

Knowledge management as a performance enhancing tool in construction project management in South Africa

Peer review

Abstract

Knowledge management is concerned with the development and exploitation of the knowledge assets of an organisation, with a view to furthering the organisation's objectives. The vital role that knowledge management processes play 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 another. Taking these accounts into consideration, this article attempted 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 was thus carried out among registered professional construction project managers in South Africa.

The levels of awareness and use of knowledge management systems among construction project management professionals in South Africa was analysed. This revealed a mostly 'medium to high' level of awareness and use. However, the Project Efficiency Review (PER) approach to performance measurement showed limited correlation between knowledge management use and enhanced performance in construction project performance. Other performance measurement approaches such as Metrics, Economic and Market Value 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.

Keywords: Knowledge management, project management, performance measurement.

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Abstrak

Kennisbestuur het ten doel om die kennisbata van 'n organisasie te ontwikkel en te benut ter bevordering van die organisasie se doelstellings. Die kardinale rol wat kennisbestuur speel in organisasies se prestasies vorm die basis van verskeie studies – 'n aantal besighede buite die konstruksiebedryf het getoon dat daar 'n behoefte is aan die aanvaarding van kennisbestuurprosesse aan die een kant, en die prestasieverbeteringsvoordele wat sodanige kennisbestuurprosesse bied, aan die ander kant. In die lig hiervan het hierdie studie onderneem om die hipotese dat effektiewe kennisbestuur 'n instrument tot prestasieverbetering in die konstruksiebedryf in Suid-Afrika daarsalstel, getoets. Die navorsingsondersoek is uitgevoer onder professionele konstruksie-projekbestuurders in Suid-Afrika.

Die bewustheidsvlakke en gebruik van kennisbestuursisteme onder professionele konstruksie-projekbestuurders in Suid-Afrika is ondersoek; die resultate het 'n 'medium tot hoë' bewustheidsvlak en gebruik getoon. Die Projekvaardigheidsoorsigbenadering tot prestasie meting is hoofsaaklik in hierdie studie gebruik. Dit het 'n beperkte korrelasie tussen kennisbestuur gebruik en verhoogde prestasie in konstruksieprojekte getoon. Ander prestasie metingbenaderings byvoorbeeld Metrieke, Ekonomiese en Markwaarde, het ook beperkte korrelasie getoon. Twee huidige wydverspreide bydraende faktore tot hierdie toedrag van sake in Suid-Afrika is die verandering aan projekbestek (omvang) en skedule verdragings. Verdere navorsing word dus aanbeveel om 'n meer toepaslike 'objektiewe' meetinstrument vir prestasie daar te stel wat hierdie kompleksiteit kan akkommodeer. So 'n instrument sou die ontwerp/skep van 'n besigheidsaak vir kennisbestuur gebruik in konstruksie-projekbestuur in die hand werk.

Slutelwoorde: Kennisbestuur, projekbestuur, prestasie meting

1. Introduction

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 project activities, processes and associated resources - especially the human resource - the project teams thus formed are usually dismantled upon the completion of the project. The consequent risk of valuable empirical project-related knowledge being lost at the end of the project is therefore highly probable, unless a conscious effort is made to accumulate and manage such knowledge in a systematic manner.

The application of knowledge management practices has been shown to contribute to enhanced business performance in several business fields and industries, such as information technology, manufacturing and petrochemical (Despres & Chauvel, 2000; Robinson, Carrillo, Anumba & Al-Ghassani, 2005: 132-150). Construction project management is not an exception. The use

of knowledge management would enable project teams to have ready access to required knowledge; it would help establish success models, avoid the repetition of past mistakes, and form a basis for the development of better procedures. The end result would be enhanced performance and eventually, profitability. This article seeks to explore the correlation between knowledge management use and enhanced performance in construction project management in South Africa.

In a highly competitive business world of the 21st century, the need for continuous strategically driven knowledge creation and management is a necessity in any organisation that wishes to achieve and maintain a competitive edge, in order to improve its performance and profitability. Large Japanese companies have relied on knowledge creation to foster long-term innovation and strong business performance (Davenport & Marchand, 2000: 165-169; Despres & Chauvel, 2000: 170-176). This explains why an increasing number of companies are adopting knowledge management in one form or another. The construction industry should not be left behind in the use of knowledge management. There is therefore a need to explore possible avenues whereby appropriate knowledge management processes can be utilised in construction project management, in order to improve business processes, i.e. enhance performance, as well as increase productivity and profitability.

