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EXPLORATORY STUDY OF THE KNOWLEDGE SOURCES AND PRODUCTION IN CONSTRUCTION DOMAIN: THE SRI LANKAN CONTEXT

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ABSTRACT: Knowledge, during the last few decades, has become the central capital, the cost centre and the crucial resource of the economy. The construction industry is a knowledge based industry and the production of knowledge is vital for projects and organizations, in order to tackle the fast changes and to be innovative. Knowledge production is influenced by variety of organizations, projects as well as by the nature of the industry in construction domain. This research has focused on establishing how the characteristics of the industry, individual projects and the organizational culture influence knowledge production by promoting or inhibiting the knowledge production within the Sri Lankan context. This study identifies and analyses different types of knowledge sources, main triggers of knowledge production and the promoters & inhibitors of knowledge production from project, organizational culture and industry perspectives. It was found that contracting organisations mostly rely on internal knowledge sources for their knowledge acquirement. The results indicates that the knowledge production takes place through ‘learning how’ and ‘learning why’ and identifies ‘learning how’ as the dominant process within the Sri Lankan construction industry. In addition it reports that knowledge production seems to focus on project delivery rather than strategic issues.

Keywords – Construction industry, Knowledge production, Knowledge sources, Knowledge triggers

1. INTRODUCTION

Knowledge can be defined as, “The understanding, awareness, or familiarity acquired through study, investigation, observation, or experience over the course of time”. It is an individual’s interpretation of information based on personal experiences, skills, and competencies (Bollinger and Smith, 2001). The intensifying focus on knowledge and its productivity is hardly surprising in increasingly knowledge intensive economies. The economic value of knowledge consists of increasing sustained superior performance: great value for customers, great wealth for investors and employees (Nasseri, 1999).

Knowledge is increasingly being recognised as a vital organisational resource that gives market leverage and competitive advantage (Leonard-Barton, 1996). In particular, knowledge has become a substance to be “managed” at its most literal sense. Yamanouchi (1995) classifies knowledge as either formal or non-formal. Nonaka (2000) identifies two types of knowledge: Explicit and Tacit. Explicit knowledge is clearly formulated or defined, easily expressed without ambiguity or vagueness, and codified and stored in a database and can be referred to as “Structural” capital. Tacit knowledge, on the other hand, may resides on the minds of organization’s employees, customers and suppliers etc., and is also known as “Human” capital.

To the organisation, knowledge is defined as what people know about customers, products, processes, mistakes, and successes (Grayson and O’Dell, 1998). It resides in databases or through sharing of experiences and best practices, or through other sources both

internal and external to the organisation. Organisations need to exploit a variety of sources, which they can draw upon for knowledge production. The identification of appropriate sources is important.

Production of new knowledge is ‘a series of transformations, by which standard sources, which are available in open markets or contained within the organizations, are used and combined within the organizational context in order to produce competences and capabilities’, according to Davis et al (2003). The process of knowledge production is activated by the triggers. Quite frequently, existing knowledge is an input to the knowledge production process. Existing knowledge can be sourced from a number of sources which can be internal or external to the organisation. During the knowledge production process new knowledge is produced by moving around the quadrants of the knowledge spiral. Knowledge production is a complex process which can occur in a number of ways, e.g. formal research, reflective practice. The effective utilisation of each source draws on the capabilities which are inherent in the organisation and its people.

The construction industry is fragmented in its nature and is project-based with many different organisations forming the “project team” with an ultimate goal to deliver a good quality product to its client. As the construction industry is an open system, it is very sensitive to change. Thus, the construction industries in the world are striving to tackle these changes and need to be innovative through the new and innovative ways of construction, efficient resource utilisation and better organisation of projects. In order to deliver better service to their clients and remain competitive, construction organisations should improve on past solutions, innovate and manage change. These can be achieved by producing new knowledge which could assist organisational efficiency and productivity.

The decision to conduct an exploratory study was mainly driven by the limited number of empirical studies both on knowledge sources and knowledge production in developing economies such as Sri Lanka. This study is based on the assumption that Sri Lankan construction industry could be recognized as a knowledge-based industry.

2. KNOWLEDGE PRODUCTION

It is widely accepted that knowledge production is moderated by both the ‘content’ and the ‘context’ of the knowledge production process (Ferlie and Loch, 2001; Nonaka and Takeuchi, 1995; Nonaka and Toyama, 2000). Thus, the knowledge acquired from a particular source can become tacit, implicit or explicit depending on the context in which it is used.

