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EFFECTIVE KNOWLEDGE MANAGEMENT AS A PERFORMANCE ENHANCING TOOL IN CONSTRUCTION PROJECT MANAGEMENT

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Johannesburg, 2007

Declaration

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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Abstract

Knowledge management is concerned with the development and exploitation of the knowledge assets of an organisation with a view to furthering the organisations' objectives. The vital role that knowledge management processes plays in the performance of business organisations has been the basis of several studies - a number of companies, operating in various other industries, have proven the need for, and performance enhancing benefits of, adopting knowledge management processes in one form or the other. Taking these accounts into consideration, this research study attempts to test the hypothesis that effective knowledge management use would constitute a performance enhancing tool in construction project management enterprise in South Africa. The research survey is thus carried out among construction project management professionals in South Africa.

The levels of awareness and use of knowledge management systems among construction project management professionals in South Africa is researched into; this revealed a mostly "medium to high" level of awareness and use. The Project Efficiency Review approach to performance measurement is primarily adopted for this study. This showed limited correlation between knowledge management use and enhanced performance in construction project performance. Other performance measurement approaches (Metrics, Economic and Market Value approaches) also showed limited correlation. Two causative factors for this situation are construction project scope changes and schedule delays, which are seemingly pervasive in contemporary South Africa. As such, further research is recommended to establish more appropriate "objective" performance measurement approaches that would be able to accommodate these complexities. This would facilitate the making of a business case for knowledge management use in construction project management.

Dedication

To God Almighty, for being with me through the wilderness thus far – and here's hoping for a quick crossing-over to the "promised land".

Acknowledgements

I would like to thankfully acknowledge the immense contribution of Professor Alfred Talukhaba and Advocate Alistair Glendinning, my research supervisors, for their instruction and guidance during the course of this research.

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List of Abbreviations

ASAQS – Association of South African Quantity Surveyors

BPR – Budget Performance Ratio

CIDB – Construction Industry Development Board

GDP – Gross Domestic Product

EPR – Employee Productivity Ratio

IT – Information Technology

MS-DOS – Microsoft Disk Operating System

OBPR – Overall Budget Performance Ratio

OEPR – Overall Employee Productivity Ratio

OPR – Overall Performance Ratio

OSPR – Overall Schedule Performance Ratio

PER – Project Efficiency Review

PMBOK – Project Management Body Of Knowledge

Pr CPM – Professional Construction Project Manager

SAACE – South African Association of Consulting Engineers

SACPCMP – South African Council of Project and Construction Management Professions

SAIA – South African Institute of Architects

SPR – Schedule Performance Ratio

CHAPTER 1: INTRODUCTION

1.1 Background

Project Management is the application of appropriate knowledge, skills, tools and techniques to project activities to meet project requirements (PMBOK 2004). It is the planning, organizing, directing and control of company resources for relatively short-term objectives that have been established, in order to achieve specific goals and/or objectives (Kerzner, 1992). Projects are usually flexible, setting up goals that need to be achieved using transient resources, including human resources often "seconded" by the resource managers (i.e. project managers) (Frimpong 2003). Construction project management can therefore be conceived of as the application of project management principles and processes in the execution of a construction project. Construction project management activities are usually undertaken by construction industry professionals, engaged singularly or as part of consulting and/or contracting organisations operating in the construction industry.

The construction industry plays a vital role in the economic development of South Africa (and indeed most countries), with over R57 billion spent in the industry in 2002 (SA Construction Industry Report, 2004). This amounts to 5% of the GDP and about 30% of the Gross Domestic Fixed Investment. The industry also contributes significantly to employment, offering job opportunities, directly or indirectly, to over one million people (Statistics SA, 2006). However, the construction industry is not without its own challenges, as records show a sharp decline in employment levels over the past 20 years, from about 255,000 formal workers in 1990 to about 160,000 in 2002 (BIFSA, 2002). The industry also recently experienced a 23,000 drop of total number of employees in the construction industry between December 2005 (estimated at 1 430 000) and March 2006 (estimated at 1 407 000) (Statistics SA, 2006)

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The factors responsible for the occurrence of past decline in the construction industry range from reduction in government capital expenditure on buildings and poor economic growth, to high interest rates and high levels of emigration of skilled construction industry professionals (BIFSA, 2002). Poor management is another reason that has been advocated as a cause of poor performance in the South African construction industry. Inadequacy of management skills and techniques has been identified as causes of severe annual loss (Schussler, 2003). The resultant poor performance has been shown to have its roots in poor management of design, planning and implementation activities in the construction industry, with consequent high rework rates, low productivity, and poor quality (Smallwood, 2000).

Ireland (1984) supports the view that the management of the building process is a major determinant of project performance, with the adoption of sound management practices seen as being fundamental to ensuring better project performance in the construction industry. It can therefore be deduced that there is a correlation between project management and performance in the construction industry.

The construction industry performance level has significant impact on the residents as well as the overall economy of South Africa. Low performance levels would logically lead to higher construction costs, which are ultimately passed on to the end-user. Customer dissatisfaction as a result of poor performance may lead to reduction in profitability and market share, and a higher level of susceptibility of construction firms to liquidation (Oliver 1980). The poor performance of the construction industry in South Africa may also bring about a divestment from the industry, which would further reduce the viability and sustainability of the construction industry further exacerbating the situation (Mbachu, 2003). Thus, the issue of poor performance in the construction industry is one that requires interrogation, with a view to elucidating on possible approaches of alleviating the situation.

1.2 Problem Statement

Construction projects present varied and often complex scenarios, involving project teams consisting of a wide range of specialist professionals (architects, engineers, quantity surveyors, planners, project managers, etc.) collaborating in the achievement of its successful completion. Due to the flexible and transient nature of construction/building project activities, processes and associated resources mentioned above, the project teams thus formed are usually dismantled upon the completion of the project. It has been noted that the project team, as a working unit, seldom outlives the project – a team created for the sole purpose of performing a given project will perform that project, and subsequently be disbanded, with team members reassigned when the project ends (PMBOK 2004). Existing personnel also retire or move on to other pursuits. The consequent risk of valuable empirical project-related knowledge being lost at the end of the project is therefore highly probable, unless conscious effort is made to accumulate and manage such knowledge in a systematic manner. Indeed, prior studies reveal that lessons learnt on many construction projects are often lost when the project team is disbanded at the end of a project and the parties move on to new projects. This results in much re-inventing of the wheel and repetition of past mistakes. The situation is further compounded by the fact that there are few mechanisms for capturing and sharing the new knowledge gained on construction projects (Latham, 2005).

Knowledge Management is concerned with the identification, acquisition, distribution and maintenance of knowledge essential to an organisation. There are several definitions of knowledge management, highlighting the different aspects of technology, processes and cultural issues involved.

Historically, the construction industry, it seems, has not effectively engaged in utilising knowledge management in its project management, thus contributing to the low performance levels elucidated earlier; the construction industry has only recently begun to adapt concepts of knowledge management to remedy the

situation outlined above (Anumba et al, 2005). There is therefore a need to explore possible performance enhancing benefits achievable by utilising appropriate knowledge management processes in construction project management in South Africa.

1.3 Objectives of Research

This research seeks to elucidate on benefits of knowledge management in construction project management enterprise, particularly the performance enhancing benefits derivable from the implementation of knowledge management as one of the basic tools in construction project management practices and activities. Specifically, the following objectives are set for this research:

- To broadly explore the present levels of awareness of the concept of knowledge management, as well as the recognition of possible performance enhancing benefits associated with its use, among construction project management professionals in South Africa.
- To examine the present general level of use of knowledge management tools and processes among construction project management professionals in South Africa
- To examine possible correlation between the use of knowledge management processes and enhanced construction project management performance.
- To examine the opportunities for, and obstacles/threats to, implementing effective knowledge management procedures and processes in construction project management enterprise.

1.3 Research Hypothesis

The application of knowledge management practices has been shown to contribute to enhanced business performance in several business fields and industries, from information technology through manufacturing to petrochemical (Despres and Chauvel, 2000; Robinson et al, 2005). The construction industry in South Africa, particularly in terms of construction project management, should not be an

exception. The hypothesis of this study is therefore that *the application of knowledge management systems and processes in construction project management would likewise contribute to enhanced project performance*. Knowledge Management use would enable project teams have ready access to required knowledge. This would help establish success models, avoid the repetition of past mistakes and would also form a basis for the development of better procedures; the end result would be enhanced performance and eventually, profitability.

1.5 Scope and Limitation

This research seeks essentially to focus on the relationship between knowledge management and enhanced performance in construction project management activities in South Africa. The traditional relationships among professionals in the construction industry has been significantly modified due to the introduction of the "professional" construction project manager to the project team – under this arrangement, the responsibility for project management and progress monitoring usually rests with the construction project manager and his/her team. This research study accordingly focuses on fully registered Professional Construction Project Manager (Pr CPM) members of the South African Council of Project and Construction Management Professions (SACPCMP).

Past research has identified knowledge management as an emerging phenomenon, a puzzling field; companies that claim to be implementing knowledge management programmes do very different things, the result of which sometimes is confusion and contradiction (Despres and Chauvel, 2000). Knowledge management activities therefore need to be defined so as to clarify a sense of vagueness regarding its value and importance. In addition, investigation would need to be carried out into how various organisations attempt to manage their knowledge resources, and how such knowledge is identified, depicted, stored and made available for future use by others.

1.6 Significance of Research

According to PMBOK (2004), knowledge is a fundamental resource in project management. Davenport and Prusak (1998) define knowledge as high value information, which can be used in making decisions and taking action. Such knowledge is intellectually intensive and is the outcome of human experience and interpretation. PMBOK (2004) glossary further describes knowledge as "knowing something with familiarity gained through experience, education, observation, or investigation; it is understanding a process, practice or technique, or how to use a tool."

In the highly competitive business world of the 21st century, the need for continuous strategically driven knowledge creation and management is a necessity, if any organisation is to achieve and maintain a competitive edge, in terms of performance and concomitant profitability. Large Japanese companies such as Canon and Sharp have relied on knowledge creation to foster long-term innovation and strong business performance (Davenport and Marchand, 2000). Indeed, the persuasive argument of the chief executive of Hewlett-Packard that "if HP knew what HP knows, we would be three times as profitable", articulates the motivation for more and more companies to move towards knowledge management in one form or another (Despres and Chauvel, 2000); the construction industry is not an exception.

It is therefore essential that appropriate knowledge management systems are put in place if the construction industry is to continuously improve its business processes (Latham, 2005). The importance of knowledge management is thus increasingly being recognised in the construction industry. There are serious dangers for companies that ignore knowledge management – they run the risk of simply repeating past mistakes, or worse, taking decisions that can lead to major disasters (Anumba et al, 2005). It is hoped that the outcomes of this research would contribute to the body of knowledge on performance enhancement through knowledge management use in the construction project management industry in South Africa.

1.7 Structure of the Report

This research report is divided into 5 chapters. Chapter 1 has thus far introduced the background for the research, the research problem as well as the research objectives, scope and limitations. Chapter 2 is a review of significant prior literature in areas related to the subject matter(s), in order to gain an in-depth understanding of the research problem. Specifically, the theories and practical performance-related benefits of knowledge management in various organisations are discussed.

Chapter 3 highlights the frameworks adopted for this study, including the research methodology and the methods used for selecting the research survey sample and data gathering. Chapter 4 embodies the data presentation and analysis, along with the discussion of the results and findings of the research.

Chapter 5, the final Chapter of the report, presents the research conclusions, and its relation and contribution to the existing body of knowledge. Recommendations are also made on possible directions of further study on the subject matter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The importance of knowledge management and its performance enhancing benefits have been largely demonstrated in various fields of business activities. Some of these benefits include improved business competitiveness, enhanced market value, significant cost savings and innovation. However, the construction industry is just recognising these benefits. Various challenges associated with knowledge management need to be addressed, such as the nature of knowledge, defining and understanding the knowledge process and resources, as well as choice of knowledge management tools. Performance measurement indices of the benefits of knowledge management systems and strategies are also elucidated; performance measurement approaches identified include the project efficiency review approach, the metrics approach, the economics approach and the market value approach.

2.2 An Overview of Knowledge Management

Human activity is inconceivable without knowledge, with the scope and types of knowledge being as wide and varied as all the varieties of human pursuits; it is knowledge which provides the basis of whole industries, plays a crucial role in the functioning of organisations, and is indeed the source of innovation and competitive advantage (Quintas, 2005).

2.2.1 Defining Knowledge Management

There are as many definitions of knowledge management as there are papers on the subject. The Oxford Advanced Learner's Dictionary defines knowledge as "the information, understanding and skills you gain through education or experience… the state of knowing about a particular fact or situation". This reveals the experiential nature of knowledge. The aforementioned dictionary also defines management as "the act or skill of dealing with people or situations in a successful way", thus showing the process to be goal-oriented.

Various authors have defined knowledge management, with all of them covering the same idea, but highlighting different aspects (Chang et al, 2003); according to Davenport and Prusak (1998), knowledge management is concerned with the development and exploitation of the knowledge assets of an organisation with a view to furthering the organisations objectives. The knowledge to be managed includes explicit, documented knowledge and tacit, subjective knowledge. Management of this knowledge thus entails all the processes associated with the creation, identification and sharing of knowledge. Young (2003) defines knowledge management as the creation and subsequent management of an environment which encourages knowledge to be created, shared, learnt, enhanced, organised and utilised for the benefit of the organisation, thus revealing a cultural aspect. Cross (1998) further posits that knowledge management is the discipline of creating thriving work and learning environment that fosters the continuous creation, aggregation, use and re-use of both organisational and personal knowledge in the pursuit of new business value. These definitions reveal the nature and various aspects to, and activities involved in, the knowledge management process.

2.2.2 Impact of Knowledge Management on Performance

Company value has been increasingly shown as being directly dependent on "intangible assets" such as intellectual capital and knowledge assets, as seen in the case of the computer software giant Microsoft, then a relatively small company with less than 14,000 employees in the 1990s, which was valued by the United States of America's stock market (in terms of market capitalisation) to be worth more than IBM, which had over 300,000 employees and had an installed base of large computers all over the world; the key to Microsoft's performance and profitability being it's product, MS-DOS (and later, "Windows"), an intangible asset which had become the standard for personal computer operating systems software. Roos and Roos (1997) state that in 1996, 94% of Microsoft's market value (US$119 billion) came from intangible (i.e. knowledge) assets. Along the

same vein, 85% of Intel's (US$113 billion) and 96% of Coca-Cola's (US$148 billion) market value were also similarly from intangible assets.

