A Comparative Study Of Three International Construction Firms: Knowledge Management Infrastructures For Optimising Organisations' Learning

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

Chee Shien Jeremy **Wu**
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ABSTRACT

This research has addressed the gap in Knowledge Management research in Construction Project Management Organisations. In comprehensively reviewing and critiquing research literature, the writer asserts that construction organisations are currently incapable of effectively learning from their past projects for application in their new/future projects (i.e. inability to learn across projects), and hence require more robust Knowledge Management infrastructures to enable the organisations and their staff to manage the knowledge they had accumulated by learning from their past projects, so that they may be able to improve new/future project performances. In addition, 'uniform' definitions that may be used in KM discourse have been rationalised and proposed.

Data and information gathered by 'embedding' the researcher in industry has generated sophisticated insights into KM operation in three construction firms of different scales from different countries. A cross-cultural comparison of three firms has shown the necessity of aligning the context of an organisation (e.g. size, structure, culture, business strategies, objectives and priorities) with the strategies and objectives for the development, implementation and maintenance of a proposed KM infrastructure. More specifically, the research has shed light on the regularity of use and effectiveness of the tools, methods and mechanisms employed by the case study firms to manage knowledge (in particular, their effectiveness in enabling learning between projects within a firm and/or between project phases within a project, in enabling the resolution of generic and recurrent and/or specific and less-recurrent problems, and in enabling staff to experience learning at the individual, division and/or corporate levels of a firm) as well as the impacts of the KM initiatives on the firms' ability to deliver projects, portfolio and program, and the critical success factors and key performance indicators of the KM initiatives employed in the firms. *[The information arising from the detailed analysis and findings of each firm is too extensive to be situated in the body of this thesis, and may be found in Appendices I.]*

The comparative analysis of the data and information collected from the study has not only suggested to the author two models of KM relating the 'vertical' and 'horizontal' transmission of data, information and knowledge through a Project Management (PM) organisation, as well as some guidelines and issues for consideration should an

organisation which to develop, implement and maintain a new KM infrastructure or simply to improve their existing one. In addition, the study has also revealed that there is no tool, method or mechanism that can single-handed manage the plethora of data, information and knowledge available within the organisation and its staff, and that it would be a fallacy to solely emphasise and employ the use of information technology to manage knowledge.

The above findings enable PM organisations to analyse the need for KM in their organisation, and what strategies, and tools, methods and mechanisms might be best suited to improve their KM and project performance. The two KM models have also been applied to the case study organisations to accentuate the gaps in the organisations' KM initiatives that need addressing. The research has also developed a measure that allows firms to compare their intentions (how important they think KM is to their core business and the ability of the KM initiatives implemented in their organisations to learn across projects and deliver projects) with the reality of what really is occurring.

The research, whilst limited to a select few case studies, has established the start of a benchmarking system against which other organisations can compare themselves.

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When I decided to leave my career (most recently as a Quantity Surveying Manager and previously as a Project Manager) in the construction industry and move to Australia to commence my PhD journey on a full-time basis, several friends and colleagues thought I had gone 'bonkers'. Basically, they felt that I should not have left my career simply for the sake of furthering my studies.

Looking back, I can say that it was probably one of the most fulfilling decisions and journey I had made in my life and was certainly well worth it. Throughout this PhD journey in Australia, I had not just gained an amazing educational experience but the most exciting, insightful and enriching life experiences (new friends, people and environment) of which I could not have asked for more.

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The completion of this thesis also marks a new stage in my life of which I hope to be able to continue to contribute my knowledge to educate the current and forthcoming generations of construction professionals as well as to serve my employers for the betterment of the construction industry.

[10] "Choose my instruction instead of silver,

knowledge rather than choice gold,

[11] for wisdom is more precious than rubies,

and nothing you desire can compare with her.

[12] I, wisdom, dwell together with prudence;

I possess knowledge and discretion."

(NIV Bible; Proverbs 8: 10-12)

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ABBREVIATIONS

IM   Information Management

KM   Knowledge Management

IMS   Information Management System

KMS   Knowledge Management System

KMI   Knowledge Management Infrastructure

OL   Organisational Learning

SMEs   Small Medium Enterprises

Note: In this thesis, the term 'firm' is used synonymously with 'organisation'.

1.0   INTRODUCTION

1.1   Background to the Research

This thesis deals with an inquiry into effective knowledge management (KM) systems in organisations that manage construction projects. Before proceeding, it is necessary to define some of the terms used.

1.1.1   The Project Life-cycle: Clarification of Definitions

For purposes of this research, the 'project life-cycle' definition of *conceptualization; initiation; planning-definition-design development; execution-implementing; controlling; and termination (commissioning and handover)* will be adopted for this research study while the term 'operations life-cycle' will be used to identify the *maintenance and refurbishment phases of the constructed facility until its decommissioning and disposal.* The author believes that these terminologies best accentuate the various phases of a project's life without neglecting either the 'pre-design, design and development phases' or the 'maintenance and refurbishment phases' of a facility.

These definitions have been synthesized in the following sections (*1.1.1.1* and *1.1.1.2*) from a review and critique of definitions used in the literature by other researchers.

1.1.1.1 Confusing Definitions of 'Project Life Cycle'

To provide an accurate and certain definition of the 'project life-cycle' is difficult because despite the extensive literature on the management of projects, there is still endless confusion over what the 'project life-cycle' is (Fish 2003). Some definitions were written specifically to suit the context in which the life cycle/phases were developed, such as for the chemical processing, defence, construction, information technology, and production industries; while other definitions are generically developed for project-based organizations. The lack of convergence on the definition of a project's 'life-cycle' is clearly evident from the range of alternatives in literature. Three predominant groups of definitions (see *Table 1*) are outlined below.

Adams and Barndt 1983; Pinto and Selvin 1988; Pinto 1995; Mian and Dai 1999; Cleland 1999	Stuckenbruck 1981; Kerzner 1989; Cleland 1990; Kerzner 1995; Cleland 1999	PMI 1987; Webster 1993
Conceptualization	Conceptualization (initiation)	Feasibility (concept & development)
Planning	Definition (growth/organization)	Acquisition (implementation- definition,
Execution	Production (acquisition)	procurement and execution)
Termination	Operational	Operation
	Divestment	Disposal

Table 1: Predominant Definitions of the 'Project Life-Cycle'

The first group of definitions comprise those of: *conceptualization, planning, execution and termination* used by Adams and Brandt (1983), Pinto and Selvin (1988), Pinto (1995), Mian and Dai (1999), and Cleland (1999). Slight variations to this include: *conceptualization, planning, implementation, phasing-out* as used by Cavendish and Martin (1982); *conceptualization, planning, testing, implementation and closure* by Kerzner (2003); *conceptualization, development, implementation (execution), and termination* by Burke 1999; *conceptualization, definition, execution, and closeout* by Archibald 2003; *conceptualization, definition, execution, finish and closeout* by Fish 2003; *conceptualization, development, implementation, and termination* by Carmicheal (2004); *conceptualization, definition, execution, turnover and divestment* by Ritz (1994); *conceptualization, development/definition, execution and close-out/finish* by Shenhar and Wideman (2000); *conceptualization, definition, development, execution and delivery* by Morris (2003); *selection, planning, execution, termination* by Hormozi, McMinn and Okeleke (1984) (adapted from the project life cycle phases of Ruhl (1988)); *conceptualization, planning, definition and design, implementation, and conversion* by Kerzner (1995); *initiation, planning, execution, controlling, and closing* by Clark (2002); *initiation, planning, executing, controlling and evaluating* by Adams and Caldentey (2004); *initiation, planning and developing, implementing and close-out* by Frame (1998); *definition, planning, executing and controlling, and close-out* by Ireland (2004); *initiation, definition, implementation and completion* by Allen (1991); *conceptual planning, process organizing, implementing and controlling, and evaluation and system improving* by Kloppenborg and Petrick (1999).

The second group comprises that of: *conceptualization (initiation), definition (growth or organization), production (acquisition), operational, and divestment (includes termination)* by Stuckenbruck (1981), Kerzner (1989), Cleland (1990), Kerzner (1995), and Cleland (1999).

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The third predominant group comprises that of: *feasibility (concept and development), acquisition (implementation- definition/procurement and execution), operation, and disposal* by PMBOK 1987, and Webster 1993). Slight variations to this are those of: *inception (strategy), feasibility (brief), scheme/system design (execution plan), procurement (detailed design, contracting, execution), commissioning and start-up, acceptance, post-completion evaluation* by Morris (1998), and those of *study period (user requirements definition, concept definition, system specification, acquisition planning), implementation (source selection, system development, and verification), operations (deployment and operations/maintenance)* by Forsberg, Mooz and Cotterman (2000).