Edmondson and Moingeon (1996) divide the knowledge production processes into two: *learning how* and *learning why*. *Learning how* is a process whereby existing skills and routines are transferred and improved. The improved skills and routines then enable the organisation to implement processes quickly with accuracy. *Learning why* focuses attention on discerning the underlying logic or causal factors in processes. At this juncture, it should be noted that *learning how* and *learning why* are not mutually exclusive, even though *learning how* is more closely associated with problem solving, while *learning why* is associated with change management and innovation in organisations.

3. KNOWLEDGE IN CONSTRUCTION DOMAIN

Wiig (1993) states that, knowledge consists of truths and beliefs, perspectives and concepts, judgments and expectations, methodologies and know-how. Wetherill et al (2002) has

considered the contents of knowledge and categorised knowledge in construction domain into three main categories:

- **Domain knowledge** - This forms the overall information context. It includes administrative information (e.g. zoning regulations, planning permission), standards, technical rules, product databases, etc. This information is, in principle, available to all companies, and is partly stored in electronic databases;
- **Organisational knowledge** - This is company specific, and is the intellectual capital of the firm. It resides both formally in company records and informally through the skilled processes of the firm. It also comprises knowledge about the personal skills, project experience of the employees and cross-organisational knowledge. The latter covers knowledge involved in business relationships with other partners, including clients, architects, engineering consultant companies, contractors, regulatory bodies, and suppliers, ect; and
- **Project knowledge** - This is the potential for usable knowledge and is at the source of much of the knowledge identified above. It is both knowledge each company has about the project and the knowledge that is created by the interaction between firms. It is not held in a form that promotes re-use (e.g. solutions to technical problems, or in avoiding repeated mistakes), thus companies and partnerships are generally unable to capitalize on this potential for creating knowledge. It includes both project records and the, recorded and unrecorded, memory of processes, problems and solutions.

These three categories which are referred to as information layers, are obviously strongly inter-linked, in that any amendment introduced to one layer is very likely to have a critical impact on the others. This study considers the project and organisational knowledge for the analysis.

4. METHODOLOGY

The nature of the problem under this study leads towards the adoption of a qualitative research strategy, as well as the choice of semi-structured interviews supported by an interview guide. As the knowledge most importantly involves “a human”, it was considered to be the best way to identify and analyze the knowledge profile from the industry professionals who are the knowledge workers in the industry. Therefore, the interviewees who are from top and middle level management were selected from contracting organisations which possess the ICTAD (Institute for Construction, Training and Development) grade of M1 & M2 operating in Sri Lanka. *(In Sri Lankan construction industry, contractors are basically classified into two as main construction contractors and specialized construction contractors. Main construction contractors are categorized into seven and specialised contractors into three different fields. Main contractors are graded from grade M1 to grade M9, but heavy construction contractors are restricted from grade M1 to M5. Primarily, three factors are taken into account, when evaluating the building construction contractors for the grading: Financial Capacity, Technical Ability, and Merit and Demerit Point. Grading facilitates easy identification and helps to minimise difficulties in choosing a target group to carry out particular work. ICTAD defines the term grading as a viewing of the capacity of the contractor to determine their ability to carry out effectively and efficiently various types and scopes of projects).*

Altogether, 45 interviews were conducted with top level and middle level managers in the contracting organisations. Duration of these interviews were from half an hour to one and a half hours. The interviewees were spread across twenty-five contracting organisations. The sample represents approximately 76% of the total population of M1 and M2 contractors operating in Sri Lanka. This is considered to be a good representation, as they represent the mainstream of construction activity and consist of many experts and experienced professionals in the industry. Table 1 presents the spreads of interviews conducted across the different professional roles in the contracting organisations. It can therefore be said that the research sample was distributed between the different hierarchical levels of the organisations.

In addition to the survey, 10 case studies were carried out in selected actual projects. The purpose of the case studies was to further support the findings of the results of initial survey. Relative Important Index (RII) method was used to score and weight the responses such that meaningful analysis of industry professional's responses could be made. The following formula was used to calculate the Relative Important Index (RII).

$$RII = \frac{\sum (W n)}{A \times N} \times 100 \%$$

Where,

W - Constant expressing the weighting given to each response.

A - The highest weighting

n - The frequency of responses

N - Total Number in the Responses

Table 1. Spread of interviews among professionals.