2. Knowledge management in construction project management

2.1 Overview of knowledge management

Various authors have defined knowledge management, highlighting different aspects. Knowledge management is mainly concerned with the development and exploitation of the knowledge assets of an organisation, with a view to furthering the organisation's objectives (Davenport & Prusak, 1998). The knowledge to be managed includes the explicit, documented, tacit as well as subjective knowledge. Management of this knowledge entails all the processes associated with the creation, identification and sharing of knowledge. Young (2003) views knowledge management in a different light, namely that the creation and subsequent management of certain environments encourage knowledge to be created, shared, learnt, enhanced, organised and utilised for the benefit of the organisation. This reveals a cultural aspect of the organisation. Recently a number of companies have proven the need and benefits of adopting

knowledge management processes, in one form or another. This argument proclaims that intellectual capital is essential to wealth generation, and is key to ensuring success in the future (Despres & Chauvel, 2000).

According to Quintas (2005: 10-30), knowledge in today's organisations exists mainly in two forms:

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

Much of the knowledge generated in organisational processes is tacit knowledge (Quintas, 2005: 10-30); people are therefore the locus of much organisational knowledge. As such, a key challenge for understanding knowledge management would be to convert as much as possible valuable tacit knowledge to explicit knowledge.

2.2 The knowledge process

Despres & Chauvel (2000: 170-176) propose six steps in the knowledge management process:

- Mapping - The individual, or even an organisation, is unable to embrace the entire universe of information available. Instead, people seek comprehensible nuggets of information with which they are familiar and comfortable, 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, and multimedia. The information must be given coherent meaning, usually by an author, in order to enable others to utilise the information.

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- 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 and therefore it can only be recognised as knowledge within some kind of social context. The value of knowledge depends on the actions which result from it.
- Innovate/evolve/transform - In order to retain its value, knowledge must evolve to keep in step with changes in the environment. This necessitates research and development programmes that build on experiences in the marketplace, as well as creativity processes that broaden intellectual horizons.

2.3 Knowledge management tools

The aforementioned knowledge process requires certain systems and tools for its operation. Knowledge management tools comprise both Information Technology (IT) and non-IT-based tools, required to support various processes and sub-processes of knowledge management. These processes include locating, sharing and codifying knowledge (i.e. converting 'tacit knowledge' to 'explicit knowledge') (Al-Ghassani, Anunba, Carrillo & Robinson, 2005: 83-102). A large number of tools are available to choose from in implementing a knowledge management strategy. Selecting appropriate knowledge management tools for individual companies needs to be carefully considered in order to ensure that the business issues and contexts are understood and that the company's goals are adequately addressed. Knowledge management tools can be broadly divided into two categories.

2.3.1 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. These 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: 83-102) propose the following examples of knowledge management techniques:

- Brainstorming - This process involves a group of people who meet to focus on a problem, and then intentionally propose as many deliberate unusual solutions as possible.
- Communities of practice - These consist of a group of people of different sets of skills, development histories and experienced backgrounds who collaborate to achieve commonly shared goals. 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 tacit knowledge owned by an organisation and its employees. It also helps in increasing the organisation's memory, developing trust and encouraging effective learning.
- 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 or 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.
- Mentoring - This is a process where a trainee or junior member of staff is assigned to a senior member of an organisation for advice on 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 organisation's knowledge base.
- Training - This helps to improve staff skills and therefore increase knowledge. It usually takes place in a formal format, which can be internal or external, and could be used to ensure that employees' knowledge is 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.

2.3.2 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, Bloomfield, Faraj & Jarvis, 2000; Egbu, 2000; Storey & Barnett, 2000: 145-156). 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 relate mainly to people and organisational culture (Davenport & 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 as well as between organisations, and public network technology (e.g. the internet) and/or private network technology (e.g. intranet, extranet) to facilitate access to and/or sharing of knowledge.
- Software technologies - Several software packages are available from various vendors capable of performing different knowledge management tasks and functions. According to Manchester (2000: 185-186), 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; context-sensitive document management tools, and workflow processing software. Increasingly, vendors in these sectors are incorporating information retrieval engines into their products.