1.1.1.2 The 'Life' of a Project: 'Life-cycle' or 'life-span'?

To add to the confusion, there is also the contention as to whether the 'life' of a project should be appropriately termed 'life-cycle' or 'life-span'.

Based on contemporary thinking (PMI 1987; PMI 1996; PMI 2000) projects are managed individually due to their unique and temporal nature; resulting in no or little possibility of learning opportunities across projects. This interpretation is used in most of the literature. In this case, the 'life' of a project could then be termed a 'life-span'.

However, if projects are perceived as being managed as collective entities in relation to the organization's business environment and where lessons learnt are captured and applied across projects (i.e. 'cross-project learning'), the entire 'life' of a project may than be suitably termed a project 'life-cycle'. Similarly, the projects' operations could also be included in the life-cycle if such lessons-learnt practices are appropriately effected.

1.1.2 Purpose of Study: Contemporary Views of Project Management, and Their Shortcomings

This section asserts that the contemporary views of project management where projects are largely temporal in nature and managed as unique individuals have not taken the organisation's environment into consideration, and the inadequacy of lessons-learnt practices within organisations have hindered efforts to discover useful lessons from both successes and failures in past projects for application in future

projects. In addition, the segregation of the project (design and construction) and operations life-cycles have hindered efforts to consider the impact of design and construction on the operations stage as well as the inability of organisations to capitalise on the valuable knowledge and past experiences of the facilities manager for application in the early stages of a project (e.g. pre-design or design stages). Detailed critiques of the above assertions are in *sub-sections 1.1.2.1* and *1.1.2.2*.

1.1.2.1 Contemporary View No. 1
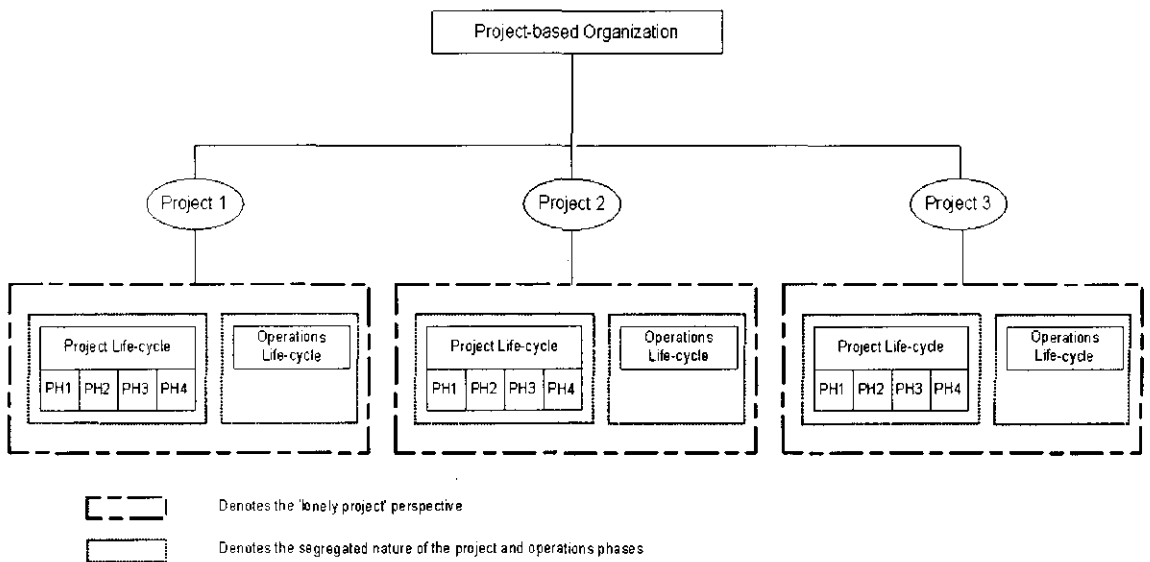
Figure 1: Contemporary Perspectives of Project Management

Project Life-Cycle Phases
PH1: *Conceptualization & Initiation*
PH2: *Planning/Definition/Design Development*
PH3: *Execution/Implementation & Controlling*

Individualistic (Unique and Temporal) Nature of Projects and Organizations

Construction organizations are generally project-based and team-based in nature. Ideally, a project-based and team-based organizational model draws together human resources (professionals from different backgrounds) into a temporary organization to cooperate with each other by sharing their views and information on a common project (McDermott 1999) using non-human resources (e.g. systems and techniques) to achieve a predetermined set of objectives (Turner 1999; PMI 2000; Walesh 2000; Blackburn 2002). Project team members work on the same goals and share joint responsibility for a particular project (McDermott 1999).

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However, this contemporary mainstream thinking of project management also has its limitations. Being grounded in a "lonely project perspective" (Kreiner 1995) in which a project is characterised as being unique (i.e. a one-off, and non recurring task or activity- where a product is different in some way from other similar products) (Bennett 1983; Pinto 1995; Archibald 2003; Williams 2003; Barber 2004), and temporal, i.e. having a fixed beginning and a definite end- a definite life span (Pinto 1995; Brusoni 1998; Barber 2004; Burke 2003; Uher and Loosemore 2004). This can cause project teams to become isolated from each other as they focus on team goals and building rapport with their team-mates, and habitually neglect what happens in the external realm of their project. Often, they end up 'rejecting ideas from outside and lose their ability to generate new ideas' (McDermott 1999: 2).

Furthermore, the construction industry is an intensively competitive (Jaafari 1996; Austin et al. 2002; RCBCI 2002; Calver and McLaughlin 2003), heavily regulated (Bertelsen 2000; CITB 2002), diversified and fragmented industry (CPSC 1998); predominantly made up of small and medium enterprises offering a narrow range of specialist expertise (Calver and McLaughlin 2003). Therefore, it is not surprising that construction organizations guard their valuable project knowledge and experiences closely, and are generally unwilling to share them with other organizations so that they may gain competitive advantage over each other.

Shortcomings

There are several shortcomings to this perspective (see *Figure 1*):

Firstly, the scope of a project's organizational context is too narrow. Although past research has shown that the implementation of an individual project is closely coupled to its organizational environment (Engwall 1992; Eskerod 1996; Blomquist & Packendorff 1998), contemporary thinking does not take into consideration the organizational environment in which the project is situated.

Secondly, the time frame is totally self-contained. Based on the contemporary perspective, every project is a unique undertaking where each project entails heterogeneous activities that may well not be repeatable in successive projects (Prencipe 2001). Often, it is easier to accept this in order to avoid the discipline of

drawing experience from the project (Barnes and Wearne 1993). Such a mindset results in project-based organizations rarely exploring the reasons for success and failure or the adaptation of management behaviour in light of these lessons. They avoid confronting the difficult task of learning from their experiences.

Should construction organizations maintain their current mindset they are missing the opportunity to gain from experiences of past works or from experiences of others, and will be unable to systematically extract and disseminate management lessons as they move from project to project; thereby prohibiting project and organisational improvement and losing competitive advantage. Studies have shown that a large amount of project assignments are of a repetitive kind, with little deviation in relation to preceding projects carried out by the organization (Kadefors 1995, Obeng 1995 and Turner & Cochrane 1993) and therefore ideally suited to implementing continuous improvement. As put by Cooper (1994), 'True systemic causes and transferable project management lessons are there to be learnt'.

Thirdly, current lessons-learnt practices are inadequate. Where these practices are in place in organizations, they are usually achieved through 'end-of-project reviews'. Despite the many practical examples of end-of-project reviews in place in organizations; e.g. BP's Post Project Appraisal (Gulliver 1987), Ericsson and ABB (Turner *et al.* 2000) etc., this rarely happens (Keegan and Turner 2001). Often, project team members do not have time to review lessons learnt as they are reassigned almost immediately to new projects before they even have time to perform post-project reviews. This means that project failures and successes are rarely analysed and learning does not happen. Hence, lessons from projects are quickly swept aside, with little effort expended on trying to discover useful lessons from both successes and failures that can be carried over to future efforts.

Whilst end-of-project reviews or simple recording of experiences may often be easier for simple projects, complex projects by their very nature exhibit behaviours whose causalities are not clear-cut, hence the simple guidance of listing what happened is now insufficient (Pinto 1999). It is therefore pertinent that organizations utilise methods that can capture the complexity of events and causality, and models that can explain why inputs were as they occurred (i.e. understanding what and why something

went wrong) and when (at which phase of the project). This is because the outcomes of large projects are usually messy and historically unclear, hence more robust methods are required to enable learning to occur and capture lessons learnt.