	Professional Role	Number of Interviews per role	Number of Interviews per level
TOP LEVEL MANAGEMENT	Managing Directors	10	35
	Directors	06	
	Project managers	02	
	Chief Engineers	07	
	Construction Managers	10	
MIDDLE LEVEL MANAGEMENT	Chief Quantity Surveyor	03	10
	Chief Estimator	01	
	Quantity Surveyor	03	
	Engineers	03	
			45

5. FINDINGS AND DISCUSSIONS

5.1. Knowledge sources

Knowledge sources, in this context, mean the 'reservoirs of knowledge', which a knowledge-worker has to fall back on in fulfilling his/her responsibilities. The effective utilisation of each source draws on the capabilities, which are inherent in the organisation and its people (Davis et. al; 2003). The main sources of knowledge where individuals and organisations can

obtain relevant knowledge for project and organisational needs have been identified from the interviews with the Management at generic level in the Contracting organisations.

In this study, the project and organisations forms the basis according to which knowledge sources are categorized. Thus, there were two main categories of knowledge sources: i.e. sources which are internal and external to the project and organisations identified and documented. Table 2 presents a variety of knowledge sources of two main categories identified among the examples. A closer observation of Table 2 shows that the respondents don't make use of internal and external sources at similar degrees as appropriate.

Table 2. Types of knowledge sources used in construction domain

Knowledge Sources			
Internal sources	RII (%)	External Sources	RII (%)
Other individuals in the organization (E.g. - Staff)	83	Other individuals external to the Organization. (E.g. - Sub Contractor, Specialist contractors, Client, Consultant team, Suppliers/Manufacturers, Regulatory bodies, Joint ventures)	81
Project Team(s)	72	Communities of Practice (Software Developers, Researchers)	50
Project Routines (Regular ways of doing works)	75	Other networks (E.g. – Seminars, Exhibitions, Conferences, Media, Work shops	42
Experience (E.g. - Personal experience, Company experience, Training)	97	Repositories (E.g. - Regulatory documents, Institutional publications, Trade publications, Web-sites, Technical information and standards, Professional and Technical Journals, Legislation and statistics, Personal library)	67
Feed backs from Site Project Management	72	Internet	56
Repositories (E.g.- Manuals, Code of practice, Reports/ Project documents, Company's library)	67	Knowledge gate-keepers (E.g. – Universities, Professional institutions, Technical colleges)	44
Work studies and Analysis	81	Financial bodies (banks, financial institutions, insurance companies)	61
Work shops	50	Experience of other construction companies	53

The type of knowledge gathered from these sources could be tacit, implicit or explicit depending on the context in which knowledge was needed or used. The contextual nature of knowledge was also evident as respondents found it difficult to identify which knowledge sources they found most useful. The most frequent reply to this question was that the usefulness of the sources depends on the circumstances, which triggered the knowledge production process. The majority of the respondents in the studied construction organisation sample noted that they rely mostly on their experience as a knowledge source.

Based on this study, it can be argued that contracting organisations rely highly on internal sources for their knowledge acquisition. This is further proved by the case studies, as the experience, other individuals, work-studies & analysis and project routines have obtained the higher RII.

During the case study interviews, it was stated that construction is experience oriented and the experience acquired from different types of project sites is necessary for the production of new knowledge. In addition, learning from project experience was emerged as the key to continuous improvement in construction.

5.2. Triggers of knowledge production

The knowledge triggers activate the process of knowledge production. A trigger can be defined as an event that is the immediate cause of knowledge production. A variety of triggers provide impulsion for knowledge production within in the construction industry. The main triggers of knowledge production identified (at generic level) from this study are presented in the following Table 3:

Table 3. Main triggers of knowledge production

Triggers of knowledge production	RII (%)	Rank
Problem solving	100	1
Project management & Administration	100	1
Innovation	94	2
Managing change	72	3
Marketing	69	4

At this stage, it is important to note that not all the change management activities result in innovation. Innovation is the introduction of new products or process to the market or a significant change in existing products and process. Innovation creates change, but does not always imply innovation. Accordingly, in this study, change management and innovation are considered as two separate entities. It is also worth to note that the management of change can be associated with organisational change as well as changes which are made during project development and implementation.

The results clearly show that ‘problem solving’ and ‘project management & administration’ are the first most frequently cited triggers. Thus, it can be concluded that those two triggers are the driving forces behind knowledge production in Sri Lankan construction industry. In addition, it has shown that ‘learning how’ is the dominant process of knowledge production within the construction industry. This follows that the industry’s main triggers of knowledge production are ‘problem solving’ and ‘project management and administration’. As the innovation and managing change are the second and third cited triggers respectively, ‘learning why’ is also influencing on knowledge production.

5.3 Knowledge production from industry perspectives

Increased competitiveness in recent years has made the Sri Lankan construction industry to a need to produce new knowledge to face the mounting challenges and to be innovative.