2.4 Knowledge management in the construction industry

The importance and implications of knowledge management in the construction project management is extensive. The decision on what knowledge an organisation needs and the knowledge intensity depends on the context of the business environment, i.e. the key knowledge about the business processes and people, for the delivery of its products (Egbu & Robinson, 2005: 31-49). 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).

Currently 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 as well as present standards, and yet they must also seek to incorporate an ever-growing pool of new ideas in order to innovate faster than the competition (Sheehan, Poole, Lyttle, & Egbu, 2005: 50-64). In the face of such challenges, effective knowledge management offers construction organisations that seek to enhance their business performance real potential in key areas necessary for effective delivery of construction projects. In order to adequately address these challenges, construction professionals and organisations face economic imperatives that can move towards increased codification of knowledge. This enhances efficiency of exploitation and transparency of sharing, while reducing knowledge costs (Egbu & Robinson, 2005: 31-49).

2.5 Knowledge mapping in construction organisations

Egbu & Robinson (2005: 31-49) posit that the point of departure for structuring construction project knowledge is to develop a knowledge map. This locates explicit knowledge and serves as a pointer to holders of tacit knowledge. Figure 1 shows a possible framework for developing 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 to learn from past and current projects through the navigation of information and codified knowledge. It also assists in capturing and integrating tacit knowledge into the project knowledge base, as well as creating new knowledge by adding, refining and broadening the scope.

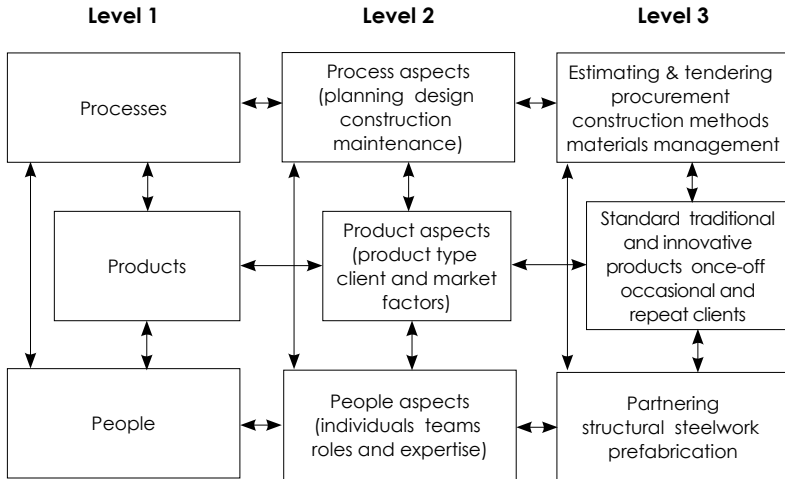


Figure 1: Knowledge mapping in construction organisation
Source: Egbu & Robinson 2005: 31-49

2.6 Potential benefits of knowledge management in construction project management

It is clear from the foregoing 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 may include:

- Increased innovation - It is recognised 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: 10-30). 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, and is inseparable from, the innovation process. New knowledge is also an output of that process (Quintas, 2005: 10-30).
- Lower dependence on key individuals - Once the tacit knowledge from key individuals is 'harvested', codified and stored using the various knowledge management tools and systems discussed earlier, there will be less dependence on

individuals; their experience would now be available to all via the knowledge retrieval system. In addition, 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 teamwork - In knowledge management-oriented companies, knowledge employees use contemporary advanced technologies to pave the way for knowledge flow via electronic networking. This, in turn, saves the time and cost of knowledge sharing, irrespective of distance and physical locations (Zou, McGeorge, & Lim, 2003: 233-250). Good communication and knowledge management practices also present 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: 185-186); inputting a query request using a keyword would produce 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 has been advocated as an area of importance for day-to-day performance, with concomitant significance to a company's business success (Kahkonen & Kazi, 2003: 163-173). Specific risk knowledge management systems would readily inform decision pertaining to key issues in construction projects (such as health and safety as well as 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 employees leave or retire from the organisation. Knowledge losses due to reduction in personnel are also minimised throughout the project (Girmscheid & Borner, 2003: 137-149).