A number of companies in the west have proven the need for and benefits of adopting knowledge management processes, in one form or the other. Hughes is a successful US high-technology company that launched 11 satellites in 1999; the company has had to develop a "knowledge highway" to link what was identified as "islands of knowledge" – deep pockets of expertise that have trouble developing synergies among themselves. The knowledge highway, which is at the centre of Hughes approach to knowledge management, is an information technology-supported network of company experts, with the aim to capture and share knowledge in order to reduce product development cycle times (Despres and Chauvel, 2000).

Another example of a company adopting knowledge management processes is Dow, the US chemicals multinational, which has created a "patent tree" that maps the company's presence and business opportunities in a market in terms of the patents it holds. Since a major source of income for the company is to license its technology, information about its patents needs to be readily available to all departments. The company also monitors competitors and other researchers in the areas in which it does business, and has developed a "knowledge tree" that includes intellectual assets and other patents. Dow's objective is to understand its internal stock of expertise in order to exploit all business potentials (Despres and Chauvel, 2000).

Robinson et al, (2005) also elucidate on some significant examples of positive impacts directly attributable to knowledge management activities and practices, in the following organisations:

- Texas Instruments saved itself the US$500 million cost of building a new silicon wafer fabrication plant by disseminating best internal working practices to improve productivity in existing plants.

- Dow Chemicals generated US$125 million in revenues from patents, and expects to save in excess of US$50 million in tax obligations and other costs over the next ten years by understanding the value of its patent portfolio and actively managing these intellectual assets.
- Chevron Oil made savings of US$150 million per year in energy and fuel expenses by proactive knowledge sharing of its in-house skills in energy use management
- Skandia AFS reduced the time taken to open an office in a new country from seven years to seven months by identifying a standard set of techniques and tools that could be implemented in any new office. (source: Robinson et al, 2005)

The foregoing reveals that an increasing number of organisations are adopting knowledge management, even as much discourse proclaim that intellectual capital is essential to wealth generation, and is key to ensuring success in the future (Despres and Chauvel, 2000). These all convincingly demonstrate the significant level of positive impact on performance, achievable through the use of knowledge management systems in business organisations.

2.2.3 Key Aspects of Knowledge Management

Knowledge in today's organisations exists largely in two main forms (Quintas, 2005):

- **Tacit knowledge** is knowledge acquired through experience of human activity and internal reflection; it often resides in peoples minds without being stated openly.
- **Explicit or codified knowledge** is the knowledge that has been written down, expressing all details and intended meaning in a clear and obvious way. Once codified, it can be interpreted and understood by others.

Much of the knowledge generated in organisational processes is tacit knowledge (Quintas, 2005); people are the locus of much organisational knowledge. As such, a key challenge for attempts at knowledge management would be to convert as much valuable tacit knowledge to explicit knowledge as possible. The

management of people and the relationship between individuals, groups and organisational knowledge are also central foci for knowledge management programmes (Quintas, 2005).

It may be argued that all activity in human organisations is 'knowledge based' to some extent, given that it is inconceivable to have human activity without knowing and knowledge; therefore all workers are knowledge workers, to some extent, and all task performed by humans are essentially 'knowledge work' (the term "knowledge worker" was coined by Drucker (1969), who supports other post-industrial accounts in showing knowledge processes to be intensifying, with knowledge-intensive work outgrowing traditional employment). As such, given the apparent plethora of "knowledge", another key issue in the management of organisational knowledge is to determine what kinds of knowledge offer the greatest value to given organisation, in order to achieve the highest positive impact (Quintas, 2005). This knowledge, which ensures success, is worth managing (Girmcheid and Borner, 2003).

The gathering pace of change in most sectors of economy occurs across several dimensions; these include changes in markets and industries, new forms of competition and new entrant competitors, globalisations in markets and changes in technology which result in product and process innovation. Such endemic change demands continuous regeneration and development of organisational knowledge, i.e. organisations and the people within them must be continually learning. This scenario would require the development of a flexible organisational culture that supports the ability to create, absorb and assimilate new knowledge, and to abandon outmoded knowledge and routines.

2.3 Understanding Knowledge Management

Even though the phrase 'knowledge management' only came into common usage in the west during the last five years of the 20th century, the actual economic value of organisational knowledge has been discussed for centuries, from the ancient Greeks to Adam Smith and Alfred Marshall, who in 1980 wrote: "Capital consists

in a great part of knowledge and organisation….Knowledge is our most powerful engine of production" (Marshall, 1982; Quintas, 2005).

Knowledge management has been referred to as a turbulent, noisy field; over the period 1990 to 2000, business and academic journals have recorded a 100 per cent rise in new knowledge management articles, and there are currently more than 1,800 different software products with a knowledge management label, creating a diversity of approaches to knowledge management (Despres and Chauvel, 2000). Most of these approaches however have similarities, which can be organised to assist in conceptualising knowledge management.

2.3.1 Knowledge Management Dimensions

A classification system developed by Despres and Chauvel (2000) proposes four knowledge management dimensions:

Process:

This addresses the series of factors that come together over time resulting in thought, leading to cognition and knowledge (detailed discussion follows in 2.3.2: The knowledge process, below). Generally, successful knowledge management programmes are process based, rather than static structures.

Type:

Knowledge is not a simple, stable quantity – different schools of philosophy and sociology give different accounts. Also, the importance of tacit and explicit knowledge is the subject of considerable work within the field of knowledge management.

Level:

Companies generally have three levels of social aggregation: individuals; groups; and organisations. Individuals are the fundamental building blocks, particularly in knowledge-intensive systems; however, most individuals accomplish their work in groups, using resources provided by the supervising organisation.

Context:

The importance of an organisation's context influences its systems, structures and expectation, and is increasingly cited in knowledge management literature. More fundamentally, nothing has any meaning outside a context – the meaning of a piece of information depends on its context. Knowledge management efforts therefore need to define the context(s) as a point of departure.

2.3.2 The Knowledge Process

This consists of six steps/activities, as proposed by Despres and Chauvel (2000):

Mapping:

The individual, or even an organisation, is unable to embrace the entire universe of information available. Instead, people search for comprehensible nuggets of information that they are familiar and comfortable with, i.e. individuals and organisations map out information environments of their own making.

Acquire/capture/create:

From these information environments, people appropriate, and perhaps subsequently combine, the most valuable nuggets of information. This stage includes individual or organisational search activities and processes which locate the information appropriate for the given work.

Bundle/collate:

A variety of media are available to bundle (i.e. package) information, e.g. paper, email, multimedia. The information must be given coherent meaning, usually by an author, in order to enable others to utilise the information.

Store:

Individuals and organisations stockpile information in memory systems of various kinds; these range from brains to hard disks, filing cabinets, libraries and data warehouses.

Apply/share/transfer:
Knowledge management implicitly recognises that information is social; information can only be recognised as data within some kind of social context. Also, the value of knowledge depends on the actions which results from it.

Innovate/evolve/transform:
In order to retain its value, knowledge must evolve to keep step with changes in the environment. This necessitates research and development programmes that build on experiences in the marketplace, creativity processes that broaden intellectual horizons, etc.

2.4 Knowledge Management Tools

The aforementioned knowledge process requires certain systems and tools for its operation. Knowledge management may be a product of the information age, but there is far more to it than just information technology (IT); ideally, it involves employees sharing "tricks of the trade" (i.e. valuable knowledge) with each other via "networks" (i.e. management tools) (Manchester, 2000). Knowledge management tools therefore comprises both IT and non-IT-based tools required to support the various processes and sub-processes of knowledge management such as locating, sharing and codifying knowledge (i.e. converting "tacit knowledge" to "explicit knowledge") (Al-Ghassani et al, 2005). There are a large number of tools available to choose from in implementing a knowledge management strategy. Selecting appropriate knowledge management tools for individual companies therefore needs to be given careful consideration to ensure that the business issues and contexts are understood and the company's goals are adequately addressed.

Attempts at defining knowledge management tools vary. Gallupe (2001) posits that they are not simply information management tools, as they should be capable of handling the richness, the content, and the context of the information and not just the information itself. Ruggles (1997) defines knowledge management tools as the technologies used to enhance and enable the implementation of the sub-

processes of knowledge management, e.g. knowledge generation, codification, and transfer. He argues that not all tools are IT based, as paper, pen or video can also be utilised to support knowledge management. To differentiate between tools, the term ‘knowledge management techniques’ and ‘knowledge management technologies’ are used to represent ‘non-IT-based tools’ and ‘IT-based tools’ respectively.

2.4.1 Knowledge Management Techniques

Knowledge management techniques (non-IT-based tools) are generally affordable to most companies, as no sophisticated infrastructure is required to implement and maintain them, although some techniques may require more resources than others. Techniques are easy to implement as they incorporate relatively simple and straightforward features, and focus on retaining and increasing the organisational knowledge, which is a key asset to organisations. Along these lines, Al-Ghassani et al (2005) propose the following examples of knowledge management techniques:

Brainstorming:

This is basically a process involving a group of people who meet to focus on a problem, and then intentionally propose as many deliberate unusual solutions as possible; this is done through pushing the ideas as far as possible, with each idea noted down and built upon. Brainstorming helps in problem solving and in creating new knowledge from existing knowledge.

Communities of Practice:

These are also called knowledge communities, knowledge networks, learning-communities, communities of interest and thematic groups. These consist of a group of people of different skills sets, development histories and experience background that work together to achieve commonly shared goals (Ruggles, 1997). They are held together by the need to know what each other knows. Examples would be associations of industry professionals/professional representative bodies or groups.

Face-to-face interaction:

This is a traditional, usually informal way of sharing the tacit knowledge owned by an organisation's employees. It also helps in increasing the organisations memory, developing trust and encouraging effective learning. Lang (2001) considers it to provide strong social ties that give rise to collective sense-making.

Post-project reviews:

These are debriefing sessions used to highlight lessons learnt during the course of a project. These reviews are important to capture knowledge about causes of failures, how they were addressed, and the best practices identified in a given project. This increases the effectiveness of learning, as knowledge can be transferred to subsequent projects. It is however crucial for post-project review meeting to take place immediately after a project is completed as project participants may move or be transferred to other projects or organisations.

Mentoring:

This is a process where a trainee or junior member of staff is attached or assigned to a senior member of an organisation for advice related to career development; the mentor provides coaching to facilitate the career development of the trainee and checks progress by providing feedback.

Recruitment:

As a way to "buy-in" knowledge, recruitment offers the opportunity for an organisation to acquire external tacit knowledge, especially of experts, thereby expanding the organisations knowledge base.

Training:

This helps to improve staff skills and therefore increase knowledge. It usually takes place in a formal format, can be internal or external, and could be used to ensure that employee's knowledge are continuously updated.

Apprenticeship:

This is a form of training in a particular trade carried out mainly via learning by doing; apprentices often work under their masters and learn through observation, imitation and practice, until they reach the required skill level.

2.4.2 Knowledge Management Technologies

Technologies depend heavily on IT as the main platform for implementation, with many organisations considering them as important enablers to support the implementation of a knowledge management strategy (Anumba et al, 2000; Egbu, 2000; Storey and Barnet, 2000). Knowledge management technologies are significant because they consume about one third of the time, effort and money required for a knowledge management system, the other two-thirds relating mainly to people and organisational culture (Davenport and Prusak, 1998). These technologies consist of a combination of hardware and software.

Hardware Technologies:

These are very important because they provide the platform for the software technologies to perform, as well as the medium for the storage and transfer of knowledge. Some possible hardware considerations include:

- The personal computer or workstation to facilitate access to required knowledge databases.
- Powerful network servers to allow networking across an organisation, and between organisations
- Public network technology (e.g. the internet) and/or private network technology (e.g. intranet, extranet), to facilitate access and sharing of knowledge.

Software Technologies:

There are several software packages available from various vendors capable of performing different knowledge management tasks and functions. According to Manchester (2000), some of the main threads of development which have each spawned products that can be utilised in knowledge management, include:

- Information retrieval, from the internet, corporate networks/intranets and other data sources. This is the most important of these technologies and can form the basis of comprehensive knowledge management strategies. Microsoft's Index Server, for example, builds on traditional information retrieval techniques to provide a method for searching many different text sources, including Microsoft Word and Adobe Acrobat. Other software packages which build on information retrieval concepts include Verity's Search 97, Fulcrum's Knowledge Network and Excalibur's Retrievalware.
- Context-sensitive document management tools (that can for example work with the content held in a document image) and work flow processing software (to manage business processes). These are also required to achieve a comprehensive knowledge management package. Increasingly, vendors in these sectors are incorporating information retrieval engines into their products; Lotus and Netscape, for example, use Verity's Search 97 package in their product.

2.4.3 Selecting Knowledge Management Tools

There are various factors which create challenges as well as opportunities for organisations in the selection of appropriate technology to manage their knowledge resources. The software technology market is very dynamic and is continually evolving with better and more refined products to support knowledge management. Also, pioneers of expert systems and knowledge-based technology in the early 1980s found that people do not surrender their knowledge easily – often because they are unaware that they have it in the first place (Manchester P. 2000).

Tsui, E. (2002) identifies the following models for deploying organisational knowledge management systems where one or a combination may be adopted:

- Customised off-the-shelf (COTS) packages are the traditional and most popular way of deploying application systems. The application packages

are selected based on the organisation's functional needs, with customisation of certain features performed to integrate it into the organisation's system.

- In-house/specialist-developed packages are usually developed for/by the organisation, often with external technical help. The high costs, risk and complexity often associated with this option however make it less attractive.
- Solution re-engineering, involves adapting existing generic packages (similar to COTS) with the help of consultants.
- Knowledge services are provided by third parties who provide access via a client (e.g. a browser). The main benefits are the avoidance of in-house maintenance by the organisation, as well as the waived software licensing fee. The primary disadvantage is the reduced security.

The choice of knowledge management tools to be adopted would depend on individual organisations strategic objectives and available financial means. Prior research suggests that communities of practice are the most widely used technique for knowledge management particularly in large organisations; other techniques utilised include brainstorming, conferences and seminars (Al-Ghassani et al, 2005). The most widely used technology is the intranet, which provide platform for knowledge sharing across large, at times geographically dispersed organisations (Carrillo et al, 2004). Other popular technologies include document management systems and groupware.

2.5 Knowledge Management in the Construction Industry

As revealed earlier in chapter 1 of this research report, the construction industry contributes largely to employment in the Republic of South Africa, offering job opportunities, directly or indirectly, to over one million people (Statistics SA, 2006). Accordingly, construction industry performance would have significant effect on other sectors of the economy.