Also, when lessons are identified, they need to be specific to cover the organization and their characteristics (e.g. organizational behaviour). This means identifying similar situations in which a success or failure have previously occurred and applying the lessons learnt to other projects but taking into account the particular context of the project.

The Need to Address the Shortcomings
To address the above shortcomings, it is pertinent that practitioners and researchers change their contemporary mindset and manage projects in a more holistic manner. This is done not only by managing projects collectively but also by having practices that enable an organization and its members to learn between projects. This is termed 'cross-project learning capability'.

The recent shift in project management theory is evident from literature. Following criticism that theory has narrowly emphasized the satisfying of project constraints and not on pursuing business benefits of managing project as collective entities, research has been extended to the management of projects with concepts such as program management, project portfolio management and organizational-level management (Morris 1994; Thiry 2002). Some examples of publications in program management include those of Thiry (2002), and Lycett, Rassau and Artto (2003), while those in portfolio management include those of Kangari and Riggs (1988); Englund and Graham (1999); Ghasemzadeh and Archer (2000); Cooke-Davis (2002a); Cooke-Davis (2002b); Elonen and Artto (2003); and Leliveld and Jeffrey (2003). In addition, PMI's (2003) new organizational project management maturity model, OPM3, has reflected the concept of combing the 'Best Practices' of the three separate domains of project, program and portfolio management.

Simply managing projects as a collective entity by applying program and portfolio management theories is insufficient. It is also necessary to enable organizations with the capability to learn between (across) their projects. It is one thing to say that

program and portfolio management is used to manage an organization's projects collectively, and another to say that the organization has the capability to enable their project members to learn from their past projects' experiences and improve their project and organization's performances. This is because cross-project learning not only enables an organization to have a bird's-eye view of all its projects and programs, but also allows systematic assessment and review of lessons learnt from one project/program and apply it to another, through its organizational routines and processes. This allows valuable information and knowledge that is accumulated to be articulated and codified between projects: thereby preventing knowledge from disappearing with its project members at the end of a project and from being gained in a 'hit and miss' fashion (Frame 1995).

1.1.2.2 Contemporary View No. 2

The Segregated Project and Operations Life-cycles

The operations phases have traditionally been clearly segregated from the design and construction phases (Arditi & Gunaydin 1998) where a project comes to an end when it is completed, commissioned and transferred to the owner/sponsor. The owner or sponsor will either employ facilities management professionals to maintain and operate the facility in-house or outsource these services. It is also generally understood that facilities management is practiced within the operations phases while project management is practiced within the design and construction phases.

Shortcomings

This perspective poses the following shortcomings (see *Figure 1*):

The scope of a 'project' is too narrow: If the 'project life-cycle' is managed separately from the 'operations life-cycle' any consideration for the impact of the design and construction of the facility on the operations stage is seldom or not considered.

Under the contemporary perspective facilities management professionals are brought into the project at a later stage (usually after the design and construction commitments have been made), resulting in the lack of optimisation through value engineering. For instance, during the early phases of the project, if one does not consider what impact

the design and specification of an HVAC system of a particular facility has on the operations phases (e.g. does not consider energy consumption hence reducing operating cost), the owner of the facility may realise at a much later stage that value-generation has not been maximised and the operating characteristics have been set.

The Need to Address the Shortcomings

The contemporary perspective described above is inappropriate- a paradigm shift is necessary. It is pertinent to look at a project in a more holistic manner; from conception to disposal instead of just conception to handover as a project life-cycle has been classically known.

This change in focus is evident from recent publications such as that of Burke (1999) and Burke (2004). Burke (1999) identifies the phases of a project life cycle as concept, design, implementation, and commission, and clearly segregates this from the operation phase (which includes maintenance, upgrading and disposal of project). In Burke (2004), however, he identifies the phases of a project life cycle as concept and initiation, design and development, implementation or construction, and commission or handover, and proposes that the classic project life-cycle is now insufficient. He posits that it is now necessary to look at a wider picture by considering the efficient operation and return on investment of the facility when deciding to build it. Also included is an additional life-cycle to explain and support the need to consider the future performance of the facility. He termed it the 'operations life-cycle'. The 'operations life-cycle' includes three main phases: maintenance phase, up-grade or expansion phase, and the decommissioning and disposal phase. The 'project life-cycle' and the 'operations life-cycle' are then known as the 'product life-cycle'.

Traditionally, the facilities or operations manager only enters the picture on or after the project is handed over from the design and construction team to the owner/sponsor. The facilities or operations managers' opinions are seldom sought during the design and construction phases of the project. The facilities manager would then manage the project in the condition it is handed over to them. This means that the knowledge and past experiences of the facilities manager is not optimised and applied at early stages of each project in order to maximise value generation.

1.1.3 Conclusions

In reviewing extensively on literature pertaining to the management and life-cycle of projects, the author concludes that the definitions for 'project life-cycle' are varied and often confusing, and has therefore synthesized the definitions of a 'project life-cycle' *(conceptualization; initiation; planning-definition-design development; execution-implementing; controlling; and termination (commissioning and handover))* and an 'operations life-cycle' *(maintenance and refurbishment until decommissioning and disposal)* of a project for purposes of this research.

In addition, there is clearly a need to look beyond contemporary views of project management and current lessons-learnt practices such as end-of-project reviews. This is because such contemporary views are not only inadequate for the increasingly complex projects managed by project-based organizations but also limit the opportunity of the organizations and its members to learn from their projects, thereby prohibiting them from transforming lessons-learnt into improved project and organizational performances.

1.2 Research Problem and Hypotheses

1.2.1 Research Objectives

The intention of conducting case studies in various (different types: e.g. sizes, cultures, business strategies and objectives) settings of 'real-life' construction organisations is to provide comparative exemplars of KM initiatives in various case studies (in particular, what had been implemented to manage knowledge in the organisations, and their effectiveness and performance outcomes) from which organisations may be able to understand and learn from in order to either develop, implement and maintain a new KM infrastructure or improve their existing ones.

1.2.2 Research Questions

The aims of this section are two-fold: first, to set-out the questions to be answered in this research in a structured and orderly manner, and second, to provide a conjecture of possible responses *(in italics)* to the questions (the conjectures are based on previous experiences the author had with KM 'systems/infrastructures' in other organisations during his previous employment in the industry).

The aim of Questions 1 to 7 is to provide an in-depth understanding of the background of the case study organisations in regards to their sizes, cultures, business types, objectives and priorities as well as the 'state of' the KM initiatives (such as purpose, origins, receptiveness, critical success factors, and measures) currently claimed to have been employed by the organisations to manage knowledge. On the other hand, Questions 8 to 14 aims to generate an in-depth understanding of the tools, methods and mechanisms currently existing in the organisations in terms of those which currently exist in the organisations, and their the effectiveness and performance outcomes.

In the course of the research, it is then hoped that the analysis and findings may provide answers to the second set of questions (Questions 15 to 18) that are not directly addressed as part of the research strategy.

All these questions have been addressed via the various modes of data collection specified in the 'Summary of Research Strategy' (*Table 14*) while specific questions to be asked in the survey questionnaires are depicted in the 'Mapping of specific questions between part one and two of the survey questionnaires' (*Table 15*).

How do construction organizations manage what they and their staff know, and in particular, learn from their past projects and apply to current and future projects?

Questions relating to the context of the organisation and the strategic objectives of its KM initiatives:

Q1 What is the purpose of the KM initiatives in the case study organisations?

A1 *An obvious purpose of KM initiatives is to manage knowledge with the aim of not only retaining knowledge within a construction organisation but also to share knowledge between individuals in the organisation. However, from the author's experience, the former more commonly occurs than the latter.*

Q2 Does Board-level representation for KM exist in the case study organisations?

A2 *Often, despite being aware of the importance of and need for KM, it is likely that organisations may still have an insufficient representation at the board-*

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level to enable the continual support and drive of such initiatives, and ensure that the initiatives are aligned with the organisation's business strategies and objectives.

Q3   Is there substantial top/senior management encouragement of the KM initiatives?

A3   *In the same way, organisations may also neglect the importance of having substantial top/senior management (e.g. directors, vice-presidents, divisional heads etc.) encouragement required to continually support and drive the initiatives (including its development, implementation and maintenance).*

Q4   Who are the initiators of the KM initiatives in the case study organisations?