- 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, as the project management essentials of time, cost and quality can be better delivered on a given project. This would be achieved using templates derived from well-designed knowledge management systems. Increased client satisfaction is a benefit that would result in improved business competitiveness and financial performance (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 go hand-in-hand with losses of efficiency in finalising the project (Girmscheid & Borner, 2003: 137-149). Such situation would be avoided, along with the repetition of past mistakes, resulting in cost savings and financial gains.
- Interdisciplinary knowledge transfer - Knowledge management has the potential to promote knowledge transfer across a variety of project interfaces in organisations, disciplines and sectors. The construction industry may find knowledge from other sectors or disciplines useful in implementing innovative systems and processes specific to the sector.

2.7 Knowledge management and performance measurement

There is the need to measure the performance benefits of utilising 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 is an evolving area - the degree whereby a project achieves its stated goals is one of the major ways of measuring its level of performance and success. Objective project goals are usually stated in terms of project time/schedule, cost/budget and quality/technical specifications (Liu & Walker, 1998: 209-219). Along these lines, Shenhar, Dvir, Levy & Maltz (2001: 699-725) identify the Project Efficiency Review (PER) as an 'objective' approach for measuring performance and success in project management. However, other researchers have argued that the use of solely objective measures (i.e. 'on time/schedule', 'within budget' and 'according to quality/

technical specification') is not sufficient for the assessment of project performance (Morris, 1986: 16-55; Baker, Murphy, & Fisher, 1983: 902-919). Accordingly, Robinson *et al.* (2005: 132-150) propose other performance measurement indices which are grouped into three approaches: namely,

- Metrics approach – This approach uses 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 knowledge management objectives (e.g. staff training, experienced recruitments), while output indicators measure the performance or result of those actions (e.g. improved client satisfaction, reduced cost and time overruns). This approach is based on the assumption that there is a relationship or correlation between the indicators of business performance and profitability.
- Economic approach - This approach attempts 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.
- Market-value approach – This 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 therefore constitutes the difference between the value assigned to an organisation by a buyer or the stock market in relation to its book-market value.

3 Research methodology

3.1 Overview

Participants in the survey were registered professional construction project manager as members of the South African Council of Project and Construction Management Professions (SACPCMP). Theoretical frameworks discussed earlier were used in two parts, i.e. the analysis of the current levels of knowledge management among the surveyed construction project managers, and subsequently, measurement of construction project management performance. 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 adopted a balanced selection of elements of two of the earlier mentioned performance measurement approaches, namely:

- **Project Efficiency Review measurement approach (PER):** The elements utilised include:
 - 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
- **Economic Measurement Approach (EMA):** The elements utilised include:
 - Repeat client business - This relates to the amount of repeat business; previous 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.

3.2 The research instrument

An information gathering instrument, consisting of a detailed questionnaire incorporating the use of investigative questions, was adopted. The information required from the respondents was organised broadly into four sections. These addressed the demographic profiles of respondents, levels of recognition of possible benefits as well as actual use of knowledge management strategies and tools in construction project management by the respondents. In addition, project management performance measurement data, and general comments from the respondent concerning any aspect of the research, were included.

3.3 Data gathering

The names and contact details of registered professional construction project managers were obtained from SACPCMP sources. The survey questionnaire, along with a covering letter introducing the research objectives and possible benefits, was subsequently sent (electronically via email) to over 150 registered members (these were selected by virtue of their email addresses being available and obtainable from SACPCMP sources). A total of 20 questionnaires were returned. Although a larger respondent sample would have been preferable, the time constraints surrounding the research programme necessitated the adoption of a time-definite cut-off point for the return of survey questionnaires. However, Goddard & Melville (2005) suggest that a sample of 20 is sufficient for a small-sample analysis, and is therefore considered appropriate for the purposes of the study. The fact that over 90% of the polled project managers reported having over 10 years of construction project management experience, coupled with the geographical spread of their locations of practice (i.e. cities spread across South Africa such as Johannesburg, Pretoria, Cape Town and Durban) further lends credibility to their feedback as well as the outcome of this research.