The importance and implications of knowledge management in the construction project management is far ranging. The decision on what knowledge an

organisation needs or the knowledge intensity depends on the context of the business environment, i.e. the key knowledge about processes and people for the delivery of its products (Egbu and Robinson, 2005). These context-based factors address issues of what is produced (products, i.e. goods/services), how it is produced (i.e. processes) and by whom (i.e. people).

There are accordingly three aspects of knowledge to manage in the construction context: (1) products or project types, (2) processes and (3) people. Knowledge management in construction organisations therefore relates to the procedures put in place to capture knowledge about products/projects, processes and people, knowledge primarily residing in people, and not technology according to Egbu and Robinson (2005). Technology is however an important enabler in the knowledge management process (see Figure 2.1). Product/project-based factors relate to the characteristics of the services or goods to be produced, whether standardised or innovative (Hansen et al, 1999). Process-based factors relate to the technical and management systems required for the delivery of products. People-based factors relate to skills, problem-solving abilities and the characteristics of teams (Egbu and Robinson, 2005).

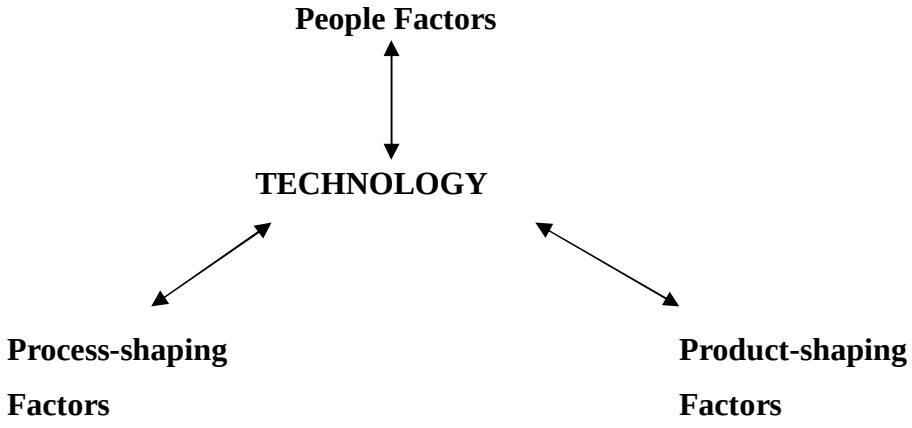


Figure 2.1 Context-based factors influencing a knowledge management strategy (Source: Egbu, C. and Robinson, H., 2005).

2.5.1 Need for Knowledge Management in Construction

Knowledge in the construction industry, as in other industries, can be viewed as a resource made up of expertise, flowing in complex inflow-outflow systems. Knowledge flows in through hiring, training and purchase of capital goods, and research; knowledge flows out through staff departures, imitated routines and sale of capital goods (Egbu and Robinson, 2005). Also, today's construction industry demands results faster than ever – decisions must be made rapidly, placing considerable pressure on the individual. Construction industry professionals and personnel must be constantly aware of past experiences, present standards, and yet must also seek to incorporate an ever growing pool of new ideas in order to innovate faster than the competition (Sheehan et al, 2005). In the face of such challenges, effective knowledge management offers construction organisations seeking to enhance their business performance real potential in key areas necessary for effective delivery of knowledge management.

For construction activities, which can now be seen as highly knowledge-intensive (Egbu and Robinson, 2005), good knowledge management practice requires knowledgeable people who are supported by integrated information sources in order to generate informed decision-making, as shown in figure 2.2. Prior research has identified design, architecture, surveying and other construction services as knowledge-intensive service sectors (Windrum et al, 1997, den Hertog and Bilderbeek, 1998). A new modern office complex for example, has a high proportion of its development costs attributable to knowledge-based elements such as design, an assessment of cost alternatives of different components of the building, advice on contractual aspects, risk and build-ability of the project, quality, health and safety issues on the project, to mention but a few (Egbu and Robinson, 2005). A range of process knowledge areas that organisations involved in construction project management may wish to explore is illustrated in Table 2.1.

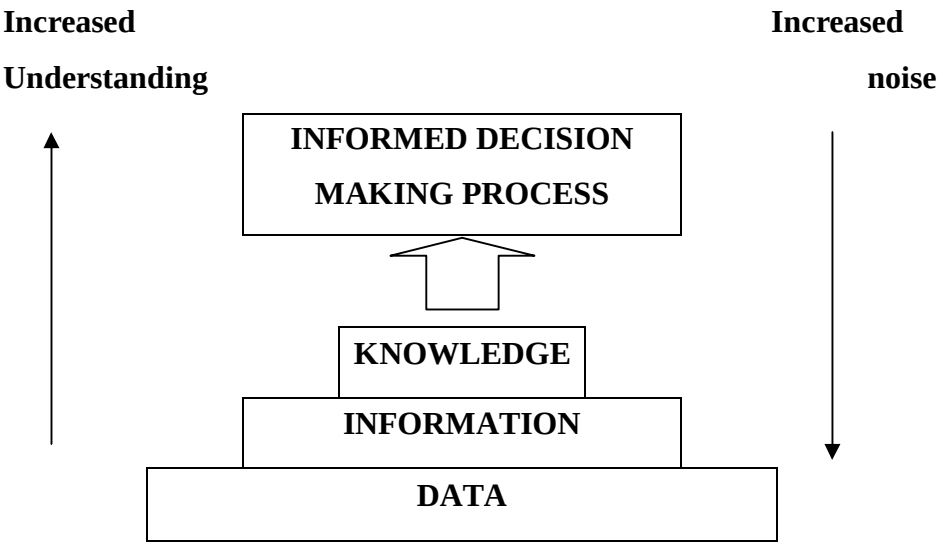


Figure 2.2 Knowledge Support for decision making (Source: Sheehan et al, 2005)

Table 2.1 Examples of process related knowledge areas (source: Egbu and Robinson, 2005)

Sub-process	Key knowledge Issues
Procurement	Partnering, design and build, construction management, traditional contracting
Estimating and tendering	Profit margins, overheads, bidding success rate, bidding costs, regional factors, sub-contracts, sub-contract quotations
Materials management	Structural steelwork, concrete
Construction methods	Prefabrication versus on-site construction, etc.

In order to adequately address these challenges, construction professionals and organisations face economic imperatives to move towards increased codification of knowledge, as this enhances efficiency of exploitation and transparency of sharing, while reducing knowledge costs (Egbu and Robinson, 2005).

2.5.2 Knowledge mapping in Construction Organisations

Egbu and Robinson, (2005) posits that the point of departure for structuring construction project knowledge is to develop a knowledge map for locating explicit knowledge and for serving as pointers to holders of tacit knowledge. Figure 2.3 shows a knowledge map with multiple levels of detail. A skill and knowledge "yellow pages"/database can also be used to provide a directory of experts – this can help in finding the right person to approach for advice and best practice. Such knowledge mapping tools are very important but need to be kept up to date to maintain its usefulness.

The knowledge map serves as a continuously evolving project memory, forming a link between different knowledge sources, and enabling the construction project team members learn from past and current projects through the navigation of information and codified knowledge. It also assists in the capturing and integrating of tacit knowledge into the project knowledge base, as well as the creation of new knowledge by adding, refining and broadening scope.

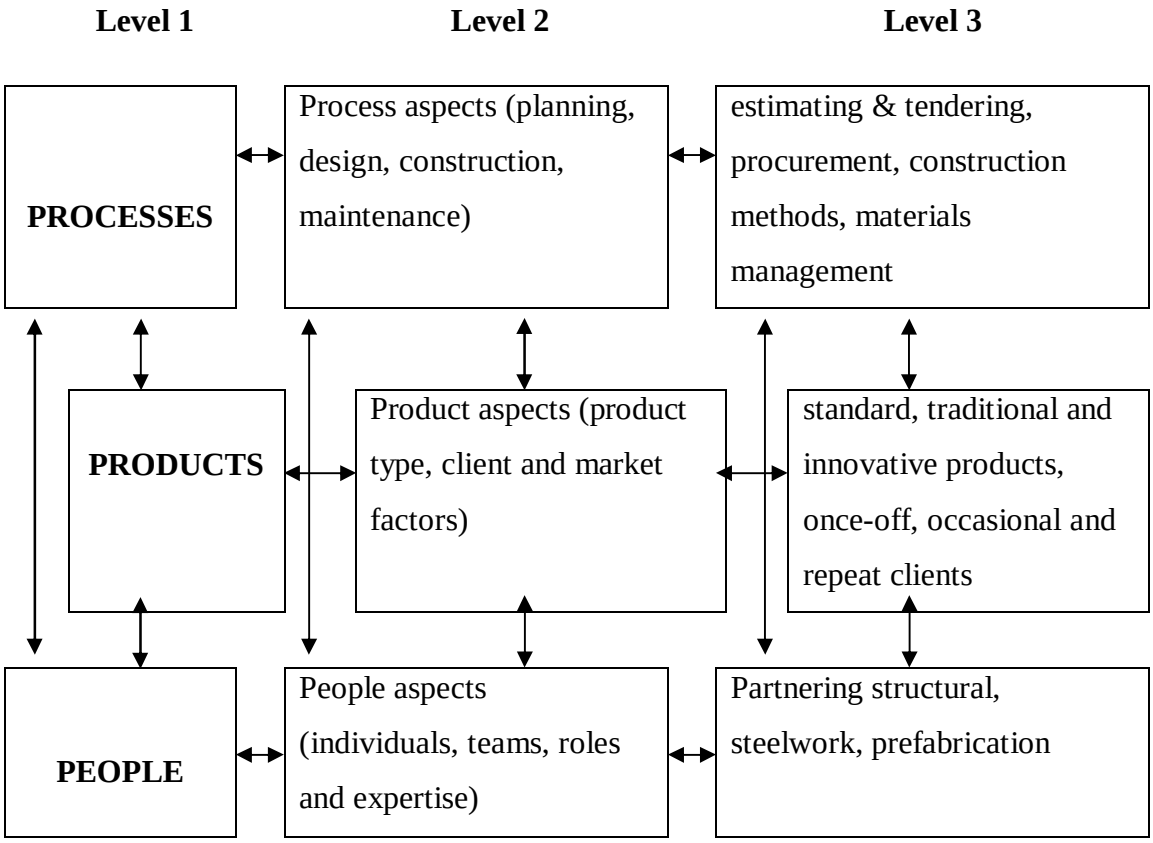


Figure 2.3 Knowledge mapping in Construction Organisation (Source: Egbu and Robinson, 2005).

2.5.3 Benefits of Knowledge Management in Construction Project Management

It has been seen from the foregoing review of literature that knowledge management as a performance enhancing tool has the potential to produce significant benefits when adopted by organisations in one form or another. Specific benefits achievable in construction project management include:

Increased Innovation

There is recognition that innovation is the key to competitiveness, and depends on knowledge creation and application; in many sectors, competitive advantage is increasingly occurring through innovation, whether in products, processes or services (Quintas, 2005). The management of innovation is essentially the management of the knowledge process – the creation, reformulation, sharing and

packaging/bringing together of different types of knowledge. Knowledge is an input to innovation, is inseparable from the innovation process, and new knowledge is also an output of that process (Quintas, 2005).

Lower dependencies on Key Individuals

Once the tacit knowledge from key individuals is "harvested" and stored using the various knowledge management tools and systems discussed earlier, there will be less dependence on the individual; their experience would now be available to all via the knowledge retrieval system. Also, projects requiring such individuals' level of skill and knowledge could now run in tandem, reducing possible delays in waiting for one project to be completed before commencing another.

Improved Team Work

In a knowledge management-oriented company, knowledge employees use today's advanced technologies to pave the way for knowledge flow through electronic networking, which in turn saves the time and cost of knowledge sharing, irrespective of distance and physical locations (Zou et al, 2003a). Good communication and knowledge management practices also presents a blueprint on where and how to access required project knowledge. These result in smooth and effective project teamwork, thereby increasing productivity.

Quicker Response

Firms that have adequate knowledge management systems in place are better able to quickly respond to queries from clients and other issues as and when they arise. The system's database can be configured along information retrieval lines (Manchester, 2000); inputting a request using a keyword would bring up an array of scenarios similar to the current query context, enabling the organisation to respond quickly. The result would be a client with the overall impression of good customer service, and an increased possibility for repeat business.

Reduced Risks

The integration of knowledge management systems and strategies in construction project management enables the sharing of project risk knowledge via specific knowledge base, and as been advocated as an area of importance for day-to-day performance, with concomitant significance to company's business success (Kahkonen and Kazi, 2003). Specific risk knowledge management systems would readily inform decision pertaining to key issues in construction projects, such as health and safety and construction best practices, thereby greatly reducing costs and down-time due to injury.

Increased Knowledge Retention

Knowledge management processes and systems enable construction organisations to retain tacit knowledge that would otherwise be lost when valued employee leave or retire from the organisation. Knowledge losses are also minimised due to reduction in personnel consistency throughout the project (Girmscheid and Borner, 2003). It has be stated that an organisation's knowledge is one of its key assets; it is therefore necessary to ensure that this knowledge is retained within the organisation and appropriately disseminated from project to project, department to department, and employee to employee. The resulting development of organisational 'knowledge assets' has been shown to enhance market value (Roos and Roos, 1997).

Increased Client Satisfaction

Increased value can be provided to construction organisation's clients and customers through effective knowledge management. With the right tools and systems, the client will be given better service value, as the project management essentials of time, cost and quality can be better delivered on a given project using templates derived from well designed knowledge management systems. The resulting increased client satisfaction is a performance benefit that would result in improved business competitiveness and financial results (Stewart, 1997).

Non Re-invention of the Wheel

Effective knowledge management practices will greatly lessen the likelihood for "re-inventing the wheel" from project to project (Latham, 2005). Rediscovering tried and trusted solutions goes hand in hand with losses of efficiency in finalizing the project (Girmscheid and Borner, 2003); such situation would be avoided, along with the repetition of past mistakes, with concomitant cost savings and financial gains.

Interdisciplinary Knowledge Transfer

Knowledge management has the potential to promote knowledge transfer across a variety of project interfaces (organisations, disciplines, sectors). Also, the construction industry may find knowledge from other sectors or disciplines useful in implementing innovative systems and process specific to the sector.

2.6 Knowledge management and performance measurement

There is the need to measure the performance of knowledge management systems and knowledge assets, in order to be able to demonstrate its business benefits, and to justify the commitment of required organisational resources to its activities and processes. Performance measurement of knowledge management and associated knowledge assets is an evolving area - a number of researches have developed several parameters for performance measurement in business organisations and a detailed discussion of several of them would be beyond the scope of this study. Hausser (1980) suggests that the purposes of assessment should determine the measurement approach frame of reference to be adopted. Accordingly, focus would be made on those measurement approaches that are considered appropriate for application in a research of this nature.