Characteristics of the industry itself include several promoting and inhibiting factors for the production of new knowledge. Table 4 represents, at a generic level, these characteristics which the interviewees considered to promote and to inhibit knowledge production respectively. The move towards change ranked first among the driving forces behind knowledge production. Reluctance to change was most frequently cited among the barriers to producing new knowledge.

Table 4. Industrial Characteristics, which Promote and Inhibit the Knowledge Production.

Promoters	Inhibitors
A move towards change in the industry (focus on quality).	Reluctance to change habitual procedure.
Introduction of the projects with innovative design and challenges to the contractor.	Low level of use and exploitation of Information Technology (IT).
Introduction of high quality and technology products.	Reluctance to admit mistakes.
Involvement of international Contractors.	Very poor knowledge in “learning organization” concept in most of the companies.
A need towards to be competitive in the industry.	Passing majority of the risk to the contractor.
A move towards different forms of procurement systems (E.g. Non-traditional system).	Low level of Education and training for the project teams and lack of Research and Development (R&D).

Project efficiency and productivity could be improved by finding innovative ways with the use of advanced technology which in turn leads to the production of new knowledge. Respondents indicated that reluctance to change the routine procedures and less effort to move towards change and finding new ways of doing things are the main obstacles to the knowledge production in Sri Lanka. Finding best solutions to these obstacles could improve the knowledge production process.

5.4 Knowledge production from project perspectives

Organisations and individuals participating in a project bring their own unique skills and resources, which may include proprietary and commercial applications, knowledge, and data. Many practitioners and researchers have acknowledged the limitations of current approaches to managing the information and knowledge relating to and arising from a project (Rezgui, 2001). Among others, the main reason for these limitations is the ‘much construction knowledge, by necessity, resides in the minds of the individuals working within the domain’. In a project the intent behind decisions is often not recorded or documented. It requires complex processes to track and record the thousands of ad-hoc messages, phone calls, memos, and conversations that comprise much project-related information.

People responsible for collecting and archiving project data may not necessarily understand the specific needs of actors who will use it, such as the actors involved in the maintenance of the building(s). Data is usually not managed while it is created but instead it is captured and archived at the end of the construction stage. People who have knowledge about the project are likely to have left for another project by this time. Their input is not captured.

Lessons learned are not organised well and it is difficult to compile and disseminate useful knowledge to other projects. Many organisations maintain historical reports of their projects. Since people always move from one company to another, it is difficult to reach the original report authors who understand the hidden meaning of historical project data. This historical data should include a rich representation of data context, so that it can be used with minimum (or no) consultation.

Table 5: Project characteristics, which promote and inhibit the knowledge production

Promoters	Inhibitors
Team efforts, effective team composition and high level of expertise.	Spend lot of effort in doing the regular work ('Re-inventing the wheel' syndrome)
Scare project resources (Time, budget, etc.)	Improper communication system among the team members.
Need to address a problem / challenge by finding bespoke solutions.	Ineffective team composition & low level of expertise.
Introduction of projects with innovative design as a challenge to the contractor.	Lack of freedom given to team members to take challenging decisions
Need to introduce / develop an effective project monitoring & controlling System to improve the project efficiency.	Lack of skilled personnel in the project team.
Presence of trust between team members/ team stability.	Adequate project resources (e.g. time, budget).

The above Table 5 indicates the promoting and inhibiting characteristics of projects cited by the respondents in the order of frequency. The result shows that the team efforts and the effective team composition play a major role in promoting knowledge production. The fundamental attribute of an effective team is its flexibility and responsiveness in responding to the emergent problems and opportunities (Davis et al, 2003). This is largely facilitated by the high level of expertise and 'adequate knowledge-base' within the team. Further, the presence of trust among the team members assists knowledge production because team members are more willing to share knowledge if they trust one another. It can be further stated that the nature of the construction project environments creates obstacles to knowledge production by spending lot of effort in regular works and not using the same people throughout the project life-cycle.

5.5 Knowledge production and organisational culture

Organisational knowledge defines the organisation, and is a reflection of the organisational culture. A strong, positive organisational culture is critical to promoting learning, development and the sharing of skills, resources, and knowledge (Poynder, 1998). Knowledge is produced in a variety of ways in different organisations. The basic assumption is that organisational culture, which is the 'way things are done' in organizations, their values, and norms, influences on knowledge production in many complex ways.

The following Table 6 shows the most frequently cited promoters and inhibitors of organisational cultural aspects on knowledge production.