4. Results and analysis

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

4.1 Broad levels of awareness of knowledge management and performance benefits

Zou *et al.* (2003: 233-250) posit that effective implementation of knowledge management systems is dependent on management and employee awareness and perception of the possible benefits of the system. This is because, no matter how good the system might 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. To this end, respondents were asked four questions, which serve as awareness indices, i.e. 1) awareness levels of knowledge management practices/processes; 2) recognition of

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business benefits of knowledge management among management-level personnel; 3) recognition of business benefits of knowledge management use among project-level staff, and 4) perceived level of correlation between knowledge management and enhanced performance in construction project management. (It is noted that such responses would be somewhat subjective). A 4-point scale and associated coding (High = 3, Medium = 2, Low = 1, Nil = 0) was used to assess the relative awareness levels, as suggested by Goddard & Melville (2005). The results revealed that 60% of the survey respondents indicated awareness level indices ranging from 'medium to high'. This leads one to conclude that the respondent project management personnel in South Africa are likely to make use of knowledge management tools, provided they are appropriately resourced with such tools (see Tables 1 and 2).

Table 1: Broad levels of awareness of knowledge

No	Respondent	Knowledge Management Awareness Index Points (Ap)				Average $A_i = \sum A_p / 4$
		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 2: Summary of knowledge management awareness levels

<i>Average Index (A)</i>	<i>Classification</i>	<i>Frequency</i>	<i>% (Total = 100%)</i>
Below 1	Low	2	10%
1 to 2	Low to Medium	6	30%
2.1 to 3	Medium to High	12	60%

4.2 General level of knowledge management use

Respondents were asked to rate general levels of use of the various categories and types of knowledge management tools discussed earlier in sections 2.3.1 and 2.3.2. Responses were also evaluated using a four-point ranking scale as described earlier in section 4.1. The respondents showed a relatively equal mix and use levels of the various knowledge management techniques and technologies, without any obvious preferences. The results showed that 90% of the respondents indicated that they use knowledge management at different levels, ranging from 'medium to high' average usage level, in different construction projects. This indicates that the majority of respondents are presently engaged in some form of knowledge management use in their various construction project management activities in South Africa (see Tables 3 and 4). ('High' usage represents above 70% average level of use, weight = 3 points; 'Medium' represents between 40% to 70%, weight = 2 points; 'Low' represents between 10% to 40%, weight = 1 point; while 'nil' represents less than 10%, weight = 0)

Table 3: General levels of use of knowledge management techniques and technologies

<i>No.</i>	<i>Respondent</i>	<i>Average level of use of knowledge management technique (U)</i>	<i>Average level of use of knowledge management technology (V)</i>	<i>Average (U + V) ÷ 2</i>
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: Summary levels of use of knowledge management tools

Average $(U + V) \div 2$	Classification	Frequency	% (Total = 100%)
Below 1	Low	0	0%
1 to 2	Low to Medium	2	10%
2.1 to 3	Medium to High	18	90%

4.3 Correlation between knowledge management use and enhanced construction project management performance in South Africa

In order to examine the possible correlation between knowledge management use and enhanced construction project management performance, it was 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 Section 3.1. With the use of these approaches, the following construction project management performance measures/indices were computed for the various respondents/organisations. Only eighteen respondents provided valid project performance data. Respondents 'S' and 'T' did not provide any project performance data in the returned questionnaires, and as such, both were excluded from further consideration in the data analysis.

4.3.1 Primary performance indices

These performance indices are based on project time and budget considerations, 'objective' criteria whereby construction project performance may be readily evaluated (Liu & Walker, 1998; Shenhar *et al.*, 2001). These are:

Schedule Performance Ratio (SPR): This ratio 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:

$$\mathbf{SPR} = \text{Actual construction time} \div \text{Planned construction time (1)}$$

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): Similar 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. As such, it is another measure of the respondent's construction project performance. Each respondent's BPR is given by:

$$\mathbf{BPRI} = \text{Final account} \div \text{Tender price (2)}$$

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.

Table 5: 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

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:

$$OPR_i = (OSPR_i + OBPR_i) \div 2 \quad (3)$$

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 is greater than 1, then actual project performance was below the planned.
- If OPR is 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 level of performance; conversely, the higher the OPR, the lower the performance.