A4   *Logically, one would expect the initiators of such initiatives to be the top/senior management staff due to the fact that since such initiatives require funding, only top/senior management would have the ability to sanction such a cause.*

Q5   How receptive are the organisation's staff to the KM initiatives, and is the level of staff's receptiveness to initiatives is a key success factor?

A5   *The author posits that the receptiveness of staff at all levels of the organisation are critical success factors of KM initiatives, and that KM initiatives that are successful would most likely (and logically) have staff (at all levels of the organisation) that are highly receptive to the initiatives.*

Q6   What are the critical factors of success for the KM initiatives?

A6   *The authors posits that critical success factors of success for such initiatives would include (but may not be limited to): alignment of organisational strategies and objectives with those of KM initiatives, ensuring staff awareness of the need for and the intended development, implementation, and maintenance of the KM initiatives, 'buying-in' all levels of staff in support, commitment and participation of the initiatives to ensure its successful development, implementation and maintenance, having a planned and structured approach to developing, managing and maintaining the initiatives, and selecting persons who are professionally trained in the 'fields' of knowledge to manage the initiatives.*

Q7   Whether KM measures exist within the organisation. If yes, what are they?

A7   *The author posits that no or little KM measures would exist in construction organisations. Should they exist, they would at best be arbitrarily measured*

and not as official measures implemented for the purpose of ensuring continual improvement of the KM initiatives nor would it directly reflect the impact of the initiatives on project and organisational performance.

Questions relating to the existence, effectiveness and performance outcomes of the tools, methods and mechanisms employed:

Q8 What are the tools, methods and mechanisms currently used in the case study organisations to manage what they know?

A8 *Some tools, methods and mechanisms which the case study firms are expected to most commonly use to manage what they know include: intranets, extranets, electronic message exchange programs (discussions via technological platforms), face-to-face group discussions/meetings, computer aided design program (e.g. project management, architectural, engineering design programs), and information technology hardware (e.g. servers and computers) that support the earlier mentioned software programs.*

Q9 How is knowledge 'transferred' or 'passed-on' from one project to another (in particular, from past projects to future projects)?

A9 *The author posits that knowledge is currently more commonly 'transferred' from one project to another by the use of information technology related tools, methods and mechanisms that aid the retention and retrieval of knowledge via organisational central repositories instead of direct face-to-face sharing of knowledge between individuals; even though one would suggest that most individuals would prefer the latter mode than the former as it would be much more convenient to obtain what they wish to know from others directly instead of having to search say a central server via an intranet to find/obtain what they know.*

Q10 How regularly used and effective are these tools, methods and mechanisms in enabling individuals to learn from one project for application in another?

A10 *Logically, only tools, methods and mechanisms that are deemed to be most capable of enabling the respondents in different organisations to obtain what they require, and understand and learn what they have obtained from previous projects would be most regularly used and effective. The author posits that different tools, methods and mechanisms would have different*

levels of effectiveness on different organisations dependent on the context of the organisation (i.e. there would not be a single prescribed set of tools, methods, and mechanisms that could single-handedly manage the plethora of data, information and knowledge in the firms).

Q11 Which of the tools, methods and mechanisms are capable of enabling learning between project phases in a project rather than between projects within an organisation?

A11 *It is most likely that some tools, methods and mechanisms would be more capable of enabling learning between project phases in a project than between projects within an organisation. For instance, tools, methods, and mechanisms that enable closer in-depth interaction and discussions (be it face-to-face or virtually) between individuals would be more effective in enabling learning between project phases in a project than between projects. Also, the need for tools, methods and mechanisms that enable either types of learning would probably be dependent on the context of the firm (size, culture, structure). For instance, it is perceived that due to the assumed compactness and collegiality of a small sized firm (20 staff) with a smaller number and size of projects, there would be less need for such a firm to implement cross-project learning tools, methods and mechanisms that enable an in-depth record and understanding of the occurrences of each phase of a project as compared to larger firms (say 1000 staff).*

Q12 What types of problems (generic and recurrent, or specific and less recurrent) have the tools, methods and mechanisms employed enabled the organization to resolve?

A12 *It is perceived that tools, methods and mechanisms that enable closer interaction and communication between staff as well as more in-depth discussion of specific issues would enable organisations to resolve more specific and less-recurrent problems instead of generic and recurrent ones.*

Q13 Which of the tools, methods and mechanisms are effective in enabling staff to experience learning at the individual, division/department, and/or corporate level?

A13 *It is perceived that different tools, methods and mechanisms have different abilities in enabling individuals to experience learning at the individual, division and corporate levels, and that tools that are more effective in*

enabling closer communication between individuals would derive better learning experiences at the individual than group levels.

Q14 Are these tools, methods and mechanisms really capable of enabling learning to occur in the organisation; in particular between its members?

A14 It is perceived that not all tools, methods and mechanisms are capable of enabling learning across organisations and members, and that there would be no single tool that would be able to single-handedly do so. It would require a holistic set of tools, methods and mechanisms to do so.

Other questions:

Q15 Is what is currently managed in the case study firms really knowledge or simply data and information?

A15 It is perceived that although organisations which have set up so called KM systems had intended to use them to manage knowledge, the author believes that what is managed is more often than not just data and information. At best, what is recorded is project base/related data and information such as project, material, labour, equipment costs, areas, and specifications etc. Also, the author believes that knowledge is personal and resides in individuals' heads, and where KM systems connote that an information technology plays a large factor in managing what the organisation knows, these systems can only retain data and information.

Q16 Do staff in the case study organisations consider loss of knowledge and know-how to be a problem that needs to be minimised?

A16 One would expect the majority of responses to this question to be a 'yes' unless individuals are ignorant or unaware of the logical notion of the value of their past knowledge and experiences.

Q17 What do staff in the case study organisations think are the most likely causes of loss of knowledge and know-how from past projects?

A17 One would perceive that poor infrastructural provision in firms to retain what their have and know (via technological and non-technological means), lack of an awareness of the importance of employing tools, methods and mechanisms (e.g. lessons-learnt sessions, post project reviews etc.) that enable learning of past project experiences, and an inability of firms to retain their good staff (high turnover and individual knowledge leaving with

the staff without any retention of what each staff knows) to be the most likely causes of loss of knowledge and know-how from past projects.

Q18 Do staff in the case study organisations think that loss of knowledge and know-how (from lack of internal sharing of knowledge and experiences) affect project performance?

A18 It would be logical for one to surmise that the majority of respondents would believe that if they would be unable to learn from their past project knowledge and experiences, they would be unable to prevent the same mistakes from occurring or emulate and implement the successes in order to improve the performances of future projects.

1.2.3 Research Deliverables

The primary aim of this research is to provide exemplars of knowledge management infrastructures and initiatives from 'real-life' construction organisations such that they may assist construction organizations to either improve an existing KM system or introduce a knowledge management infrastructure through the process of identifying/selecting, developing and implementing the appropriate tools, methods and mechanisms that could most effectively enable learning and transference of data, information and knowledge across projects with each organisation.

In the process of doing so, the research also aims to develop a holistic data, information and knowledge management model that could best reflect what would be 'managed' (e.g. data, information and/or knowledge) by the relevant party (individual, group, and/or institution), the relevant knowledge processes involved (acquire, organise, share, create, utilise/apply), and the type of knowledge (tacit and/or explicit) 'managed' by the knowledge process/es.

Furthermore, the research aims to assess the current knowledge management infrastructures, identify gaps, and recommend areas of improvement for each of the case study organisations.

1.3   Justification for the Research

Being concerned with overseeing substantial projects on a regular and recurrent basis, it is essential that construction organizations learn from experience so that they may practice 'continual improvement'. In order to do so, they need to move beyond traditional project management methodologies which are becoming increasingly irrelevant (Jaafari 2003; Bryde 2003), and learn how to learn from past actions and performances to enable themselves to improve future management actions (O'Keeffe and Harrington 2001; Cooper, Lyneis and Bryant 2002). It is pertinent to understand what constitutes an organization's learning capacity as it may be its only sustainable competitive advantage (Bontis, Crossan and Hulland 2002). Therefore, organizations need to learn how to share the knowledge and experiences of their team members, not just between members in a project but also across projects within their organization.

The intent of this research is to identify the tools, methods and mechanisms that can be purposefully implemented to facilitate knowledge transfer within a project and between projects in construction organisations (i.e. the 'vehicles' that enable or facilitate the embodiment and dissemination/transference of project knowledge) by individuals in an organisation for the purpose of learning from past project to improve the performance of future projects.