The degree by which a project achieves its stated goals is one of the major ways by which its level of performance and success can be measured. Objective project goals are usually stated in terms of project time/schedule, cost/budget and quality/technical specifications (Liu and Walker, 1998). Along these lines, Shenhar et al (2001) identifies the Project Efficiency Review (PER) as an

"objective" approach for measuring performance and success in project management. However, other researchers argue that the use of solely objective measures (i.e. 'on time/schedule', 'within budget' and 'according to technical specification') is not sufficient for the assessment of project performance (Morris, 1986; Baker et al, 1983). Accordingly, Robinson et al (2005) proposes other performance measurement indices which are grouped into three approaches namely Metrics, Economic and Market value. The characteristics, advantages and disadvantages of these 4 identified performance measurement approaches for research purposes are discussed below:

2.6.1 Project Efficiency Review approach

The Project Efficiency Review (PER) approach focuses on the actual project achievement measured against the project implementation plan. This approach concerns itself with the effectiveness of the actual project implementation process, and thus presents a quick, "objective" view of performance benefits achieved in an organisation. The approach has the advantage of relatively readily available data sources (i.e. information on planned versus actual project schedule, budget and technical specifications, which are obtainable from past project records) and consequently lends itself to application to most research sample groups. PER however has the shortcoming of using single dimensions of success in project performance measurement.

2.6.2 Metrics approach

These utilises input and/or output indicators to monitor the performance of knowledge assets or knowledge management programmes. Input indicators reflect actions or enablers required to achieve required objectives (e.g. staff training, experienced recruitments), while the output indicators measure the performance or result of those actions (e.g. improved client satisfaction, reduced cost and time overruns). Metrics can be single or composite (i.e. an aggregate of individual indicators into a single index such as the Intellectual Capital (IC) index). This approach is based on the assumption that there is a relationship or correlation between the indicators and business performance and profitability (Stewart (1997)

posits that if you cannot demonstrate the link between improvement in indices such as customer satisfaction and improved financial results, you are not measuring customer satisfaction correctly). Examples of the three basic metrics types are given in Table 2.2

There are some problems associated with the metrics approach. It is often difficult to combine different metrics into a single numeric measure to correlate with business performance. Also, and more importantly, metrics do not always provide adequate information about performance to enable continuous improvement initiatives to be undertaken.

Table 2.2 Examples of Metrics (Source: Robinson et al, 2005)

Metrics Type	Metrics
Human	Employee satisfaction (e.g. absenteeism, job security)
	Training and experience (e.g. education, project managers on major assignments
	Knowledge networks (e.g. communities of practise)
	Knowledge worker turnover rate
Structural	Innovation (e.g. research collaboration, patents, trademarks)
	IT infrastructure (e.g. volume of knowledge content, usage)
	Bidding process (e.g. bid/win ratio)
	Construction process (e.g. defects, waste, pollution)
	Safety procedures (e.g. accidents)
Customer	Customer satisfaction
	Loyal customers (e.g. repeat business)
	Number of customers gained versus customers lost
	Business intelligence (knowledge about competitors, customers and markets)

2.6.3 Economic approach

Economic approaches attempt to calculate the actual contributions or net improvements in business performance, while recognising that the costs associated with implementing knowledge management programmes are crucial - the objective is to assess whether the benefits exceed the costs. Economic approaches could also involve the valuation of specific knowledge assets or components (for example, quantifying the economic value of people to an organisation where human capital comprises a significant proportion of organisational value, and/or other intangibles). Table 2.3 provides examples of some economic performance measures, and associated benefits.

Shortcomings of the economics approach involve issues with the quantification of performance benefits accrued from knowledge management initiatives – quantification of productivity increases may involve assumptions, and tend to rely extensively on ‘guestimates’

(A close look at tables 2.2 and 2.3 reveals that the Metrics and Economic approaches share some similar indices, such as employee/staff turnover rate, bidding process/bid-win ratio, defects/wastes and client satisfaction/repeat business.)

Table 2.3: Examples of Economic Performance Measures, and associated Benefits (Source: Robinson et al, 2005)

Performance Measures	Definition	Expected benefit
Staff retention/ staff turnover	Percentage of staff retained or leaving	Reduction or increase in staff recruitment costs
Safety	Number of reportable accidents per 100,000	Reduction in accident costs
Productivity	Output/turnover per employee; value added per employee	Increase/decrease in turnover/output
Absenteeism	Percentage of days absent per employee	Reduction in the cost of absenteeism
Compliments/ Complaints	Number of compliments/ complaints from customers	Potential gain/loss of business opportunities
Defects	Number of major defects	Reduction in cost of defects
Repeat business	Value of repeat business as a percentage of turnover	Increase in the value of repeat business
Bidding – bid/win Ratio	Number of bids won out of total submissions	Reduction in the cost of tendering
Waste	Quantity of waste/number of skips	Reduction in landfill charges, fuel costs
Noise pollution	Numbers of complaints/notices issued/fines	Reduction in sanctions/fines

2.6.4 Market value approach

Market value approaches focus on the whole organisation, the aggregate of knowledge assets or market factors. The market value approach is based on the principle that the value of a company comes from both its hard financial capital (physical and monetary assets) and soft knowledge or intellectual capital. Knowledge or intellectual capital should therefore explain the difference between

the value assigned to an organisation by a buyer or the stock market in relation to its book market value. Knowledge management researchers and practitioners believe that the growing discrepancy between market value and book value is largely attributed to intellectual capital (where the market value exceeds the book value) or intellectual liabilities (where book value exceeds market value). There is evidence of market values significantly exceeding book values in certain business sectors that are knowledge-intensive, such as management consulting, biotechnology, pharmaceuticals, and information technology and software development services. For example, in 1995, IBM paid US$3.5 billion for Lotus, which represented seven times its book value (Jordan and Jones, 1997). This is a strong reflection than the hidden, soft assets of knowledge. A fundamental criticism of the market value approach however, is that it often responds to the vagaries and volatility of the stock market, and other such factors outside the direct control of companies and their management.

The main objective of this research involves the assessment of possible correlation between knowledge management and enhanced performance in construction project management. The study involves the survey of a sample group made up of various respondents with differing backgrounds and experience in terms of construction project management. The performance measurement approaches adopted must therefore be able to accommodate the sample group. Given the variety of potentially usable performance measurement indices, past researchers have suggested the limiting of the range used in evaluation for practical reasons, while focussing on major criteria (Ireland, 1983; De Cortis and Dyer, 1977). Thus, considering the need for practicality, while also excluding largely subjective measurement indices such as ‘quality’ and ‘satisfaction’, this research would adopt a balanced selection of elements of both Project Efficiency Review and Economic measurement approaches. These two approaches would cater for the possible range of levels of respondent/organisational maturity and experience that could exist among the sample group.

2.7 Summary

The literature review was aimed at elucidating previous studies and discourse in the areas of knowledge management and its impact as a performance enhancing tool in various industries. The connection between effective knowledge management and improved business performance has thus been established, with examples given of significant benefits achieved and achievable, as highlighted in prior studies.

In terms of construction project management, the performance enhancing benefits achievable with knowledge management use include innovation, improved team-work, quicker response, risk reduction, knowledge retention and increased client satisfaction, all of which contribute to significant cost savings, improved business competitiveness and enhanced market value. Three basic aspects to knowledge management in the construction context were identified - the products or project types, the processes and the people – along with various knowledge management tools.

The literature review also identified performance measurement approaches – Performance Efficiency Review and Economic - that would be used to ascertain the impact of instituting knowledge management systems in construction project management enterprise. The literature review thus provides a basis for the theoretical frameworks adopted for this research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The research study adopts both descriptive and explanatory research methods, as this enables the testing of the theories and hypotheses developed and discussed in previous chapters (Saunders et al, 2003; Goddard and Melville, 2005). Detailed investigative questionnaires, incorporating the key research variables, are utilised as the primary research instrument for information gathering. The research strategy and research instrument development were informed by the theoretical frameworks enunciated in the literature review.

Participants in the survey are interested fully registered Professional Construction Project Manager (Pr CPM) members of the South African Council of Project and Construction Management Professions (SACPCMP). This sample group was selected in order to enhance the validity of the results of the research.

3.2 Research Strategy

The research is broken into two phases:

- The first phase (chapter 2) entailed a review of significant prior literature in the fields of knowledge management and related topics, along with its application in various fields of human endeavour. The literature review identified the importance of knowledge management as a performance enhancing tool, along with specific benefits achievable in its use in construction project management. A broad range of knowledge management tools were discussed. In addition, four types of performance measurement approaches i.e. the Project Efficiency Review, Metrics, Economic, and Market Value approaches, were also identified as possible frameworks with which to investigate the degree of effectiveness of knowledge management programmes in construction project management.
- The second phase involves conducting a survey that incorporates the frameworks elucidated in phase one, using descriptive and explanatory

research study methods and associated research instrument (described in detail in section 3.4).

Both descriptive and explanatory research study methods, employing the use of detailed investigative questionnaires, are adopted for this study. The advantages of the adoption of this strategy are as follows:

- It would enable the comparison of various current levels of knowledge management use of various respondents with concomitant levels of performance, with a view to examining possible correlation between "high" levels of knowledge management use and "high" levels of construction project management performance.
- Patterns revealed within the study group will enable the testing of the theories and hypothesis (developed in chapter 1 and substantiated in chapter 2), which would lead towards the development of valid and well-grounded conclusions.
- It is considered appropriate for a research report such as this, which is time-limited to approximately 6 months.

(Saunders et al, 2003; Goddard and Melville, 2005)

The theoretical frameworks developed earlier are used to organise and direct data acquisition and analysis, and also shape the data gathering instruments (Yin, 1994).

3.3 Theoretical Frameworks Adopted for the Study

Theoretical frameworks were adopted for the study in two parts, i.e. the examination of the current levels of knowledge management attempts among the surveyed construction project management professionals, and subsequently the attempt at measurement of construction project management performance

There is currently no universal standard for measuring or evaluating knowledge management programmes (Robinson et al, 2005). As discussed earlier, variety of performance measures could be adopted to evaluate the impact of knowledge

management activities. It is recognised that at the lower levels of maturity and organisational structure, basic metrics to monitor and review knowledge management strategies suffices. However, as an organisation progresses, a more robust measurement system may be required.

With the variety of potentially usable performance measurement indices, researchers have attempted to limit the range used in evaluation for practical reasons, pointing out that it is not feasible to employ the entire range of available indices (Ireland, 1983), and thereby focussing on the major criteria (De Cortis and Dyer, 1977). Hence, in the light of the need for practicality, coupled with a need to exclude largely subjective measurement indices such as 'quality' and 'satisfaction', this research strategy would adopt a balanced selection of elements of both Project Efficiency Review and Economic measurement approaches. These two approaches would cater for the possible range of levels of respondent/organisational maturity and experience that could exist among the sample group. Specifically, in the attempt to evaluate the performance enhancing benefits of knowledge management application in construction project management, the measurement indices adopted for this research are as follows:

- Actual versus planned construction project schedule/time: this relates to the extent to which the project actual construction/completion time achieved the project planned completion time
- Actual versus planned construction project budget/costs: this relates to the extent to which the project actual budget achieved the project planned budget
- Repeat client business: this relates to the amount of repeat business; prior research has shown this to be an indication of level of client/customer satisfaction, which ultimately affects business performance.
- Employee productivity: this relates to the output/value contributed per employee, in terms of size/value of construction projects handled per professional employee, for a given period (i.e. per month).

- Staff retention/staff turnover: this relates to the percentage of professional staff retained or leaving

It has been noted that the associated time frame is an important consideration in the development of a framework for the evaluation of project performance (Szilagyi, 1988). Therefore, and in order to achieve a current credibility for the outcomes of this research, the above indices would be applied to projects undertaken by the study sample group within the last 5 years (i.e. roughly between 2001 and 2005 inclusive).

3.4 The Research Instrument

A self-developed information gathering instrument, which is comprised of a detailed questionnaire incorporating the use of investigative questions, is adopted for this study. This has been shown to be the most advantageous approach to obtain information in research categories of a descriptive and explanatory nature, within which this research study falls (Saunders et al, 2003). Questionnaire surveys have also been conducted in research studies on related subject areas, with satisfactory results (Chang et al, 2003, Zou et al, 2003b)
The information required from the respondents are organised broadly into 4 sections:

- Section 1 relates to the demographic profiles of respondents.
- Section 2 incorporates the levels of recognition of possible benefits, as well as actual use of knowledge management strategies and tools in construction project management by the respondents.
- Section 3 is concerned with examining project management performance measurement data.
- Section 4 seeks to elicit general comments form the respondent concerning any aspect of the research.

Details of the different sections of the information gathering instrument, presented in Appendix A, are described below:

3.4.1 Section 1 – Demographics

This section of the questionnaire is designed to enable categorisation of the population and the elimination of possible respondents who do not belong to the appropriate representative sample population. Information elicited includes respondents' background, as well as personal and organisational levels of experience.

3.4.2 Section 2 – Levels of Awareness and Use of Knowledge Management in Construction Project Management

As mentioned earlier, there are key issues and dimensions relating to effective knowledge management. This section seeks to assess the respondent's (and by extension, the respondent's organisation) level recognition of the concept of knowledge management, and its applicability in construction project management, particularly in the following areas:

- Organisational current knowledge management awareness. Prior studies have indicated the importance of awareness and perception - no matter how good the system may be, it will exist in name only if people are not using it (Zou et al, 2003a).
- Recognition of possible benefits associated with the use of knowledge management in construction project management
- Respondents' overall levels of knowledge management use and effectiveness

3.4.3 Section 3 - Project Performance Measurement

This section if the questionnaire is based on a literature review-informed approaches for performance measurement (section 2.6, 3.3). The broad categories of information sought include:

- General project information: this was aimed at categorising projects along various possible groups such as client category, construction date of project.
- Project management performance measurement indices: in line with the measurement indices elucidated for project performance measurement (section 3.3).

3.4.4 Section 4 - General Comments

In this section, respondents are asked to provide additional information, in particular regarding considerations for choice of knowledge management tools utilised, attempts to consciously manage project knowledge, along with comments on perceived opportunities and obstacles/threats to successful implementation of knowledge management programmes. Respondents are also asked for information that might have any bearing on the subject matter of the research and general comments concerning any aspect of the research.