Table 6. Organizational cultural aspects, which promote and inhibit the knowledge production

Promoters	Inhibitors
An environment, which encourages innovation to deliver better value to client.	Time pressure
Willingness to embrace technological developments including IT.	Reluctance to change & embrace new ideas & developments in the project
Effective, flexible top-down, bottom up, lateral communication	'Unrealistic' strategic targets and Short time company principles & objectives
Commitment from everyone for continued improvement	Lack of Recognition for the new methods / system proposals.
Recognition for the new methods/ system proposals	Difficulties encountered in finding the 'right' person, information, knowledge.
Culture of promoting experimentation, research and development.	Lack of reward for wider organizational performance.

Case study results reveal that 'time pressure', which does not make time available for reflection on the project experience, is the most frequently cited obstacle. If organisations are to deliver better value through innovation, then they need to be prepared to provide adequate time for their employees to reflect and provide relevant knowledge needed for appropriate innovations.

6. CONCLUSION

The construction industry is a knowledge based industry and the production of knowledge is crucial for organisations and for projects. Organisations produce knowledge at different rates from variety of sources to meet organisational and project needs. The identification of appropriate sources is vital to the knowledge production which in turn will lead to the success of a project.

Organisational capabilities play a vital role in knowledge production. For example, skilled and competent work force is the key in knowledge Production, especially in addressing problem solving situations and project management & administration, which are main triggers for knowledge production

The influence of industry and project characteristics on knowledge production is different from the influence of the knowledge production triggers, as discussed above. Knowledge triggers activate the knowledge production process thus, have a direct influence. However, the characteristics of the industry, organisational culture and the characteristics of projects have an indirect influence on knowledge production through their influence on the business environment.

This study concludes that construction organisations produce knowledge through both by 'learning why' and 'learning how' and the 'learning how' is the dominant process in the Sri Lankan construction industry. Most importantly, contracting organisations produce knowledge through transforming existing knowledge and reflective practices.

In addition, it was found that knowledge production in the construction industry seems to focus on project delivery rather than strategic issues. This might be an outcome of our choice of respondents who were closer to the operational side of the businesses.

As the 'experience' was found to be the most useful internal knowledge source. Construction industry can be considered as an experience oriented industry. Therefore, it can

be concluded that the construction industry is a knowledge based experience oriented industry.

7. RECOMMENDATIONS

As this study has found that there appear to be no formal and systematic approach to the production of new knowledge in Sri Lankan contractors context, it makes some general recommendations to the industry to be capable enough to adopt the changing circumstances quickly and to achieve competitive advantage. There is some evidence that a more concerted and formal approach, in places, may improve organisational knowledge production. For example, more formal meetings, brainstorming exercises, and better reflective and focused group sessions could be useful. Formalising the knowledge production approaches, where appropriate and necessary, may increase the organisation's knowledge production capability. Organizations may be better served if more articulation of knowledge production capability is considered.

Individuals and organisations appear to be capable of producing the new knowledge which they need by drawing upon the appropriate knowledge sources in Sri Lanka. As individuals are important sources for knowledge production, organizations need to develop the strategies to incentive the employees. This should have the effect of motivating the individuals to share knowledge, thereby contributing to the wider knowledge production in the organization. Also organisations should focus more on the issues of knowledge triggers and consider appropriate strategies for dealing with them.

Many problems in the construction sector arise because of its barriers to '*organisational learning*'. At present, Sri Lankan construction industry is not familiar with the concepts of organisational learning or learning organisations. This has been proved by this study. Most of the respondents have agreed that 'very poor knowledge in learning organisation concept in most of the construction companies' is one of the most important characteristic of the industry which inhibits the knowledge production. Therefore, there is a crucial need to create a tradition of 'learning organisation' and more specifically for developing countries like Sri Lanka. An organisation's only sustainable competitive advantage lies in its ability to learn faster than its competitors to produce world-class construction. Moreover, for an organisation to be successful in today's rapidly changing environment, its capacity to learn must exceed the rate of change imposed on it. If the industry is to improve, construction organisations must integrate learning within day-to-day work processes, in such a way that they not only share knowledge and continuously improve, but also, operate efficiently and effectively in response to their changing environment.

As a result, there is a need for construction companies to incorporate learning into their working processes and practices. Effectively meeting the challenge of organizational learning depends on developing organisational cultures that continually encourage people to cross-functional boundaries, not just to tell each other their news, but also to inquire and to come to greater level of mutual trust and understanding. Construction companies need to seek alternative ways of enabling a learning culture within which they will allow learning to take place, which will lead to performance improvement and competitiveness.

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