1.4   Methodology

Case studies will be conducted in three construction organisations located in Australia, Singapore and Taiwan via a multi-pronged approach for purposes of validating the data and information found from each mode of collection. These modes are: survey questionnaires, personal interviews/discussions, direct observations, and analysis of documentary materials.

The author spent a substantial amount of time (approximately two to three months) embedded in each firm and assisted the organisations in collecting the data and information. Further details of the research methodology and plan can be found in *Section 3.0*.

1.5 Outline of the Report

This thesis is organised as follows:

- **Chapter 1** provides a clarification on the definitions to be utilised in this research as well as introduces the purpose of this research and the research problem/s. In doing so, it highlights the research objectives, questions and the potential deliverables of the research and results, thereby providing a condensed overview of the project and a roadmap for how the problem would be addressed through the succeeding chapters.

- **Chapter 2** positions the research within the relevant literature by extensively reviewing, discussing and comparing the key concepts underlying the premise of this research- in particular, Knowledge Management and Organisational Learning, and builds the theoretical foundation for the research in relation to the context of construction organisations.

- **Chapter 3** details the research methodology and plan to address the research questions and hypotheses identified in Chapter 1.

- **Chapter 4** provides the detailed comparative study (analysis, findings and discussions of the data and information collected to test the research problems/questions earlier identified) between the three case study organisations with regards to the context of the organisations in relation to the overall regularity of use and effectiveness of the KM tools, methods and mechanisms employed to enable learning from one project for application in another, and more specifically the effectiveness of the tools, methods and mechanisms in enabling learning between projects within a firm and/or between project phases within a project, in enabling the resolution of generic and recurrent and/or specific and less-recurrent problems, and in enabling staff to experience learning at the individual, division and/or corporate levels of the firm as well as the impacts of the KM initiatives on the firms' ability to deliver projects, portfolio and program, and the critical success factors and key performance indicators of the KM initiatives employed in the firms.

- **Chapter 5** then identifies and makes recommendations on the areas of improvement for the three case study organisations. This includes the development of the following: a framework for enabling the identification of tools, methods and mechanisms for connecting people-to-organistion and people-to-people; a data, information and knowledge management models and their application to (as well as importance to consider) the context of the three case study organisations, and finally an analysis of current KM infrastructure in each of and the changes recommended for the three firms. In addition, it provides guidelines and issues for consideration when developing, implementing and maintaining a KM infrastructure.

- **Chapter 6** presents the conclusions and implications for the research. This includes summarising the findings of and discussions on the research questions and problem, and the practical contributions and applications of the research to the body of knowledge and the construction industry in particular. Finally, opportunities for future research are identified and discussed.

2.0   LITERATURE REVIEW

The literature review has concluded that although data, information and knowledge are distinct in terms of definitions, they are inevitably related to one another. In addition, personal wisdom (including the individual's capabilities of intuition and discernment) is necessary to organize, analyse, reflect and understand information that they had acquired from others (be it verbally or retrieved from non-technological and technological systems) to convert information to knowledge.

In addition, information management is distinct from knowledge management in that the former focuses on the management of explicit information while the latter is more encompassing in that it manages what the organization and its employees have (explicit information and tacit knowledge) which incorporates information management and taking the organisation's structure/design, strategies, culture, communications, human resources and alignment of organizational strategies with KM initiatives. Furthermore, it is erroneous to term a set of KM initiatives (or KM tools, methods and mechanisms) as a KM system because the word 'system' has a technology-centric connotation to it, and that since knowledge only resides in individuals' heads (i.e. knowledge is personal), a KM system cannot manage knowledge (it can at best only manage information). Instead, a more apt and holistic name for a set of KM initiatives aimed at managing data, information and knowledge would be a KM Infrastructure (which includes technological and non-technological tools that manage data and information residing in the organization as well as the facilitation of converting tacit knowledge to explicit information and vice-versa).

Finally, the author also asserts that although KM and OL are distinct in terms of definitions, there is a need for both to coexist to ensure that organizations that have adopted KM or have a KM Infrastructure become learning organizations.

2.1   Organisational Learning (OL)

2.1.1   Introduction: The Variegated Nature of OL Literature

Despite the large and growing (Gherardi 2001; Bell, Whitwell and Lukas 2002; Easterby-Smith, Crossan and Nicolini 2000) amount of literature on organizational learning, there is still generally little consensus as to the meaning or basic nature of the

term 'organizational learning' as well as conceptual confusion between the terms organizational learning, knowledge management and intellectual capital (Bontis, Crossan and Hulland 2002; Berends, Boersma and Weggeman 2003).

This could be due to the lack of synthesis and accumulation of work by different research groups (Huber 1991; Kim 1993; Easterby-Smith, Crossan and Nicolini 2000; Zietsma *et al.* 2002), the variety of domains in which organizational learning research has been carried out (for example Bell, Whitwell and Lukas 2002, Woiceshyn 2000; Panagiotidis and Edwards 2001, Tovstiga, Odenthal and Goerner 2004), and the diversity of perspectives (Bontis, Crossan and Hulland 2002) used to look at organizational learning issues. Other researchers, such as Easterby-Smith, Crossan and Nicolini (2000) attempt to review key debates in past organizational learning literature and identify discussions that they reckon are 'interesting' and worth further research effort. These include the nature and location of organizational learning, the methods for investigating organizational learning, and the territorial disputes between competing concepts. Some of the perspectives that were highlighted are the emergence of the 'social constructivist', 'communities of practice', 'communities of creation', 'ecologies of knowledge', and 'activity systems' perspectives. These perspectives are briefly summarised.

The 'social constructivist' perspective (such as Huber 1991, Bruffee 1993 and Crossan, Lane and White 1999) propounds the view that the occurrence of learning and knowledge is created mainly through conversations and interactions between people while 'communities of practice' (such as Brown and Duguid 1991) takes a community building approach to organizational learning. 'Communities of creation' (such as Sawhney and Prandelli 2000) is grounded in the concept of a shared space for emerging relationships that serves as a foundation for knowledge creation. Participation in the shared space means transcending one's own limited perspective or boundary and contributing to a dynamic process of knowledge development and sharing. 'Ecologies of knowledge' (such as Star 1995) is a combination of the 'communities of practice' approach and 'learning region' approach (first coined by authors of innovation studies and economic geography (Florida 1995)) (Forsman and Solitander (WIP)). It is also defined by CIL (2002) as an interdisciplinary field of management theory and practice, focused on relational and cultural aspects of

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knowledge creation and utilisation where the heart of it is the art and science of collaborative midwifeing the emergence of meaning and value for productive conversations. Activity theory (such as Blackler 1993) examines the nature of practical activities, their social origins, and the nature of the 'activity systems' within which people collaborate.

2.1.2 Critical Identification and Discussion of Key Concepts in Literature

Despite its variegation, the study of organizational learning literature to date indicates that much of the underlying concepts of organizational learning literature are actually either intertwined or interrelated, similar, or an extension of each other.

2.1.2.1 Synthesizing a Most Predominant 'Model'

The most prominent 'modellings' of organizational learning is that of the different archetypes of learning (for example, the single-loop and double-loop learning presented by Argyris and Schon (1978)). In an attempt to synthesize the various archetypes of learning, the author has categorised them into three 'Forms' of learning-1st Form, 2nd Form and 3rd Form (see **Table 2**). However, it is important to note that due to the different ways of defining and perceiving organizational learning, the author argues that (following the view of Burgoyne and Hodgson (1983)) the different 'forms' of learning identified are not unique but linked, indistinct and amalgamated with each other.

'Forms' of Learning

Most authors refer to two 'forms' of learning processes. Apart from *single-loop* and *double-loop* learning by Argyris and Schon (1978), other variants to the archetypes of learning include those of *lower* and *higher level* learning by Fiol and Lyles (1985), *exploitation* and *exploration* by March (1991), *adaptive* and *generative* learning by Senge (1992), *non-strategic* and *strategic* learning by Mason (1993), *maintenance* and *anticipatory* learning by Fulmer (1994) and Fulmer, Gibbs and Keys (1998), *1st order* and *2nd order* learning by Lant and Mezia (1992), *operational* and *conceptual* learning by Kim (1993), *incremental* and *radical* learning by Miner and Mezias (1996), and *incremental* and *transformational* learning by DiBella and Nevis (1998).