3.5 The Population

The target population for the study were the fully registered members of the South African Council for Project and Construction Management Professions (SACPCMP). The choice of this population was informed by the following considerations:

- The SACPCMP is the statutory body established to oversee the practice of the project and construction management professions in South Africa, and as such is recognised by the South African government, and government bodies.
- The SACPCMP is also widely endorsed by key players and organisations in the South African construction industry such as the Construction Industry Development Board (CIDB), the South African Institute of Architects (SAIA), South African Association of Consulting Engineers (SAACE) and the Association of South African Quantity Surveyors (ASAQS); this makes it a source of reliable, authoritative and accurate information

3.6 Data Gathering

The names and contact details of Professional Construction Project Manager (Pr CPM) members of the South African Council of Project and Construction Management Professions (SACPCMP) were obtained from the association's website (www.sacpcmp.co.za). The survey questionnaire, along with covering letter introducing the research objectives and possible benefits, was subsequently sent electronically (i.e. via email) to over 200 of the registered members, in September 2006 (the said questionnaire and covering letter are included in appendix A of this report.) Some of the members were contacted telephonically both prior and subsequently to the emailing of the questionnaire, in order to encourage their participation in the research

A total of 20 questionnaires were completed and returned by the respondents, mostly electronically by email (some respondents replied by post); this was despite several promises from various contacted SACPCMP registered professionals given over the telephone that they would complete and return the questionnaires. Some of the questionnaires sent via email were also not delivered (i.e. the emails were returned with error messages), due to probable changes in the email addresses of the SACPCMP members from what is given on the SACPCMP website.

Although a larger sample would result in better estimates, Goddard and Melville (2005) suggest that a sample of 20 is however sufficient for a small-sample analysis, where the subject sample is believed to be representative of the population being studied and such population is believed to be of a normal distribution. This sample size is therefore considered appropriate and is adopted for the purposes of this research. Also, further considerations supporting the use of this sample size includes that of time and cost constraints. As such, the research is carried forward into the analysis stage using the said sample size.

CHAPTER 4: DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

The data analysis was carried out on the information provided by the respondents via the survey questionnaire. It is assumed that the respondents have no bias and are sincere in their responses given in the questionnaire.

Analysis of the awareness levels of possible performance benefits of knowledge management, as well as levels of actual knowledge management use were successfully carried out. The correlation between knowledge management use and enhance performance was computed on the derived primary performance measurement indices, utilising a test for linear correlation. The results obtained were subsequently discussed, with the consideration of possible factors that could have influenced the outcomes of the survey.

4.2 Survey Responses

As indicated earlier, a total of 20 responses were received from those to whom questionnaires were sent. Some of the data collected were either incomplete or unusable in certain instances, and are indicated accordingly in the relevant following sections.

4.3 Demographic Results

Table 4.1 below depicts the number of years of experience of the respondents in the field of construction project management. From the distribution illustrated in Table 4.1 and summarised in Table 4.2, it can be seen that the majority of respondents have over 10 years experience in the field of construction project management in both personal and organisational capacities (95% and 60% respectively). This represents a high level of construction project management experience among the respondents, and would therefore facilitate the achievement of the research objectives (the respondents are more likely to “know what they are talking about”). It would also enhance the reliability of the conclusions drawn from this study.

Table 4.1: Respondents' Years of Experience

No.	Respondent (N = 20)	Years of Personal Experience	Years of Organisational Experience
1.	A	> 10	>10
2.	B	> 10	< 5
3.	C	> 10	5 – 10
4.	D	> 10	> 10
5.	E	5 – 10	5 – 10
6.	F	> 10	> 10
7.	G	> 10	5 – 10
8.	H	> 10	> 10
9.	I	> 10	> 10
10.	J	> 10	> 10
11.	K	> 10	> 10
12.	L	> 10	5 – 10
13.	M	> 10	> 10
14.	N	> 10	< 5
15.	O	> 10	< 5
16.	P	> 10	>10
17.	Q	> 10	< 5
18.	R	> 10	>10
19.	S	> 10	>10
20.	T	>10	>10

Table 4.2: Summary of Respondents' Years of Experience

Years of Experience	Personal		Organisational	
	Frequency	% (Total = 20)	Frequency	% (Total = 20)
Below 5	0	0	4	20%
5 to 10	1	5%	4	20%
Above 10	19	95%	12	60%

4.4 Method Adopted for Data Analysis

The raw data from the questionnaire was inspected and scrutinised to ensure accuracy. It is assumed that responses were sincerely and thoughtfully made and the respondents were unbiased in their giving of information. It is also assumed that the responses of registered members of the SACPCMP are representative of the level of knowledge management use in relation to construction project management, within the various organisations within which they function.

4.2.1 Computation of Level of Awareness of Knowledge Management

This relates to the first stated objectives of this research. The operation entails calculating the stated levels of awareness of the concept of knowledge management among construction project management professionals in South Africa. The respondents were asked to provide information on levels of awareness of knowledge management as well as possible concomitant performance enhancing benefits associated with its use in construction project management. A series of four-point scale questions, with point range from 0 to 3 (0 = "Nil", 1 = "Low", 2 = "Medium", and 3 = "High") were used in the questionnaire to elicit this information (see questionnaire in appendix A), which was considered appropriate (Goddard and Melville, 2005).

The average index points for level of awareness of knowledge management is given by

$$\mathbf{Ai} = \sum \boldsymbol{Ap/4}$$

Where '**A**' represents the respondents level of awareness, '**i**' represents each of the respondents, '***Ap***' represents the points given/marked by the respondents for each level of awareness index and ***4*** is the total number of such indices.

4.2.2 Computation of General Level of Knowledge Management Use

This relates to the second objective of this research, and also utilises a series of four-point scale questions similar to that indicated in section 4.2.1, seeking to

elicit levels of use of various knowledge management tools (i.e. techniques and technologies) as discussed in the literature review in chapter 2.

Similarly to above, the average index points for levels of use of knowledge management techniques is given by

$$\mathbf{Ui} = \sum \boldsymbol{Up/8}$$

Where '**U**' represents the respondents levels of use of knowledge management techniques, '**i**' represents each of the respondents, '***Up***' represents the points given for level of use of each type of knowledge management technique, and ***8*** is the total number of such indices.

Likewise, the average index points for level of use of knowledge management technologies is given by

$$\mathbf{Vi} = \sum \boldsymbol{Vp/3}$$

Where '**V**' represents the respondents levels of use of knowledge management technology, '**i**' represents each of the respondents, '***Vp***' represents the points given for level of use of each type of knowledge management technology, and ***3*** is the total number of such indices.

Appendix B presents a complete breakdown of calculation of points for the various indices for each respondent and associated organisation.

4.2.3 Project Performance Analysis

In order to evaluate the project performance of each respondent organisation, with a view to achieving the third objective of this research (i.e. establishing possible correlation between levels of knowledge management use and enhanced performance), data obtained from the project performance section of the

questionnaire were used to derive indices to carry out required performance evaluation, as follows:

Primary Performance Indices

These performance indices are based on project time and budget considerations, which were identified in the literature review as "objective" criteria by which construction project performance may be readily evaluated (Liu and Walker, 1998, Shenhar et al, 2001). They are:

Schedule Performance Ratio (SPR): This is a ratio which represents the construction time overruns. It depicts a measure of the level of the respondent's ability to achieve the required time constraints in a project, and as such is a measure of the respondent's construction project performance. Each respondent's SPR is given by:

SPRi = Actual Construction Time ÷ Planned Construction Time (1)

where '**i**' represents each of the respondents. The ratio can be averaged over each respondent's total number of projects given to arrive at an Overall Schedule Performance Ratio (OSPR) for each respondent.

Budget Performance Ratio (BPR): Similarly to the SPR above, this ratio represents the construction budget/cost overruns. It depicts a measure of the level of the respondent to achieve the required cost constraints in a project, and as such is a measure of the respondent's construction project performance. Each respondent's BPR is given by:

BPRi = Final Account ÷ Tender Price (2)

where '**i**' represents each of the respondents. The ratio can also be averaged over each respondent's total number of projects given, to arrive at an Overall Budget Performance Ratio (OBPR) for each respondent.

Overall Performance Ratio (OPR): This is taken as the average of the Overall Schedule Performance Ratio (OSPR) and the Overall Budget Performance Ratio (OBPR) for each respondent, and is given by:

$$\mathbf{OPRi} = (OSPRi + OBPRi) \div 2 \qquad (3)$$

where '**i**' represents each respondent. The OPR is an attempt to measure the "objective" overall project performance, considering the planned versus actual project fundamentals of schedule/time and budget/costs.

From equations (1), (2) and (3), it can be deduced that:
If OPR = 1, then actual project performance was at par with the planned.
If OPR greater than 1, then actual project performance was below the planned.
If OPR less than 1, then actual project performance was better than the planned.

The interpretations also imply that the lower the value of OPR for any given respondent, the higher the concomitant level of performance; conversely, the higher the OPR, the lower the performance.

Secondary Performance Indices

These are based on the following indices, which also form part of the performance measurement approaches discussed in the literature review:

Employee Productivity Ratio (EPR): This relates to the output/value contributed per employee, in terms of the size/value of projects handled per professional employee. This use of this index is based on the consideration that a project personnel that is well knowledge-resourced via the use of knowledge management tools, will exhibit enhanced productivity vis-à-vis one that is otherwise (Robinson et al, 2005). An EPR can be obtained as follows:

EPRi = Project Final Account÷ (Number of personnel x Actual Project Duration)

where '**i**' represents each of the respondents. The ratio can be averaged over each respondent's total number of projects given to arrive at an Overall Employee Productivity Ratio (OEPR) for each respondent. (For the purposes of this study, a "Full-time" employee involvement is weighted as 1 personnel, a "Part-time" employee as ½, and a "Supervisory" employee involvement as 1½.) The classification of this index as secondary in informed by the consideration that certain projects, though large in size and associated budget, may only involve limited scope of works, and/or may run for a limited duration (e.g. an office building, or residential development, comprised of limited and/or repetitive construction works/activities); these would require lesser level of project personnel involvement than more complex projects with broader scopes (this research does not attempt to engage the differing levels of scope of the respondents' projects). (Another consideration in the relatively subjective method of determining what constitutes "full-time", "part-time" and "supervisory" level involvement of project management personnel.)

Repeat-Client Patronage: This relates to whether the respondent-selected project's client was a repeat client. This is an indication of the level of client satisfaction, which has been shown to be a performance benefit that would result in improved business competitiveness and financial results (Stewart, 1997). However, the use of this index in the context of this research is limited by the possible arbitrariness of choice of project given by the each respondent (the fact that a given respondent did not include any project awarded by a repeat client for consideration in the questionnaire cannot lead one to conclude that the said respondent has not undertaken any such project). This is therefore a crucial limitation in the use of this performance index in the context of this research. This consideration also informs the use of this measure as a secondary performance index, and its use will be limited to "Yes" or "No" indicators only.

Staff Retention/Staff Turnover: This pertains to the percentage of professional staff retained or leaving. It has been suggested that the level to which an employee perceives he is adequately provided with the necessary knowledge resources to carry out his duties contribute to job satisfaction. The performance effects of this would be in terms of reduction or increase in staff recruitment costs (Robinson et al, 2005).

Appendix C presents a complete breakdown of calculation of points for the various performance measurement indices for each respondent and associated organisation

4.5 Broad Levels of Awareness of Knowledge Management and Performance Benefits

Zou et al (2003) posit that one of the essential requirements for the effective implementation of knowledge management systems include top-level management commitment as well as a convivial culture within which employees are prepared and motivated to exploit the system. This is dependent on management and employee awareness and perception of the possible benefits of the system, since no matter how good the system may be, it will exist in name only if people are not using it.

In order to broadly measure the present levels of knowledge management awareness, respondents were asked to rate both personal and organisational awareness levels of perceived performance benefits associated with the use of knowledge management in construction project management. As suggested by Goddard and Melville (2005), a 4 point scale question, with associated coding (High = 3, Medium = 2, Low = 1, Nil = 0) was used to assess the relative awareness levels. All the responses from the 20 respondents were valid, and thus enabled the establishment of the broad levels of awareness of all respondents and their respective organisations. Table 4.3 below represents the broad levels of awareness of knowledge management processes and possible benefits, among the respondents and associated organisations respectively.

Analysis was carried out based on the information provided by the respondent, the broad levels of awareness of the concept of knowledge management, as well as recognition of possible performance enhancing benefits associated with its use in construction project management. The results revealed that awareness levels can be said to range mostly from “medium to high” (60%) (see Table 4.3, Table 4.4). The analysis therefore achieves the first objective of this research study (it must be noted however the relatively subjective nature of this information as provided by the respondents).

Table 4.3: Broad Levels of Awareness of Knowledge

No	Respondent	Knowledge Management Awareness Index Points (***Ap***)				Average **Ai = ∑ *Ap/4***
		Index 1	Index 2	Index 3	Index 4	
1.	A	3	3	3	3	3
2.	B	0	0	0	0	0
3.	C	1	3	2	2	2
4.	D	3	3	3	3	3
5.	E	2	2	2	2	2
6.	F	3	3	2	2	2.5
7.	G	3	3	2	2	2.5
8.	H	3	3	3	2	2.75
9.	I	2	2	2	2	2
10.	J	2	3	3	2	2.5
11.	K	2	3	3	3	2.75
12.	L	1	3	2	2	2
13.	M	1	3	3	3	2.5
14.	N	3	3	2	3	2.75
15.	O	3	3	3	3	3
16.	P	3	3	2	2	2.5
17.	Q	1	1	1	1	1
18.	R	1	1	0	0	0.5
19.	S	3	2	1	1	1.75
20.	T	3	3	3	3	3

Table 4.4: Summary of Knowledge Management Awareness Levels

Average Index (A)	Classification	Frequency	% (Total = 20)
Below 1	Low	2	10%
1 to 2	Low to Medium	6	30%
2.1 to 3	Medium to High	12	60%

4.6 General level of Knowledge Management Use

The second objective of this research is to examine generally the present level of use of knowledge management tools (i.e. both techniques and technologies as discussed in the literature review) in construction project management, with a view to establishing possible correlation between knowledge management and enhanced performance.

Respondents were asked to rate general levels of use of the various categories and types of knowledge management tools identified in the literature review, also using a four point scale as described in section 4.5 (see section 2b of research questionnaire, appendix A for details of rating scales). All 20 respondents gave valid responses, which are used in the measurement of the general level of use of each respective tool, as depicted in Table 4.5 below (see appendix B for comprehensive breakdown of calculation of points for the various indices for each respondent). The respondents showed a relatively equal mix and use levels of the various knowledge management techniques and technologies, without any obvious preferences stated or apparently observed in the use of both categories.