The Overall Performance Ratios (OPR) were computed and found to be as shown in Table 5 above. The OPR as calculated represent the primary performance measurement indices for the various respondents to the research survey. These indices are subsequently used to explore the possible correlation between the various levels of knowledge management use and construction project management performance levels of the respondents.

4.3.2 Secondary performance indices

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

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. The 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 is 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 article, 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, is informed by the consideration that certain projects, though large in size and associated budget, may only involve limited scope of work, and/or may run for a limited duration (e.g. an office building or residential development may comprise limited and/or repetitive construction work/activities). These would require lesser levels of project personnel involvement than more complex projects with broader scopes. However, the study made no attempt to engage with differing levels of scope of the respondents' projects. Neither did it consider the relative subjective methods of determining what constitutes 'full-time', 'part-time' and 'supervisory' level involvement of project management personnel.

Table 6: 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

The Overall Employee Productivity Ratio (OEPR) of the various respondents was also computed and found to be as shown in Table

6. 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 was excluded from further consideration by virtue of its limited usability.

4.4 Examination of a possible correlation

In order to examine a possible correlation between knowledge management use and enhanced construction project management performance, a test for linear correlation was adopted. The Pearson's product-moment coefficient of linear correlation was utilised, as described in Goddard & Melville (2005). The coefficient was calculated using 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 knowledge management (variable X) was associated with a proportionate increase in the value project management performance (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). A value of 0 or thereabouts indicates very little correlation.

Table 7: 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

The levels of knowledge management use indices computed earlier were set as variable X, and are juxtaposed with the primary performance measurement indices (obtained using the Project Efficiency Review measurement approach/Overall Performance Ratio) similarly computed for corresponding respondents, which are set as variable 'Y' (see Table 7; the respondents are listed in order of decreasing average knowledge management use levels). The purpose of adopting the test for linear correlation is to 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). This would indeed help establish a possible correlation between the levels of use of knowledge management processes and enhanced construction project management performance (Goddard & Melville, 2005).

From the above (Table 7) calculations give the following:

$$n = 18, \sum X_i = 42.59, \sum Y_i = 20.37, \sum X_i Y_i = 48.12, \sum X_i^2 = 102.34 \text{ and } \sum Y_i^2 = 23.83.$$

Hence:

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

The coefficient of linear correlation 'r' was thus calculated to be of a value of - 0.07. The magnitude of 'r' shows very little correlation between the high levels of knowledge management use and high construction project management performance levels. This reveals that there are other significant factors which contribute to construction project management performance, and its measurement, within the South African context. It is therefore necessary to further explore possible contributory factors that could have resulted in this outcome. The following factors were identified within the context of the study.

4.4.1 Performance measurement approaches

The use of PER, based on 'objective' measure, was adopted for the purposes of the article. However, the inherent realities of the construction project environment in South Africa, particularly as indicated in the respondent survey, reveal its application to be inappropriate, for the following reasons:

- Changes in project scope - Over 55% of the respondents providing project performance data experienced significant changes in project scope, which they believed impacted on both the construction project schedule (i.e. the actual project construction duration), as well as the project budget (i.e. the project final account). The impacts of these scope changes were mostly negative and their 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 originated from the client, or other project participant outside the direct influence of the construction project manager associated with the 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 out of the 18 respondents provided valid project performance data) of the respondents reporting some form of delay. These delays were also outside the control of the construction project management team. The reasons reported for unforeseen and uncontrollable delays included client financing (39%), contractor delays (22%), delays with procurement (33%) and electric power outages (6%), with some respondents reportedly experiencing a combination of delays. Again, such delays would negatively impact on the actual construction project schedule, thereby skewing performance measurement using the PER approach.

4.4.2 Framework for enhanced performance assessment

The assessment of enhanced performance, within the framework adopted for the study, attempted to compare the various current levels of knowledge management use of respondents with current levels of performance. This is done with a view to examining the

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, with respect to the adoption/implementation of knowledge management systems and processes. This approach has been suggested by other authors, and has seen some degree of success in its use (Sheehan *et al.*, 2005: 50-64; Zou *et al.*, 2003: 233-250). 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 does 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 luck to find such an organisation that is about to embark on a knowledge management implementation process. In addition, patience is needed in order to realise performance-enhancing benefits. As one can readily imagine, this option of research methodology could not be explored within the context of the study, due to considerations mentioned in section 3.3.