In addition to these two 'forms' of learning, a third 'form' of learning called *deutero* (otherwise known as *triple-loop*) learning was also suggested by Argyris (1995). Other researchers who identified three 'forms' of learning include Chaharbaghi and Newman (1996) who identified *incremental, transformational,* and *developmental and behavioural learning* and *tool making* while Pedler, Burgoyne and Boydell (1997) identified the learning processes of *implementing, improving* and *integrating.*

Others who had identified four 'forms' of learning include those of Bateson's (1972) *zero*-learning, *proto*-learning *(learning 1), deutro*-learning *(learning 11)* and *trito*-learning *(learning 111),* and Marquardt's (1996) identified *adaptive* learning, *anticipatory* learning, *deuteron* learning, and *action* learning.

However, instead of providing the definitions and perspectives of each of the different archetypes of learning by the different authors (which appears to be extremely difficult to find synthesis, much less compare these models with one another), the author proposes that the characteristics of the above-mentioned 'forms' of learning can be elicited and captured into three main 'forms' (1st, 2nd and 3rd Forms) of learning (see ***Table 2***).

CHARACTERISTICS	'FORMS' OF LEARNING		
	1st Form	2nd Form	3rd Form
MEASURE	Reactive	Active	Proactive
FUNCTION	Measures outcomes against organizational norms and expectations without questioning or changing existing assumptions, patterns of behaviour, values and norms which govern the aims, objectives, rules, and procedures designed to obtain them.	Challenges the nature and existence of prevailing deep-rooted assumptions, conditions, procedures and conceptions that underpin effective performance and the nature of learning itself.	Examines the way in which one learns and consequently to learn differently such as the learning orientations, styles, processes and structures that promote learning.
PROCESS	Doing what the business already knows or being done more efficiently (i.e. gaining competence in a certain activity, routine or technology).	Reframing a problem by searching for and developing alternative (or new) ways of doing things (e.g. alternative routines, rules, technologies, goals, and purposes) instead of just performing current routines more efficiently.	Reflecting, inquiring into and assessing previous contexts and episodes of organizational learning (such as reasons for and effect of previous successes and failures), thereby developing new means of and/or strategies to tackle (and implement) real problems encountered.
PREREQUISITE FOR PROCESS TO OCCUR	None	Non-defensive and open dialogue	Organization must be aware and admit that learning must occur (i.e. awareness of ignorance).
TYPE OF KNOWLEDGE INVOLVED	Primarily tacit (based on experience)	Primarily explicit (change of routines, rules, technologies, goals and purposes)	Tacit and Explicit (conversion of experiential knowledge into explicit forms that can be shared with others through a process of observation (concrete experience), assessment (reflection), designing (form abstract concept), and implementation (test concept).
IMPACT OF LEARNING	Short-term and Temporary: correcting errors in tasks or actions when they arise.	Long-term: addressing long-run consequences of present actions (i.e. anticipating problems or trends for the future)	Long-term: addressing the capacity of organizations and its members to continuously learn from their past for the benefit of (and application to) their future.
LEVEL OF COMPETITIVE ADVANTAGE	None or little	Competitive Advantage	Sustainable Competitive Advantage
SUITABILITY OF LEARNING TO TASK	For routine and repetitive jobs	For complex and non-programmable tasks/issues (such as removing old habits and altering the behaviour of individuals)	For understanding the learning system, of which organizations (both within and between organizations) and their members are a part, in order to enable purposeful change and identify the limits of the change.

Table 2: 'Forms' of Learning

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1st Form of Learning

The 1st 'form' of learning takes a reactive role whereby outcomes are measured against organizational norms and expectations. Existing assumptions, patterns of behaviour, values and norms governing the aims, objectives, rules and procedures designed to obtain the outcomes are not questioned. Basically, it refers to doing what the business already knows and/or tasks or activities that are currently being done more efficiently. The knowledge involved is primarily tacit since the focus of this 'form' of learning is the routine detection and correction of weaknesses in behaviour based on experience (i.e. trial and error) in order to reach a predetermined norm and expectation or particular task (i.e. a reference point). Furthermore, the impact of learning that occurs at this 'form' of learning is short-term and temporary, resulting in no or little competitive advantage to the organization. This 'form' of learning is associated with exploitative behaviours which seeks to refine existing processes and emphasizes the objective of efficiency making it suitable only for tasks or actions that are routine and repetitive in nature.

2nd Form of Learning

The 2nd 'form' of learning, however, takes an active role whereby deep-rooted assumptions, conditions, procedures and conceptions that underpin effective performance and the nature of learning itself are challenged (i.e. questioned). It involves moving beyond performing existing routines to reach a particular set of objectives, and reframing problems by searching for and developing alternative (or new) ways of doing things (such as routines, rules, technologies, goals, and purposes); thereby involving knowledge that is more explicit in nature. This 'form' of learning usually occurs where despite the attainment of a particular set of objectives via routine actions, organizational goals and objectives cannot be met within the existing frameworks or where competitive advantage is lost. In contrast with the 1st 'form' of learning, the 2nd 'form' of learning requires the presence of non-defensive and open dialogue between individuals to enable them to share their knowledge and experiences with each other so as to derive new and better ways of doing things. The impact of learning that occurs at this 'form' is long-term since it addresses long-run consequences of present actions through the anticipation of problems or trends for the future; resulting in competitive advantage for the organization. This 'form' of learning exhibits exploratory behaviours where the organization learns by engaging in risk

taking, playing and experimenting with ideas, discovery and innovation making it suitable for application to complex and non-programmable tasks or issues (such as the removal of old habits or cultures within organizations and altering the behaviour of individuals).

3rd Form of Learning

The 3rd 'form' of learning takes learning another step further by adopting a proactive role through examining the way in which one learns and consequently to learn differently via learning orientations, styles, processes and structures that promote learning. It involves inquiring into previous contexts and episodes of organizational learning (such as reasons and effect of successes and failures) through a process of observation (concrete experience), assessments (reflections), designing (constructing abstract concepts), and implementing (i.e. testing) the concepts or designs in new situations (such as developing new means to tackle real problems encountered). The focus of this 'form' of learning is the process by which one learns, what we learn, the identification of key facets of what is learnt, and applying the solutions to the problems. However, to facilitate this 'form' of learning, there is a need for organizations to be aware of and admit that learning must occur (i.e. awareness of ignorance). Therefore, since this 'form' of learning involves the process by which individuals convert concepts (derived from their experiential knowledge through a thought process) into reality (real solutions to problems), it involves both tacit and explicit knowledge. The impact of this 'form' of learning is long-term as it addresses the capacity of its organizations and its members to continuously learn from their past for the benefit of (and application to) their future thereby providing a learning environment that provides sustainable competitive advantage for the organization.

A recent framework for organizational learning by Crossan, Lane and White (1999) has attempted to integrate all these various 'forms' of learning by building on the tension between exploitation and exploration in organizations. Apart from this, the framework has encapsulated the other predominant concepts or themes in organizational learning literature. This is evident in the following section which attempts to examine and identify them through an examination of Crossan, Lane and White (1999) framework with a host of other frameworks and perspectives.

2.1.2.2 A Review of Other Predominant Frameworks and Concepts in Literature

Modes (Processes) and Levels of Learning: Four Is (Intuiting, Interpreting, Integrating, Institutionalizing) and Three levels of Organizational Learning

A predominant concept that can be elicited from organizational learning literature is that of the four I's (*intuiting, interpreting, integrating, institutionalizing*) and the three organizational levels (*individual, group and organization*), first perceived by Crossan, Lane and White (1999), at which learning occurs. This concept (see *Table 3*) has been used by the following authors as the basis of their research in relation to a variety of issues and domains. These include studies on business performance by Bontis, Crossan and Hulland (2002), strategic renewal of an organization by Crossan and Berdrow (2003), strategic leadership by Vera and Crossan (2004), two additional processes of feedforward learning (known as 'attending': occurring at the individual-intuiting level and 'experimenting': occurring at the individual-interpreting level) with studies in the forestry industry by Zietsma *et al.* (2002), learning and sense-making (drawing from Nonaka and Takeuchi's (1995) theory of knowledge creation) in the music arena by Tovstiga, Odenthal and Goerner (2004), and technology adoption as a process of organizational learning in the oil industry by Woiceshyn (2000).

Other variants to the processes of learning can be observed from Huber (1991), Carroll (1998), and Crossan, Lane and White (1999). Huber (1991) proposes the four processes of learning as knowledge *acquisition*, information *distribution*, information *interpretation*, *storing and retrieving* information to/from organizational memory while Carroll (1998) proposed those of *observing, reflecting, creating and acting*. Woiceshyn (2000), in her framework and study on technology adoption in oil firms, posits that through *observing* and *interpreting* (the knowledge they acquire), individuals can share their observations and interpretations via groups and organizations through the process of *integrating* and thus forming the basis of coherent *collective action*.