Analysis similar to that highlighted in section 4.5 is carried out on the information provided by the respondent, in order to measure the general levels of use of knowledge management tools and processes among the respondents. The result shows that the use levels ranges mostly from “medium to high” (90%) (see Table 4.5, Table 4.6). This indicates that most of the respondents are presently engaged in some form of knowledge management use in their various construction project management activities in South Africa. The analysis therefore achieves the second objective of this research study.

Table 4.5: General Levels of Use of Knowledge Management Techniques and Technologies

No.	Respondent	Average Level of Use of Knowledge Management Technique (U)	Average Level of Use of Knowledge management Technology (V)	Average (U + V) ÷ 2
1.	A	1.88	2.67	2.28
2.	B	1.63	3	2.32
3.	C	2	2.33	2.17
4.	D	2.63	3	2.82
5.	E	2.75	1	1.88
6.	F	2.13	3	2.57
7.	G	1.88	3	2.44
8.	H	2.5	2.67	2.58
9.	I	1.63	2.67	2.15
10.	J	2.63	3	2.81
11.	K	1.88	3	2.44
12.	L	2	2.33	2.17
13.	M	1.88	2.67	2.27
14.	N	2	1.33	1.67
15.	O	2.63	3	2.82
16.	P	1.88	3	2.44
17.	Q	1.75	3	2.38
18.	R	1.75	3	2.38
19.	S	1.63	2.67	2.15
20.	T	1.38	3	2.19

Table 4.6: Summary Levels of Use of Knowledge Management Tools

Average (U + V) ÷ 2	Classification	Frequency	% (Total = 20)
Below 1	Low	0	0%
1 to 2	Low to Medium	2	10%
2.1 to 3	Medium to High	18	90%

The next challenge would therefore be to explore possible correlation between the various levels of knowledge management use and levels of construction project performance, i.e. to establish whether high levels of knowledge management use indeed correlates with high/enhanced construction project management performance.

4.7 Correlation between Knowledge Management Use and Enhanced Construction Project Management Performance.

In order to examine a possible correlation between knowledge management use and enhanced performance in construction project management, it is necessary to first measure the performance levels of the various respondents/organisations participating in the research survey; the selected approaches for performance measurements have been discussed earlier in sections 2.6, 3.3 and 4.2.3 of this report. With the use of these approaches, the following construction project management performance measures/indices were computed for the various respondents/organisations (respondents 'S' and 'T' did not provide any project performance data in the returned questionnaires, and as such, these are excluded from further consideration in the data analysis of this research)

4.7.1 Primary Performance Measurement Indices (OPR)

The Overall Performance Ratios (OPR) were computed as previously detailed in section 4.2.3 and found to be as shown in Table 4.7 (see appendix C for comprehensive breakdown of calculation of points for the various performance measures for each respondent and associated organisation). These OPR thus calculated represents the primary performance measurement indices for the various respondents to the research survey. These indices would be used to

explore possible correlation between the various levels of knowledge management use and concomitant construction project management performance levels of the said respondents.

Table 4.7: Primary Performance Measurement Indices of Respondents

No.	Respondent	Overall Schedule Performance Ratio (OSPR)	Overall Budget Performance Ratio (OBPR)	Overall Performance Ratio (OPR)
1.	A	1.01	1.12	1.07
2.	B	1.60	1.01	1.31
3.	C	1.06	1.25	1.56
4.	D	1.00	1.12	1.06
5.	E	1.08	1.13	1.11
6.	F	1.00	1.13	1.07
7.	G	1.56	1.08	1.32
8.	H	1.42	1.90	1.66
9.	I	1.00	0.96	0.98
10.	J	1.00	0.96	0.98
11.	K	1.10	1.00	1.05
12.	L	1.06	1.25	1.16
13.	M	0.71	0.86	0.79
14.	N	1.28	1.22	1.3
15.	O	1.03	0.96	1.00
16.	P	1.00	1.08	1.04
17.	Q	0.95	0.92	0.94
18.	R	1.31	0.96	1.14

4.7.2 Secondary Performance Measurement Indices

The Overall Employee Productivity Ratio (OEPR) of the various respondents were also computed as previously detailed in section 4.2.3 and found to be as shown in Table 4.8 (see appendix C for comprehensive breakdown of calculation

of points for the various secondary performance measurement indices for each respondent and associated organisation). The “Repeat Client” measure is also depicted in the same table. It was noted that only 5 of the respondents (i.e. 25%) recorded any level of staff turnover data during the course of the projects provided for consideration. As such, this measure is excluded from further consideration in this research, by virtue of its limited usability.

Table 4.8: Secondary Performance Measurement Indices of Respondents

No.	Respondent	Overall Employee Productivity Ratio (OEPR) (R Million/Personnel Month)	Repeat Client (“Yes” or “No”)
1.	A	4.02	Yes
2.	B	1.95	No
3.	C	0.15	Yes
4.	D	0.39	No
5.	E	0.03	Yes
6.	F	1.50	Yes
7.	G	0.30	Yes
8.	H	0.11	Yes
9.	I	1.65	Yes
10.	J	0.12	Yes
11.	K	0.20	Yes
12.	L	0.10	Yes
13.	M	1.00	No
14.	N	0.48	No
15.	O	2.57	Yes
16.	P	2.26	Yes
17.	Q	1.98	No
18.	R	1.98	Yes

4.7.3 Examination of Possible Correlation

In order to examine possible correlation between knowledge management use and enhanced construction project management performance, a test for linear

correlation is adopted. Specifically, the Pearson's product-moment coefficient of linear correlation is utilised (as described in Goddard and Melville, 2005). The coefficient is calculated by the following formula:

$$r = \frac{\{n\sum XiYi - (\sum Xi)(\sum Yi)\}}{\sqrt{\{n\sum Xi^2 - (\sum Xi)^2\}}\sqrt{\{n\sum Yi^2 - (\sum Yi)^2\}}}.$$

This parameter "r" lies between -1 and 1. A value of 1 indicates a perfect linear dependence with a positive slope (an increase in the value of the variable X is associated with a proportionate increase in the value of the variable Y); a value of -1 indicates a perfect linear dependence with a negative slope (an increase in the value of variable X is associated with a proportionate decrease in the value of variable Y; this would be the expected scenario for possible correlation, if any, in this research, given the nature of the OPR values as highlighted in section 4.2.3). A value of 0 or thereabouts indicates very little correlation.

The purpose of adopting the test for linear correlation is to scientifically/ mathematically examine the possible dependence of levels of project management performance (as measured by the Overall Performance Ratio (OPR) indices) on the levels of knowledge management use (measured by the average levels of use of various knowledge management tools as indicated by the respondents' to the survey). This would indeed help establish possible correlation between the use of knowledge management processes and enhanced construction project management performance (Goddard and Melville, 2005).

The levels of knowledge management use indices computed earlier (see Table 4.5) are set as variable X, and are juxtaposed with the primary performance measurement indices (i.e. the OPRi) similarly computed for corresponding respondents (see Table 4.7), which are set as variable "Y" as shown in Table 4.9 below. The respondents are also listed in order of decreasing average knowledge management use levels. The coefficient of linear correlation is subsequently calculated.

Table 4.9: Levels of Knowledge Management Use and Overall Performance Ratio

No	Respondent	Average Levels of Knowledge Management Use (X)	Overall Performance Ratio (Y)
1	D	2.82	1.06
2	O	2.82	1.00
3	J	2.81	0.98
4	H	2.58	1.66
5	F	2.57	1.07
6	G	2.44	1.32
7	K	2.44	1.05
8	P	2.44	1.04
9	Q	2.38	0.94
10	R	2.38	1.14
11	B	2.32	1.31
12	A	2.28	1.07
13	M	2.27	0.79
14	C	2.17	1.56
15	L	2.17	1.16
16	I	2.15	0.98
17	E	1.88	1.11
18.	N	1.67	1.13

From the above (Table 4.9) Calculations give n = 18, $\sum Xi = 42.59$, $\sum Yi = 20.37$, $\sum XiYi = 48.12$, $\sum Xi^2 = 102.34$ and $\sum Yi^2 = 23.83$. Hence:

$$r = \frac{18 \times 48.12 - (42.59 \times 20.37)}{\sqrt{\{(18 \times 102.34) - 42.59^2\}} \times \sqrt{\{(18 \times 23.83) - 20.37^2\}}} = \mathbf{-0.07}$$

It can therefore be seen that, although there exists a negative value for "r", as would be expected and stated earlier, the magnitude of "r" shows very little

correlation between the high levels of knowledge management use and high construction project management performance levels. Thus, this reveals that there are other significant factors which contribute to construction project management performance, and its measurement, within contemporary South African context. Possible factors for this situation are considered in detail in section 4.9 of this research.

Attempt is also made at utilising the secondary performance measurement indices to examine possible correlation between knowledge management use and enhanced construction project performance, as shown in Table 4.10 below.

Table 4.10: Levels of Knowledge Management Use and OEPR, Repeat Clients

No	Respondent	Average Levels of Knowledge Management Use		Secondary Performance Measurement Indices	
		X Values	Classification	OEPR (R Mill/Personnel month)	Repeat Client
1	D	2.82	Medium to High	0.39	Yes
2	O	2.82		2.57	Yes
3	J	2.81		0.12	Yes
4	H	2.58		0.11	Yes
5	F	2.57		1.50	Yes
6	G	2.44		0.30	Yes
7	K	2.44		0.20	Yes
8	P	2.44		2.26	Yes
9	Q	2.38		1.98	No
10	R	2.38		1.98	Yes
11	B	2.32		1.95	No
12	A	2.28		4.02	Yes
13	M	2.27		1.00	No
14	C	2.17		0.15	Yes
15	L	2.17		0.10	Yes
16	I	2.15		1.65	Yes
17	E	1.88	Low to Medium	0.03	Yes
18	N	1.67		0.48	No

A comparative analysis between the average OEPR (as shown in Table 4.10) for the respondents with knowledge management use levels classified as “medium to high” vis-à-vis those of “low to medium” is carried out. Hence:

Average OEPR = $\sum$OEPR ÷ N

For respondents with knowledge management use levels classified as “medium to high”(N = 16), the average OEPR is R 1.27 million per employee-month; for respondents with knowledge management use levels classified as “low to medium” (N = 2), the average OEPR is R 0.26 million per employee-month. Thus, the higher average OEPR for respondents with relatively higher knowledge management use levels suggests a measure of dependence of employee productivity levels on the levels of knowledge management use in construction project management.

Also, Table 4.10 shows that 83% of respondents with knowledge management use levels classified as “medium to high” recorded patronage by repeat clients, compared with 50% of respondents with knowledge management use levels classified as “low to medium”. This also suggests a measure of dependence of customer satisfaction (and hence, enhanced performance, as discussed in section 2.5.3) on levels of knowledge management use.

It must however be restated that these two indices (i.e. OEPR and Repeat-client patronage) have been considered as secondary measures, for the purposes of this research, due to considerations mentioned earlier in section 4.2.3. Also, the sample population for respondents with knowledge management use levels classified as “low to medium”, (i.e. 2) is too small to enable such analysis to be ascribed much reliability.

4.8 Respondents’ General Comments

In order to achieve a holistic scope for this research, respondents were asked for comments on what, in their experiences, constitute key opportunities and threats regarding knowledge management use in construction project management in contemporary South Africa. They were also asked for comments on factors which informed their knowledge management use patterns.

4.8.1 Opportunities for and Threats to Knowledge Management Use

Several opportunities were identified for increased knowledge management use, the primary being the need for readily available, relevant and reliable information/knowledge, coupled with the provision of appropriate database(s) and software to facilitate its storage and access when required, in order to inform the decision making process. It was noted that out of all 20 respondents to the questionnaire survey, only 4 i.e. 20%, report any conscious attempt at managing project knowledge via a knowledge process and/or knowledge database/map (as discussed in section 2.3 and 2.5.2 of this report); not surprisingly, the respondents indicating a knowledge database as a key opportunity did not have any such system in place.

It is also noted that the organisations using a knowledge map had slightly higher performance measurement indices when compared to other organisations with similar knowledge management use levels. The relatively small sample of 4 however is relatively restrictive to permit inference.

The threats identified to knowledge management use include primary issues of affordability i.e. in terms of limited resources available to construction project management teams, coupled with perceived high cost of entry-level knowledge management systems. Also mentioned include limited commitment on the part of the respondent organisation's management, as well as limited skills and experience in the use of knowledge management processes among construction project personnel. These considerations are seemingly quite pervasive within the construction project management industry, and are not necessarily limited to the contemporary South African context (Zou et al, 2003, Sheehan et al, 2005). There is therefore the need for concerted effort to address this perception.

4.8.2 Knowledge Management Use Patterns

The type of knowledge management tool used was largely informed by the respondents' perceived suitability of same in achieving desired project outcome, based on experience. Also considered were issues of value-for-money, as well as

affordability, especially by respondents who considered their operations to be "small". As mentioned earlier, there were no stated or observed apparent preferences in choice of particular tool. Few respondents (3) whom indicated a choice for particular software used Microsoft Projects.

4.8.3 Other Comments

Most of the respondents also commented on the need for additional training for construction project-personnel in information and knowledge management use, in order to enhance its level of effectiveness in construction project management use.

The above findings fulfil the last objectives of this research. These findings are also largely supported by prior research and discourse by other authors (Egbu and Robinson, 2005; Prusak 2000; Sheehan et al, 2005; Zou et al, 2003a), thus establishing an acceptable measure of credence.

4.9 Discussion of Results

The third objective of this research is to examine a possible correlation between the use of knowledge management processes and enhanced performance in construction project management. The hypothesis that the experiences of other industries, which experienced higher performance levels with increased use of knowledge management processes, would be applicable to the construction project management industry would thus be tested. As demonstrated from the computations for a test for linear correlation between knowledge management use and enhanced performance in construction project management in section 4.7.3, the resultant value of "r" = - 0.07 reveals a minimal negative correlation. This situation brings about the necessity to explore further possible contributory factors that could have resulted in its occurrence. The following factors are thus identified:

4.9.1 Performance Measurement Approaches

The literature review identified the use of the Project Efficiency Review (PER) method, based on "objective" measures such as "project time/schedule" and

"project budget", as primary performance measures. These were accordingly adopted as such for the purposes of this research. However, the very inherent realities of the construction project environment in contemporary South Africa, particularly as revealed in the respondent survey, reveals its application to be inappropriate, for the following reason:

Changes in Project Scope

Over 55% (i.e. 10) of the respondents providing project performance data experienced significant changes in projects scope, which they believed impacted on both the construction project schedule (i.e. the actual project duration), as well as the project budget (i.e. the project final account). The impacts of these scope changes are usually negative and its extent usually unforeseeable at the planning phase of the construction project, during which the target/planned project schedule and budget are set. These scope changes usually originate from the client, or other project participant outside the direct influence of the construction project management professional associated with the said project. The resultant effect of this situation on the construction project management performance measurement, using the PER approach-derived indices, is to skew such measurement in an unpredictable manner.