Liu & Walker (1998: 209-219) 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 article. 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.

An attempt is also made to utilise EMA indices to examine a possible correlation between knowledge management use and enhanced construction project performance. For respondents with knowledge management use levels classified as 'medium to high', the average overall employee productivity ratio (OEPR) was R1.27 million per employee-month; for respondents with knowledge management use levels classified as 'low to medium', the average OEPR was 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 in South Africa.

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Likewise, 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) on levels of knowledge management use.

4.5 Respondents' general comments

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

4.5.1 Opportunities and threats for 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 only 20% of the respondents reported any conscious attempt at managing project knowledge via a knowledge process and/or knowledge database/map. Not surprisingly, the respondents indicated that a knowledge database was a key opportunity though they did not have any such system in place.

Identified threats to knowledge management use include primary issues of affordability such as limited resources available for construction project management teams, coupled with perceived high cost of entry-level knowledge management systems. Also mentioned was the 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 South African context as observed by Zou *et al.* (2003: 233-250) and Sheehan *et al.* (2005: 50-64).

4.5.2 Knowledge management use patterns

The type of knowledge management tool used was to a large extent informed by the respondents' perception of its suitability in achieving the 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'. There were no stated or observed apparent preferences in choice of particular tool. Few respondents indicated a choice for particular software used, such as Microsoft Projects.

4.5.3 Other comments

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

These findings are to a large extent supported by previous research and discourse by other authors such as Egbu & Robinson (2005: 31-49), Prusak (2000: 182-186), Sheehan *et al.* (2005: 50-64) and Zou *et al.* (2003: 233-250).

5. Conclusions and recommendations

This article has provided insight into the concept of knowledge management and its use as an efficiency-enhancing tool in construction project management, among various professional construction project managers in South Africa. The conclusions drawn from the discussion include the following:

- Most construction project management professionals show a significant level of awareness and appreciation of knowledge management use and possible associated performance-enhancing benefits in construction project management in South Africa.
- Most professionals are engaged in some form of knowledge management use in construction project management, and mostly at a high level.
- A minimal degree of correlation between the level of knowledge management use and the level of performance was observed. 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 South Africa. These factors are

crucial to the evaluation of the 'objective' performance measurement indices utilised in the correlation analysis. The prevalence of these factors impacts on the indices in such a way as to skew these indices in an unpredictable manner. The use of economic performance measurement approaches, however, established a measure of dependence of enhanced construction project performance on knowledge management use.

Regarding possible opportunities and threats to effective knowledge management implementation in the construction project management profession in South Africa, two main opportunities were identified:

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

The following threats were identified:

- 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.

The article, however, has also shed some light on certain areas that require further studies:

- The deriving of appropriate assessment methods for measuring the performance benefits achieved *via* knowledge management use in construction project management. The use of the PER method, although based on 'objective' measures such as project schedule and budget, would be seriously impacted by factors such as changes in project scope and delays as indicated in the article. 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 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. 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 knowledge management activity (Sheehan *et al.*, 2005: 50-64). One of the key challenges, in an attempt to evaluate this business case, 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, as indicated earlier in this article.

From the foregoing discussions and analysis, it is apparent that addressing the issue of the 'performance measurement paradox' would play a crucial role in further research in the field of knowledge management and its use in the construction project management industry (similar conclusions have been drawn by Zou *et al.* [2003: 233-250]). 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 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: 50-64). Given these considerations, professional construction project managers in South Africa will have to actively

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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 the study. Professionals and organisations will also 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.

References

Al-Ghassani, A., Anumba, C., Carrillo, P. & Robinson, H. 2005. Tools and techniques for knowledge management. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.), *Knowledge management in construction*. UK: Blackwell Publishing, pp 83-102.

Anumba, C., Bloomfield, D., Faraj, I. & Jarvis, P. 2000. Managing and exploiting your knowledge assets: Knowledge based decision support techniques for the construction industry, Report 382. UK: Construction Research Communications Ltd.