Alternatively, Gnyawali and Stewart (2003), posit two modes of learning, namely the informational and interactive modes of learning. The informational mode refers to systematically based structural processes used to *acquire, distribute, and interpret* information (similar to processes proposed by Huber 1991- see above). It focuses on

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minor improvement (i.e. refining) existing knowledge (i.e. what is already known) and dissemination of such knowledge. The interactive mode, on the other hand, refers to 'systematically based social processes used to develop shared schemas through the *action and interactions of various individuals and units of the organization*' (Gnyawali & Stewart 2003, p. 71) where it is critical in resolving conflicts and developing shared understanding. The modes of learning which an organization decides to use would depend on the organization's perception of the environment (i.e. the magnitude of uncertainty and equivocality). For instance, if an environmental condition is highly uncertain, the organization should focus on the informational mode to create the necessary knowledge to reduce uncertainties. Examples include vicarious learning, learning through imitation, congenital learning, learning by actively searching the environment and noticing other competitors. However, should the organization be highly equivocal, the organization should focus on interactive learning. This includes dialogue, learning from direct experience, rich and deep learning from a few but important incidents, insight development, discovery and learning in the process of innovation. Also, should an environment be dynamic, complex and difficult to understand, organizations should use a combination of methods.

Mechanisms (i.e. Repositories or Stocks) and Flows of learning

Another similarity observed from literature is that of organizational learning 'mechanisms' and 'repositories' espoused by Gnyawali and Stewart (2003) and Vera and Crossan (2004) respectively. Gnyawali and Stewart (2003) define 'mechanisms' as the *culture, structure, strategy, human processes and learning* laboratories that facilitate the sharing, validating and integration of individual and group learning into organizational learning. Vera and Crossan (2004) define organizational 'repositories' as *culture, structure, strategy, systems and procedures*, and suggests that learning generated by individuals and groups that is embedded in these nonhuman aspects of the organization should be aligned with a firm's strategy (i.e. vision and goals).

However, it is pertinent to point out that the 'mechanisms' identified by Gnyawali and Stewart (2003) refers only to the organizational level 'repositories' (also known as organizational level 'stocks') of learning. 'Repositories' of learning also exist at two other levels of the organization, namely the individual and group levels (see Vera & Crossan 2004 and Bontis, Crossan & Hulland 2002). Individual learning stocks

include individual competence, capability, and motivation (similar to the factors of 'effort' and 'capability (intellectual capital)' required for learning to take place- as proposed by Woiceshyn (2000)) to undertake required tasks. Group learning stocks include group dynamics and the development of shared understanding.

Whereas learning 'stocks' comprise the inputs and outputs of the learning processes, learning flows enable learning to move from one level of the organization to another. Feed-forward flow enables individual learning to move to group and organizational levels of learning thereby allowing firms to innovate and renew while feedback flow enables organizational learning to move to group and individual levels of learning thereby allowing firms to reinforce what it has already learnt and ensures that organizational repositories guide group and individual learning (Crossan, Lane & White 1999).

A Predominant Theme in the Different Perspectives: The Importance of 'collaboration', 'interaction', 'dialogue', 'conversation', and 'sharing and transferring'.

Amidst the variety of perspectives, it is pertinent to note a predominant 'theme' in organizational learning literature. For instance, the importance of *'conversations and interactions between people'* (social constructivist perspective), *'community building approach'* (communities of practice perspective), *'participation of a shared space'* (communities of creation perspective), *'productive conversations'* (ecologies of knowledge), *'activity systems within which people collaborate'* (activity systems perspective), as well as that of *'dialogue, communities of interaction, negotiations, arguments, information sharing and transfer'* (contingency model proposed by Gnyawali and Stewart (2003)) accentuate the need for individuals to work collectively, converse and interact with each other (by sharing their individual *intuitions and interpretations*) in order to develop shared understandings through mutual adjustments (*integration*). Once these actions become recurrent, they are embedded in the organization (*institutionalized*) to ensure routine actions occur. This is made possible by 'organizational learning mechanisms' which act as the basis for developing and retaining the 'stock' of knowledge, and facilitating the 'flow' of knowledge at multiple levels in the organization.

Level	Process	Mechanisms/ Repositories	Inputs	Outcomes
Individual	Intuiting: Developing new insights through the preconscious recognition of the pattern and/or possibilities inherent in a personal stream of experience.	- Motivation - Commitment - Effort - Capability - Competence	- Experiences - Images	Metaphors
	Interpreting: Explaining (through words and/or actions) new insights to develop cognitive maps about the domains in which individuals operate.		- Language - Cognitive Map	Conversation/ Dialogue
Group	Integrating: Sharing of individual interpretations to develop a common understanding. Through dialogue, individuals suspend their assumptions and communicate with each other to explore difficult issues from different view points, make mutual adjustments and take collective action.	- Group Dynamics - Developing Shared Understanding	- Shared Understandings - Mutual Adjustment	Interactive Systems
Organization	Institutionalizing: Ensuring routine actions occur. Tasks are defined, actions specified, and organizational mechanisms put in place to ensure certain actions occur. These tasks will initially be ad hoc and informal. But once the coordinated action taking is recurrent and significant, the routines will be embedded into the organization's repositories such as systems, structures, procedures and strategy.	- Culture, structure, strategy, system, procedure, process	- Routines - Diagnostic Systems	Rules & Procedures

Table 3: The 4I's Framework of Organizational Learning (adapted and modified from Bontis, Crossan & Hulland (2002)

2.1.2.3 Thoughts and Discussions

The variety of organizational learning literature should not be regarded as a flaw. Instead, the wide scope and varied perspectives in organizational learning literature should be treated as a valuable asset and used to develop the foundations for building up the depth of the literature. Existing literature on organizational learning has largely been used as a tool to understand the occurrence of organizational learning in non-project organizations or to further develop, modify and extend existing theories (of which is already plentiful). Instead, it should be used to gain an in-depth understanding of the way projects are currently being managed in construction organizations and their learning capacities (i.e. whether (and what) learning has occurred at various levels of the organization, has learning occurred and how, why does something occur the way it does (e.g. to explain project successes and failures), has the learning been effective, and understanding which (and whether the) organizational learning systems has been effective or not). It is hoped that the critical identification and discussion of key concepts in existing organizational learning literature may assist in answering these queries, and subsequently in the development of an operable organizational learning framework.

2.2   Knowledge Management (KM)

Before we delve into the definitions of knowledge management, it is necessary to clarify the terminology of knowledge versus its counterparts of data, information, and wisdom.

2.2.1   Introduction: Differing Perspectives towards KM

Although it is now commonplace to say that knowledge is a most critical asset which must be managed in an organization and that it is the key to a firm's sustainable competitive advantage, yet not many academics or industry practitioners invest time on reflecting what knowledge actually/really is or means, and on the difference between knowledge management and information management (IM).

Often, most vendors of information processing or management softwares and programs and strong proponents of IM regard it and KM as the same thing. Some vendors even go further by claiming that their software/programs (be it 'off-the-shelf' or customised) are a panacea to the difficulties of managing knowledge in firms. To add to the already confounding scenario, knowledge management proponents have contrasting perspectives to managing knowledge: some associate it with the hard side of management- information management systems and technologies, while others broaden KM to include the softer-side of management such as leadership style, support and commitment, organizational culture, rewards and recognition programs. So, can we really be clear about what is KM and is it the same as IM?

Firstly, it is pertinent to clarify what is meant by the term 'knowledge'. In order to do so, the definitions of data, information and knowledge will be examined. This is followed by discussions on the relationships between data and information, and between information and knowledge. Some critical dimensions of the conversion process from data-to-information and from information-to-knowledge will also be discussed.

Secondly, once the terms information and knowledge have been defined, the definitions of information management and knowledge management will be examined, and the relationships between IM and KM discussed.

2.2.2 Data, Information, and Knowledge: Are they the same?

In order to fully comprehend the differences between IM and KM, it is important to review the foundational definitions of data, information and knowledge.

2.2.2.1 Data, Information and Knowledge: Definitions

Data

It is clear from the list of definitions (*Table 4*) identified from literature that although there are much less doubts as to what data is, some authors still differ from the majority.

