SSM as a KM tool. This path is manifested in form of list of actions that demand internal change projects and increased collaboration with the external knowledge sources.

This chapter has also discussed the contribution of the research from an academic and practice point of view. The chapter also presents an argument that techniques developed in this thesis enhance the body of knowledge in the area of KM and provides a convincing case for the construction organisations to start considering the implementation of the KM initiatives. In section 7.2, the specific requirements of a PhD thesis, together with a summary of contributions made by this thesis were presented. Finally, this chapter has presented recommendations that have arisen from this thesis and also shows future directions of research emanating from this research.

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Appendix A: Sample Notes Taken in Phase 1

Interview No 4
Organisation Interviewed: A

Expert in IT stuff. Using Lotus 123 in 80s.

If you have basic IT skills learning such system is not problem. (Basic IT Knowledge)

He had driven this application from the start in the organization (Diffusion)

Initially showed a response that shows he didn't like to be questioned as user.

Advantage is electronically keeps everything, filing system (Advantages of ICT)

He knew people more and their capabilities when they have get togethers in one of the project of which he was a project manager. He underrated few before (Culture/trust)

Would u like to have meeting remote, you cannot see me I cannot see you. We have no interaction. A lot of body language has to go in communication which doesn't happen in written words. (Limitations in ICT)

The use of the system should be planned at the start of the project that how this project is going to be delivered using this system by defining different packs right in the beginning.

The system saves you the time. Managing Information Ingoing/outgoing/filing system. (Advantages of ICT)

Need to improve on Estimating while tendering. (Limitations in ICT)

Get together should be started. They have benefits. Time seems to be wasted but it can be legitimised that persons get the stress off them, know each other capabilities and know each other more. (Knowledge Sharing & networking)

Should have facility where ever I go I can access. I go out of this office, can't access my files hence use is limited. (Limitations in ICT)

Memo: Very high skills in IT therefore he loves using the application and aware of its all the functions and shortcomings and have meaningful suggestions to improve the system. Because of high IT skills, he didn't have any training course. He learnt it by himself and this is possible.

** Text in parenthesis show the coding for this data set during the interview*

Appendix B: Sample Notes Taken in Phase 2

Interview No 1
Organization Interviewed: A
Main Topic: Pretender Stage Exploration

- IB leads the pre-tendering team and looks after the two main aspects of pre-tenders, design management and estimation.
- Fairly good user of Lotus Notes (IMS: Information Management System).
- Whenever pretender for a potential project has to be carried out a Tender Pack is set up on IMS that provides central database for correspondence.
- The biggest problem faced in completing this task is the lack of historical information of previous projects.
- Historical Information is important while deciding the rates for the project under consideration.
- Regional Manager makes a decision to go for a tender or not.
- He is of the view that knowledge is lost when history of the projects is not kept.
- There is an awareness required of the significance of project history.
- Organisation used to win 1 in 2 or 3 tenders but now the winning rate is 1 in 5 to 7.
- Division Structure is a problem.
- There is need to protect access to prevent corruption.
- No body is prepared to pay for developing project histories.
- It is project manager's responsibility but often they have no time at the end of the project and most probably they are assigned a new project.
- There is a need to look into the organization selection procedure of the Project Managers to figure out who does what well and assign him the job accordingly.
- Pool of PM is not very good. There is need to have a range of project managers to match with particular clients.