Baker, B.N., Murphy, D.C. & Fisher, D. 1983. Factors affecting project success. In: Cleland, D. & King, W. (Eds.). *Project management handbook*, New York: Van Nostrand Reinhold, pp. 902-919.

Davenport, T. & Marchand, D. 2000. Is KM just good information management. In: Marchand, D. & Davenport, T. (Eds.), *Mastering information management*. UK: Financial Times, Prentice Hall, pp. 165-169.

Davenport, T. & Prusak, L. 1998. *Working knowledge: Managing what your organisation knows*. Boston: Harvard Business School Press.

Despres, C. & Chauvel, D. 2000. How to map knowledge management. In: Marchand, D. & Davenport, T. (Eds.), *Mastering information management*. UK: Financial Times, Prentice Hall, pp. 170-176.

Egbu, C. 2000. The role of IT in strategic knowledge management and its potential in the construction industry. In: Proceedings of the UK National Conference on Objects and Integration for Architecture, Engineering and Construction, 13-14 March. Watford: BRE.

Egbu, C. & Robinson, H. 2005. Construction as a knowledge-based industry. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.). *Knowledge management in construction*, UK: Blackwell Publishing, pp. 31-49.

Girmscheid, G. & Borner, R. 2003. Knowledge management in construction companies oriented on project success factors,

knowledge construction. In: Proceedings of the Joint International Symposium of CIB Working Commissions, Singapore: Department of Building, National University of Singapore, pp. 137-149.

Goddard, W. & Melville, S. 2005. *Research methodology: An introduction*. 2nd Edition. South Africa: JUTA Lansdowne.

Kahkonen, K. & Kazi, A.S. 2003. Knowledge repository for construction projects – Hype or real solution? knowledge construction, In: Proceedings of the Joint International Symposium of CIB Working Commissions, Singapore: Department of Building, National University of Singapore, pp. 163-173.

Latham, M. 2005. Foreword. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.). *Knowledge management in construction*. UK: Blackwell Publishing, pp. vii-viii.

Liu, A.M.M. & Walker, A. 1998. Evaluation of project outcomes. *Construction Management and Economics*, 16(2), pp. 209-219.

Manchester, P. 2000. Tools for knowledge management. In: Marchand, D. & Davenport, T. (Eds.). *Mastering information management*, UK: Financial Times, Prentice Hall, pp. 185-186.

Morris, P.W.G. 1986. Managing project interfaces – Key points for project success. In: Cleland, D.I. & King, W.R. (Eds.). *Project management handbook*. New York: Van Nostrand Reinhold, pp. 16-55.

Prusak, L. 2000. Making knowledge visible. In: Marchand, D. & Davenport, T. (Eds.). *Mastering information management*, UK: Financial Times, Prentice Hall, pp. 182-186.

Quintas, P. 2005. The nature and dimensions of knowledge management. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.). *Knowledge management in construction*, UK: Blackwell Publishing, pp. 10-30.

Robinson, H., Carrillo, P., Anumba, C. & Al-Ghassani, A. 2005. Performance measurement in knowledge management. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.). *Knowledge management in construction*, UK: Blackwell Publishing, pp. 132-150.

Sheehan, T., Poole, D., Lyttle, I. & Egbu, C. 2005. Strategies and business case for knowledge management. In: Anumba, C., Egbu, C. & Carrillo, P. (Eds.). *Knowledge management in construction*, UK: Blackwell Publishing, pp. 50-64.

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Shenhar, A.J., Dvir, D., Levy, O. & Maltz, A.C. 2001. Project success: A multi-dimensional strategic concept. *Long Range Planning*, 34(6), pp. 699-725.

Stewart, T. 1997. *Intellectual capital: The new wealth of organisations*. New York: Doubleday.

Storey, J. & Barnett, E. 2000. Knowledge management initiatives: Learning from failure. *Journal of Knowledge Management*, 4(2), pp. 145-156.

Young, R. 2003. *Introduction to knowledge management in construction*. London: BSI.

Zou, P., McGeorge, D. & Lim, C. 2003. Case studies in knowledge management. In: *Construction Companies, Knowledge Construction, Proceedings of the Joint International Symposium of CIB Working Commissions*, Singapore: Department of Building, National University of Singapore, pp. 233-250.