Delays in Actual Project Schedules

This was a more prevalent occurrence, with over 88% (i.e. 16) of the respondents reporting some form of delay. These delays were also outside the control of the construction project management team. Reasons reported for unforeseen and uncontrollable delays include client financing, contractor delays, delays with procurement and electric power outages. Again, such delays would negatively impact on the actual construction project schedule, thereby skewing performance measurement using the PER approach.

4.9.2 Framework for Enhanced Performance Assessment

The assessment of enhanced performance, within the framework adopted for this research, attempts to compare the various current levels of knowledge

management use of respondents with concomitant levels of performance. This is done with a view to examining possible correlation between “high” levels of knowledge management use and “high” levels of construction project management performance; this approach therefore necessarily cuts across various organisations/respondents.

An alternative framework is via detailed case studies of selected organisations, in order to establish “before” and “after” performance levels of individual organisations involved in construction project management. This approach has been suggested by other authors, and has seen some degree of attempt at its use (Sheehan et al, 2005, Zou et al, 2003a). Such a framework would be able to accommodate, to an extent, the various scope-change and delay factors inherent in the industry, provided that the impact of such factors do not vary excessively with time, or such variations average out. However, such a framework requires a high degree of familiarity with the subject organisation’s processes, in terms of both “before” and “after” the knowledge management system’s implementation. It also requires the shear luck to find such an organisation that is about to embark on a knowledge management implementation process, as well as the patience to allow the said implementation reasonable time to yield possible concomitant performance enhancing benefits - Zou et al (2003a), in their detailed case studies of two construction project organisations carried out along these lines in 2002, were yet to establish any “objective” measure of performance level for the “after” situation when contacted in August, 2006, i.e. approximately 4 years after the said case studies. Due to these considerations, such a framework was not, and indeed could not, have been adopted, nor considered appropriate, for a research report such as this, which is time-limited to approximately 6 months.

Liu and Walker (1998) have noted that there are inherent complexities in project environments, which result in complex project goals. This, it seems, is being reflected in the construction project industry in South Africa, as elucidated in this research. The complexities in this instance are the result of changes in project scope and delays, which presently seem to be pervasive in the local industry.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Key Research Findings

This research study has investigated the concept of knowledge management, and its use as an efficiency enhancing tool in construction project management in South Africa, from the perspective of the professional construction project management professional. The study has adopted both descriptive and explanatory research methods, and was carried out over a period of approximately seven months (i.e. from May to November, 2006). The following paragraphs details the conclusions drawn from the findings of this research study.

The first objective was to explore the levels of awareness of knowledge management, and recognition of possible performance enhancing benefits associated with its use. Results showed that 60% of survey respondents exhibited a "medium to high" level of awareness in this regard, while 30% and 10% exhibited "low to medium" and "low" levels of awareness respectively. It can therefore be concluded that most construction project management professionals show an "above medium" level of awareness and appreciation of knowledge management use and possible concomitant benefits in construction project management in South Africa.

The second objective was to examine the present levels of use of knowledge management tools. In this regard, results showed that 90% of survey respondents showed a "medium to high" level of use of knowledge management tools, while 10% of respondents showed a "low to medium" level of same. This leads to the conclusion that almost all surveyed professionals are engaged in some form of knowledge management use in construction project management, and mostly at a "medium to high" level at that. Nil preferences or prevalence were identified in the choice or use of either category of knowledge management tool (i.e. technique and technology), as discussed earlier.

The third objective of this research study was to examine possible correlation between knowledge management use and enhanced construction project management performance in South Africa. A test for linear correlation was carried out between indices computed for levels of knowledge use and those computed for primary performance measures. The analysis thus showed a minimal level of correlation between level of knowledge management use and concomitant level of performance, given the performance measurement approaches utilised for this study. The possible causative factors considered for the lack of significant correlation are the apparent high incidence rates of scope changes and schedule delays, inherent in the construction industry in contemporary South Africa. These factors are crucial to the evaluation of the "objective" primary performance measurement indices utilised in the correlation analysis, and the prevalence these factors impact on the said indices in such a way as to skew these indices in an unpredictable manner.

The results of the research however established a measure of dependence of construction project performance on knowledge management use. A comparative analysis using the secondary performance measurement indices indicated some measure of dependence of enhanced performance on a "medium to high" level of knowledge management use. Since these indices were deemed secondary due to certain considerations (discussed in section 4.2.3 of this research), the analysis does not give sufficient credence to draw significantly reliable conclusions upon.

Regarding opportunities for, and threats to, effective knowledge management implementation in the contemporary construction project management profession in South Africa, the research identified 2 main opportunities:

- The use of a knowledge database/map, and associated software for accessing such, as a way to consciously manage construction knowledge, and also to serve as a key resource to inform subsequent construction project management related decisions. Egbu and Robinson (2005) also support this view (see section 2.5.2).

- Additional training for construction project management personnel in the values and use of knowledge management tools in order to alleviate perceived inadequacies in this regard.

The research also identified the following threats:

- Issues of affordability, vis-à-vis perceived high cost of entry-level knowledge management systems and tools suitable for use in construction project management
- Limited commitment of organisational top-level management to the implementation and use of knowledge management processes and tools in construction project management
- Inadequate levels of training of construction project personnel in the use of knowledge management processes and/or tools.

It was also noted that some of these opportunities and threats have been earlier identified by other authors in prior research and discourse, hence lending credence to such findings.

5.2 Conclusions and Recommendations for Further Research

This study has revealed generally high levels of knowledge management awareness and use in the construction project management profession in South Africa. It has also elucidated on the various opportunities and threats surrounding its effective use.

The research study, however, has also thrown some light on certain associated areas that require additional study and possible research. These studies would give further insights into the nature and impact of such areas on the use of knowledge management, and possible concomitant enhanced performance, in construction project management in South Africa. These areas are:

- The deriving of appropriate assessment methods for measuring the performance benefits achieved via knowledge management use in construction project management. The use of the Project Efficiency Review (PER) method, although based on “objective” measures such as

project schedule and budget, would be seriously impacted by factors such as changes in scope and delays as indicated in this study – these factors tend to seriously affect the two very crucial parameters upon which the PER-based performance measurement approach is factored, i.e. project time and cost. It is therefore necessary to devise performance measurement approaches that can either isolate and exclude the effects of the changes in project scope and delays, or otherwise accurately compensate for them. The need for such appropriate knowledge management performance method has also been identified by Zou et al (2003).

- The development of appropriate database systems and related application software, and/or the increase in awareness levels of the availability of such systems, for use in construction project management. Egbu and Robinson (2005) have also identified this as essential in any attempt to implement knowledge management in construction project management. Appropriate context sensitive information retrieval software would also need to be developed.
- The development of strategies aimed at securing the commitment of top-level management of organisations to knowledge management implementation in construction project management. This can best be achieved by establishing a "business case" for knowledge management use, i.e. by evaluating and measuring the concrete impact in terms of business value derivable from engaging in such activity (Sheehan et al, 2005). One of the key challenges, in an attempt to evaluate this business value, has been identified as the "intangibility of some of the benefits of knowledge management". Also identified is the issue of appropriate methods of performance measurement. Thus, addressing of the issue of the "performance measurement paradox" would therefore play a crucial role in further research in the field of knowledge management use in the construction project management industry (Zou et al, 2003a).

There is also the need to create greater awareness of the fact that knowledge management use in construction project management does not necessarily have to

be expensive. Non-information technology-based knowledge management techniques are generally affordable, as they do not require expensive, sophisticated infrastructure to build and are relatively simple to implement and use. This would encourage entry-level and possibly smaller construction project management organisations to embrace the use of knowledge management processes and systems in their operations.

As the construction project management profession progresses into the future, it has been noted that knowledge will be a critical resource, will transfer more effortlessly than money, will make for incredible levels of competition, and will spread “near-instantly” (Sheehan et al, 2005). Given these considerations, the construction industry in South Africa will have to actively embrace the use of knowledge management. Achieving effective knowledge management use will be challenging, given the local South African context as elucidated in the findings of this study; professionals and organisations will have to create and maintain not only knowledge management systems, but also a culture that truly recognises the benefits of knowledge management, as well as encourages its members to seek and use such knowledge.

APPENDIX A: Research Instrument and Covering Letter (typed on School of Civil and Environmental Engineering Letter-head) sent to Questionnaire Survey Respondents

September 20, 2006.

Dear Sir/Madam

LETTER OF INTRODUCTION TO A RESEARCH SURVEY

This letter serves to introduce to you a research survey, titled "EFFECTIVE KNOWLEDGE MANAGEMENT AS A PERFORMANCE ENHANCING TOOL IN CONSTRUCTION PROJECT MANAGEMENT", undertaken by a post-graduate student of the School of Civil Engineering, Faculty of Engineering and the Built Environment, University of the Witwatersrand. The attached questionnaire is designed to determine quickly and simply the level of knowledge management practices in your firm, as well as its impact on performance in recent construction projects undertaken. The research survey is being carried out among professional construction project managers. A summary of key research findings will be sent to you/your organisation on request.

The questionnaire is divided into four sections: section 1 seeks demographic information; section 2 focuses on levels of awareness and use of knowledge management processes, tools and activities; section 3 looks at project data, while section 4 seeks for your general comments

Please note that all responses and comments will be treated in confidentiality, and will only be used as statistical data for the research.

Thank you for your time and anticipated cooperation.

Yours faithfully,

Adekunle Olajide Taiwo

RESEARCH SUPERVISOR'S ATTESTATION:
I confirm that Mr. Adekunle Olajide Taiwo is a registered post-graduate student of the Faculty of Engineering and Built Environment and that the information he requests is solely for research purposes. Your kind assistance is appreciated.

Professor Alfred Talukhaba
Research Supervisor

The Research Questionnaire

Instruction for completing the questionnaire: Please answer questions as completely as possible (mark with an "**X**" as appropriate). Please return electronically via email to ktaiwo365@yahoo.com or by post mail to: AO Taiwo, PO Box 339, WITS 2050 Johannesburg, South Africa.

SECTION 1: DEMOGRAPHICS

a) Personal/Organisational

1) In which field is your professional/skills background?

Architecture _____ Building _____ Engineering ____ Q.S. _____
Other (please specify) _____

2) How long (on a personal capacity) have you been involved in the construction project management practice?

Less than 5 yrs ____ 5 – 10 yrs ____ More than 10 yrs ____

3) Are you (personally) a registered Construction Project Manager?

Yes ____ No ____

4) Which one of the following briefly describes your day-to-day role in your organisation (kindly mark more than one with "**X**" if required):

Planning ____ Organising ____ Directing ____ Controlling ____
Other (please specify) _____

5) How long has your firm been involved in construction project management?

Less than 5 yrs ____ 5 – 10 yrs ____ More than 10 yrs ____

SECTION 2: LEVELS OF AWARENESS AND USE OF KNOWLEDGE MANAGEMENT PROCESSES AND TOOLS

Knowledge management is concerned with the use and development of an organisation's knowledge assets, with a view to furthering the organisations objectives. The knowledge to be managed includes explicit, documented knowledge and tacit, subjective knowledge. Management of this knowledge thus entails all the processes and tools associated with the continuous creation, identification, aggregation, learning, sharing, use and re-use of both organisational and personal knowledge in the pursuit of enhanced business value. This section seeks to explore the levels of awareness and use of knowledge management in construction project management organisations.

a) Kindly rate the levels of the following indices in your organisations:

	KNOWLEDGE MANAGEMENT INDICES	ORGANISATIONAL LEVELS			
		HIGH 3	MEDIUM 2	LOW 1	NIL 0
1	Awareness of Knowledge Management practices/processes				
2	Recognition of business benefits of knowledge management among management-level personnel				
3	Recognition of business benefits of knowledge management use among project-level staff				
4	Perceived level of correlation between knowledge management and enhanced performance in construction project management.				

b) Kindly rate the levels of use of the following knowledge management tools in your organisation in the spaces provided below (Note: "High" usage represents an above 70% average general level of use, "Medium" represents between 40% to 70%, "Low" represents between 10% to 40%, while "Nil" represents less than 10% average general usage level):

	KNOWLEDGE MANAGEMENT TOOL	LEVELS OF USE			
		HIGH 3	MEDIUM 2	LOW 1	NIL 0
	TECHNIQUES				
1	Brainstorming				
2	Face-to-face interaction/meetings				
3	Post-project reviews				
4	Training				
5	Mentoring				
6	Apprenticeship				
7	Recruitment of experts				
8	Communities of practice/professional associations				
	TECHNOLOGIES				
9	Personal computers/workstations				
10	Network Technology (e.g. Intranet or Internet access)				
11	Professional project management software (please specify below):				
	GENERAL				
12	Levels of effectiveness of knowledge management use				

SECTION 3: PAST PROJECT DATA

Kindly fill in project data using the tables below. Each table should be used for one project. The following points should be noted in filling the tables:

- The subject construction project need to have **been managed and completed by your organisation within the last 5 years** approx (i.e. completion date falls between 2001 and 2005 inclusive)
- The start date for construction is the **handover date** of site to the contractor
- The completion date is the date of **issue of practical completion certificate.**
- Only projects implemented **within the Republic of South Africa** should be included in the survey
- Kindly ensure the information provided is as accurate as possible
- Kindly tick or fill in the required information as appropriate

Name of Project (optional) _____ **Year Completed** _____
Client Category and Profile:
Public _____ Private _____ Other (please specify) _____
New Client _____ Repeat Client _____

Project Performance:

<table>
<tr><td colspan="3">Project Schedule</td><td colspan="2">Project Budget</td><td colspan="2">Project Managers</td></tr>
<tr><td></td><td>Planned</td><td>Actual</td><td></td><td>Amount</td><td colspan="2">Numbers involved</td></tr>
<tr><td>Start Date</td><td>dd/mm/yy</td><td>dd/mm/yy</td><td>Tender Price</td><td>R</td><td>Full Time</td><td></td></tr>
<tr><td>Completion Date</td><td>dd/mm/yy</td><td>dd/mm/yy</td><td>Final Account</td><td>R</td><td>Part Time</td><td></td></tr>
<tr><td>Total Duration (Months)</td><td></td><td></td><td colspan="2" rowspan="2">Reasons for undue increases, if any:</td><td>Supervisory</td><td></td></tr>
<tr><td colspan="3" rowspan="2">Reasons for undue delays, if any:</td><td colspan="2">Estimated project staff turnover rate during course of project (%)</td></tr>
</table>

Name of Project (optional) _____ **Year Completed** _____
Client Category and Profile:
Public _____ Private _____ Other (please specify) _____
New Client _____ Repeat Client _____

Project Performance:

Project Schedule			**Project Budget**		**Project Managers**	
	Planned	**Actual**		Amount	Numbers involved	
Start Date	dd/mm/yy	dd/mm/yy	Tender Price	**R**	Full Time	
Completion Date	dd/mm/yy	dd/mm/yy	Final Account	**R**	Part Time	
Total Duration (Months)			Reasons for undue increases, if any:		Supervisory	
Reasons for undue delays, if any:					Estimated project staff turnover rate during course of project (%)	

Name of Project (optional) _____ **Year Completed** _____
Client Category and Profile:
Public _____ Private _____ Other (please specify) _____
New Client _____ Repeat Client _____

Project Performance:

Project Schedule			**Project Budget**		**Project Managers**	
	Planned	**Actual**		Amount	Numbers involved	
Start Date	dd/mm/yy	dd/mm/yy	Tender Price	**R**	Full Time	
Completion Date	dd/mm/yy	dd/mm/yy	Final Account	**R**	Part Time	
Total Duration (Months)			Reasons for undue increases, if any:		Supervisory	
Reasons for undue delays, if any:					Estimated project staff turnover rate during course of project (%)	

Kindly make additional copies of this page for additional projects if required.
SECTION 4: GENERAL COMMENTS

Kindly answer the following questions:

1) What considerations informed the choices and patterns of knowledge management tools used **as indicated by you in section 2** of this questionnaire?

2) What processes (if any) do you/your organisation adopt to consciously manage construction project knowledge?

3) Do you/your organisation have a "knowledge database/resource map" for locating pertinent project management knowledge?

Yes _____ No _____

If yes, please describe briefly:

4) What further opportunities do you identify for implementing effective knowledge management in your organisations/operations?

5) What obstacles/threats do you identify to the use of effective knowledge management to construction project management enterprise?

6) Do you have any additional information about your self/organisation/projects that you consider relative to this research?

7) Do you have any other comments concerning any aspect of Knowledge Management?

Thank you for your time!

Please return electronically via email to ktaiwo365@yahoo.com or by post mail to: AO Taiwo, PO Box 339, WITS 2050 Johannesburg, South Africa.

APPENDIX B: GENERAL LEVELS OF USE OF KNOWLEDGE MANAGEMENT TOOLS: TECHNIQUES (U)

RESPONDENT/ ORGANISATION	INDEX POINTS (Up; High = 3, Medium = 2, Low = 1, Nil = 0)								
	Brain storming	Face-to-face meetings	Post-project reviews	Training	Mentoring	Apprentice-ship	Recruitment of experts	Professional Associations	Average Level of Use (Ui = ∑Up/3)
A	1	3	3	2	2	0	2	2	**1.88**
B	2	3	2	2	2	0	1	1	**1.63**
C	2	3	2	1	2	2	3	1	**2**
D	2	3	2	3	3	3	3	2	**2.63**
E	3	3	2	3	3	3	3	2	**2.75**
F	2	3	2	3	3	1	1	2	**2.13**
G	3	3	2	1	1	0	2	3	**1.88**
H	2	3	3	3	2	2	3	2	**2.5**
I	2	2	2	1	1	1	2	2	**1.63**
J	2	3	3	3	3	3	2	2	**2.63**
K	3	2	1	3	2	0	2	2	**1.88**
L	2	3	2	1	2	2	3	1	**2**
M	3	3	2	1	1	1	3	1	**1.88**
N	3	2	3	2	2	0	3	1	**2**
O	3	3	2	3	3	1	3	3	**2.63**
P	1	3	3	2	2	0	2	2	**1.88**
Q	2	3	2	2	2	0	2	1	**1.75**
R	0	1	1	2	2	2	3	3	**1.75**
S	1	2	2	2	1	0	3	2	**1.63**
T	2	3	1	1	2	0	1	1	**1.38**

APPENDIX B (Contd.): GENERAL LEVELS OF USE OF KNOWLEDGE MANAGEMENT TOOLS: TECHNOLOGIES (V)

RESPONDENT/ ORGANISATION	INDEX POINTS (Vp; High = 3, Medium = 2, Low = 1, Nil = 0)				AVERAGE (U+V)/2
	Personal Computers/ Workstations	Network Technology (e.g. Intranet/Internet Access	Professional Project Management Software	Average Level of Use (Vi = ∑Vp/3)	
A	3	3	2	**2.67**	**2.28**
B	3	3	3	**3**	**2.32**
C	3	3	1	**2.33**	**2.17**
D	3	3	3	**3**	**2.82**
E	1	1	1	**1**	**1.88**
F	3	3	3	**3**	**2.57**
G	3	3	3	**3**	**2.44**
H	3	3	2	**2.67**	**2.58**
I	3	3	2	**2.67**	**2.15**
J	3	3	3	**3**	**2.81**
K	3	3	3	**3**	**2.44**
L	3	3	1	**2.33**	**2.17**
M	3	3	2	**2.67**	**2.27**
N	1	1	2	**1.33**	**1.67**
O	3	3	3	**3**	**2.82**
P	3	3	3	**3**	**2.44**
Q	3	3	3	**3**	**2.38**
R	3	3	3	**3**	**2.38**
S	3	3	2	**2.67**	**2.15**
T	3	3	3	**3**	**2.19**

APPENDIX C: PROJECT DATA FOR RESPONDENTS

Project Data for Respondent/Organisation A

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	14	11	Nil Given	
Actual Schedule (Months)	13	12		
SPRi	**0.93**	**1.09**		**1.01**
Tender Price (R mill.)	160	27		
Final Account (R mill.)	180	30		
BPRi	**1.13**	**1.11**		**1.12**
Project Personnel Number Involved	2.5	1		
EPRi	**5.54**	**2.5**		**4.02**
Repeat Client (Yes/No)	Yes	No		

Project Data for Respondent/Organisation B

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	17	5	Nil Given	
Actual Schedule (Months)	24	9		
SPRi	**1.41**	**1.8**		**1.60**
Tender Price (R mill.)	110	14		
Final Account (R mill.)	112	14		
BPRi	**1.02**	**1.00**		**1.01**
Project Personnel Number Involved	2	1		
EPRi	**2.33**	**1.56**		**1.95**
Repeat Client (Yes/No)	No	No		

Project Data for Respondent/Organisation C

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	29	19	46	
Actual Schedule (Months)	31	18	53	
SPRi	**1.07**	**0.95**	**1.15**	**1.06**
Tender Price (R mill.)	10	8	5	
Final Account (R mill.)	14	10	5.5	
BPRi	**1.4**	**1.25**	**1.12**	**1.25**
Project Personnel Number Involved	3.5	2	2	
EPRi	**0.13**	**0.28**	**0.05**	**0.15**
Repeat Client (Yes/No)	Yes	Yes	No	

Project Data for Respondent/Organisation D

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	13	12	11	
Actual Schedule (Months)	12	12	12	
SPRi	**0.92**	**1.00**	**1.08**	**1.00**
Tender Price (R mill.)	4.5	5.2	3.3	
Final Account (R mill.)	5.2	5.5	3.8	
BPRi	**1.16**	**1.06**	**1.15**	**1.12**
Project Personnel Number Involved	1	1	1	
EPRi	**0.4**	**0.46**	**0.32**	**0.39**
Repeat Client (Yes/No)	No	No	No	

Project Data for Respondent/Organisation E

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	9	15	1	
Actual Schedule (Months)	10	17	1	
SPRi	**1.11**	**1.13**	**1**	**1.08**
Tender Price (R mill.)	2.9	1.7	0.00065	
Final Account (R mill.)	3.2	2.2	0.00065	
BPRi	**1.10**	**1.29**	**1**	**1.13**
Project Personnel Number Involved	5	4	2.5	
EPRi	**0.06**	**0.03**	**0.00**	**0.03**
Repeat Client (Yes/No)				

Project Data for Respondent/Organisation F

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	60	Nil Given	Nil Given	
Actual Schedule (Months)	60			
SPRi	**1.00**			**1.00**
Tender Price (R mill.)	120			
Final Account (R mill.)	135			
BPRi	**1.13**			**1.13**
Project Personnel Number Involved	1.5			
EPRi	**1.5**			**1.5**
Repeat Client (Yes/No)	Yes			

Project Data for Respondent/Organisation G

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	9	3	3	
Actual Schedule (Months)	12	2	8	
SPRi	**1.33**	**0.67**	**2.67**	**1.56**
Tender Price (R mill.)	8	8	4	
Final Account (R mill.)	10	8	4	
BPRi	**1.25**	**1.00**	**1.00**	**1.08**
Project Personnel Number Involved	11	5	11	
EPRi	**0.08**	**0.8**	**0.05**	**0.3**
Repeat Client (Yes/No)	Yes	No	Yes	

Project Data for Respondent/Organisation H

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	13	9	12	
Actual Schedule (Months)	18	16	13	
SPRi	**1.38**	**1.78**	**1.08**	**1.42**
Tender Price (R mill.)	4.35	10.9	11.3	
Final Account (R mill.)	5.1	27.1	23.1	
BPRi	**1.17**	**2.49**	**2.04**	**1.9**
Project Personnel Number Involved	6	10.5	13.5	
EPRi	**0.05**	**0.16**	**0.13**	**0.11**
Repeat Client (Yes/No)	No	Yes	Yes	

Project Data for Respondent/Organisation I

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	6	6	6	
Actual Schedule (Months)	6	6	6	
SPRi	**1.0**	**1.0**	**1.0**	**1.0**
Tender Price (R mill.)	4.4	5.2	5.7	
Final Account (R mill.)	3.9	5.0	5.9	
BPRi	**0.89**	**0.96**	**1.04**	**0.96**
Project Personnel Number Involved	0.5	0.5	0.5	
EPRi	**1.3**	**1.67**	**1.97**	**1.65**
Repeat Client (Yes/No)	Yes	Yes	Yes	

Project Data for Respondent/Organisation J

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	20	16	On-going	
Actual Schedule (Months)	20	16		
SPRi	**1.0**	**1.0**		**1.0**
Tender Price (R mill.)	9.2	3.2		
Final Account (R mill.)	8.7	3.1		
BPRi	**0.95**	**0.97**		**0.96**
Project Personnel Number Involved	3	2		
EPRi	**0.15**	**0.10**		**0.12**
Repeat Client (Yes/No)	Yes	No		

Project Data for Respondent/Organisation K

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	12	13	8	
Actual Schedule (Months)	14	13	9	
SPRi	**1.16**	**1.00**	**1.13**	**1.10**
Tender Price (R mill.)	3.8	7.8	7.5	
Final Account (R mill.)	3.9	7.9	7.3	
BPRi	**1.03**	**1.01**	**0.97**	**1.00**
Project Personnel Number Involved	3	3	2.5	
EPRi	**0.09**	**0.20**	**0.32**	**0.20**
Repeat Client (Yes/No)	Yes	Yes	Yes	

Project Data for Respondent/Organisation L

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	29	19	46	
Actual Schedule (Months)	31	18	53	
SPRi	**1.07**	**0.95**	**1.15**	**1.06**
Tender Price (R mill.)	10	8	5	
Final Account (R mill.)	14	10	5.5	
BPRi	**1.40**	**1.25**	**1.10**	**1.25**
Project Personnel Number Involved	7.5	4	1	
EPRi	**0.06**	**0.14**	**0.10**	**0.10**
Repeat Client (Yes/No)	Yes	Yes	No	

Project Data for Respondent/Organisation M

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	2.13	Nil Given	Nil Given	
Actual Schedule (Months)	1.5			
SPRi	**0.71**			**0.71**
Tender Price (R mill.)	1.75			
Final Account (R mill.)	1.5			
BPRi	**0.86**			**0.86**
Project Personnel Number Involved	1			
EPRi	**1.0**			**1.0**
Repeat Client (Yes/No)	No			

Project Data for Respondent/Organisation N

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	24	15	Nil Given	
Actual Schedule (Months)	26	22		
SPRi	**1.08**	**1.47**		**1.28**
Tender Price (R mill.)	8	12		
Final Account (R mill.)	8.8	16		
BPRi	**1.1**	**1.33**		**1.22**
Project Personnel Number Involved	1.5	1		
EPRi	**0.23**	**0.72**		**0.48**
Repeat Client (Yes/No)	New	New		

Project Data for Respondent/Organisation O

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	46	42	Nil Given	
Actual Schedule (Months)	49	42		
SPRi	**1.07**	**1.00**		**1.03**
Tender Price (R mill.)	361	50		
Final Account (R mill.)	348	48		
BPRi	**0.96**	**0.96**		**0.96**
Project Personnel Number Involved	2.5	0.5		
EPRi	**2.84**	**2.29**		**2.57**
Repeat Client (Yes/No)				

Project Data for Respondent/Organisation P

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	18	8	10	
Actual Schedule (Months)	16	8	11	
SPRi	**0.89**	**1.0**	**1.1**	**1.0**
Tender Price (R mill.)	150	25	82	
Final Account (R mill.)	170	24	94	
BPRi	**1.13**	**0.96**	**1.15**	**1.08**
Project Personnel Number Involved	4.5	1	6	
EPRi	**2.36**	**3.0**	**1.42**	**2.26**
Repeat Client (Yes/No)	Yes	No	No	

Project Data for Respondent/Organisation Q

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	18	3.5	Nil Given	
Actual Schedule (Months)	16	3.5		
SPRi	**0.89**	**1.0**		**0.95**
Tender Price (R mill.)	119	21		
Final Account (R mill.)	100	21		
BPRi	**0.84**	**1.00**		**0.92**
Project Personnel Number Involved	4	2.5		
EPRi	**1.56**	**2.4**		**1.98**
Repeat Client (Yes/No)	No	No		

Project Data for Respondent/Organisation R

Project Particulars	Project A	Project B	Project C	Overall Indices
Planned Schedule (Months)	4.5	7.5	Nil Given	
Actual Schedule (Months)	7	8		
SPRi	**1.56**	**1.07**		**1.31**
Tender Price (R mill.)	5.5	3.4		
Final Account (R mill.)	5.7	3		
BPRi	**1.04**	**0.88**		**0.96**
Project Personnel Number Involved	0.5	0.5		
EPRi	**1.63**	**0.75**		**1.98**
Repeat Client (Yes/No)	No	Yes		

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