Authors	Definitions of Data
Data as raw facts and distinct from information	
Bradburn & Patrick 2005	A commodity.
Bellinger, Castro & Mills 2004	Represents a fact or statement of even without relation to other things.
UNE 2004	Unorganised & unprocessed facts
	Discrete facts about events
	A prerequisite to information
Wilson T.D. 2002	Consists of simple facts.
Davenport T. 2002	Data is not information
Choo *et al.* 2000	Facts and messages
Quigley & Debons 1999	Text that does not answer questions to a particular problem
Davis & Olson 1985	Taken-for-granted facts
Davenport & Prusak 1998	A set of discrete facts
Davenport 1997	Simple observations
Spek & Spijkervet 1997	Not yet interpreted symbols
Ackoff, R. 1989	Data is raw. It exists without any significance beyond its existence.
	Symbols
Webster 1961	Something that has been given, granted or admitted; a premise upon which something can be argued or inferred.
Data includes or embeds information and knowledge, and as a view or statement about an observation	
Kock, McQueen & Corner 1997	Carriers of information and knowledge
	A means through which information and knowledge can be stored
KIBDS 2006	An expression of feedback
	A statement (rightly or wrongly) about an observation

Table 4: Definitions of data

Most authors describe data as something that is more 'simplified and raw' in nature- for instance, discrete (and raw) facts and messages, symbols, simple observations which have yet to be contextualised and that they exist without any significance beyond what they are. In other words, data has no meaning in relation to where it was derived from such as an individual, group, project and organisation and that it is distinct from information. A few others, however, defined it as "carriers of information and knowledge" (which elicits a connotation that these two are embedded in or form part of data) (Kock, McQueen & Corner 1997), and "expression of feedback" (elicits a connotation that data is a statement or view regarding an observation) (KIBDS 2006).

Information

From literature (*Table 5*), most authors describe information as: data that has been processed and organised into a form that is meaningful to a recipient (Davis & Olson 1985), the result of data that has been analysed (Bourdreau & Couillard 1999), data that has been interpreted (Bourdreau & Couillard 1999; Probst et al 2002), and data that has been contextualized (i.e. data that relates to a given condition or situation, thereby giving the data meaning)(Bellinger, Castro & Mills 2004; KIBDS 2004) and understood- thereby inferring that information is somewhat distinct from data, and yet a derivation of it.

Several others, however, describe information as being equivalent to knowledge (Fosket 1982), and as the derivation of our knowledge (Wilson 2002). The author concludes that this is incorrect since information is data that has been contextualised; the former is more detailed than mere data. Furthermore, information retrieved or received is not necessarily meaningful to an individual. The effectiveness of the information received also depends on the individual's capability to reflect, assess, analyse and understand and learn from the information in its past and future context to give rise to knowledge for application. In addition, some individuals may find the information more useful and meaningful than others.

Since data - being just raw and discrete facts (without any context- how, why, what, where etc.) - provides nothing more than facts, information cannot be equivalent to analysed data. Without context, data does not have any purpose nor meaning to it. Instead, with context, information can then be reflected upon, assessed, analysed, interpreted, and understood.

Hence, it is more appropriate to regard information as (at best) contextualised data that has yet to be interpreted and understood.

Authors	Definitions of Information
Information as data that has been processed within a context (contextualised), and hence distinct from data.	
KIBDS 2006	Data in context (i.e. contextualised data). Provides understanding of the data.
Bellinger, Castro & Mills 2004	Embodies the understanding of a relationship of some sort, possibly cause and effect.
Gahran 2004	Information is content which informs our minds (includes facts, observations, sensations, messages).
UNE 2004	Aggregation of processed data which makes decision making easier; usually has some meaning and purpose.
Davenport K. 2002	Data endowed with relevance and purpose.
Probst *et al* 2002	Interpreted data.
Saint-Onge 2002	Organised data.
Wilson T.D. 2002	Information is our expression of what we know (e.g. when we utter messages of one kind or another- oral, written, graphic, gestural, or even through body language)
Choo et al. 2000	Data vested with meaning.
Bourdreau & Couillard 1999	Result of analysing and interpreting data- phrases or images that carry meaning; Things that are held to be true in a given context and that drive people to action.
Kanter 1999	Power to act and to make value-producing decisions
Quigley & Debons 1999	Text that answers the questions who, when, what, or where.
Vail 1999	Information made actionable in a way that adds value to the enterprise.
Davenport & Prusak 1998	A message meant to change the receiver's perception.
Davenport 1997	Data with relevance and purpose.
Spek & Spijkervet 1997	Data with meaning.
Drucker 1995	Data endowed with relevance and purpose.
Nonaka & Takeuchi 1995	A flow of meaningful messages.
King 1993	Data that made a difference.
Wiig 1993	Facts organised to describe a situation or condition.
Davis & Olson 1985	Comprised of data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective actions or decisions.
Ackoff 1989	Data that has been given meaning by way of relational connection. The meaning may or may not be useful.
Information is equivalent to knowledge, and knowledge that has been interpreted into verbal or non-verbal forms	
Fosket 1982	Information is what we know.
Wilson 2002	Information is our expression of what we know (e.g. when we utter messages of one kind or another- oral, written, graphic, gestural, or even through body language).

Table 5: Definitions of Information

Knowledge

Contrary some notions that information is equivalent to knowledge (Fosket 1982; Liebeskind 1996), most authors believe that knowledge involves the application of cognitive (i.e. mental) processes to comprehend information and learn from the process (Wilson 2002; UNE 2004), and involves the ability to judge and interpret rather than having been told about it (Payne and Sheehan 2004) in order to become useful while others define it as 'true and justified beliefs (Choo *et al.* 2000; Nonaka & Takeuchi 1995).

Others go further by explaining that knowledge includes a blend of data and information that has been processed (Grey 2002), for example organised, analysed and reflected upon, using past experiences that are embedded in individuals' minds (i.e. knowledge is personal) (Terra and Angeloni 2002; Wilson 2002). Hence, because knowledge is personal in nature, it connotes that it is either impossible or more difficult to manage knowledge than data and information. Furthermore, Wilson also reckons that knowledge management is just a term used to encompass a variety of activities none of which are concerned with management of knowledge, and that these

activities are either concerned with the management of work practices or communication practice in order to simply enable information sharing.

Authors	Definitions of Knowledge
Knowledge as a cognitive (i.e. mental) inquiry process to comprehend and interpret data and/or information for future application using past personal experiences that reside in individuals' minds	
■ **Knowledge as an outcome of rational process of inquiry**	
Sheehan & Payne 2004	Knowledge is more than information It is actionable information. It involves more than just being told or having found the contents of documents and databases that exist in an organization. It is also about the ability to access the know-hows and experts to the information (i.e. it is about having the ability to judge and interpret the knowledge).
UNE 2004	Human understanding of a subject matter that has been acquired through proper study and experience. Usually based on learning, thinking and proper understanding of problem area.
Davenport K. 2002	Information endowed with application.
Spiegler 2000	Process of knowing, a reflexive process that takes data and information, in a social context, together with the factors (such as context, experience, basic truths, best practices, common sense, judgement, rules of thumb, values and belief, emotions, desires, and socialising into a culture), and generates new data, information, and/or knowledge. It either evolves or reverts to its raw material.
Davenport & Prusak 1998	Mix of experiences, values, insights, and contextual information.
Kock, McQueen & Corner 1997	Provides the basis for the prediction of the future with a degree of certainty based on information about the past and the present.
Maxwell 1984	Result of rational inquiry.
KIBDS 2006	Knowledge isn't contextualised information and certainly distinct from information. Knowledge is the basis of what you can, will, would, should, or might do with information.
Bellinger, Castro & Mills 2004	Represents a pattern that connects and generally provides a high level of predictability as to what is described or what will happen next.
Grey 2002	The full utilization of information and data, coupled with the potential of people's skills, competencies, ideas, intuitions, commitments and motivations.
Murray 2002	Body of experience and understanding of the processes for managing both planned and unplanned situations.
■ **Knowledge as personal true and justified beliefs such as understanding, perspectives and concepts, judgements and expectations, methodologies and know-how; coupled with the individual's skills, competencies, commitment and motivation**	
Gahran 2004	The human experience of information- it's what our minds do with all that content.
Wilson 2002	What we know: involves mental processes of comprehension, understanding and learning that go on in the mind and only in the mind.
Choo et al. 2000	Justified, true beliefs.
Alavi & Leidner 1999	Knowledge resides in a person's mind.
Spek & Spijkervet 1997	The ability to assign meaning.
Grant 1996	Involves both knowing how (generally more tacit knowledge) and knowing about (generally more explicit knowledge).
Nonaka & Takeuchi 1995	True and justified belief.
Wiig 1993	Truths and beliefs, perspectives and concepts, judgements and expectations, methodologies and know-how.
Fosket AC 1982	Knowledge is what I know.
Grey 2002	The full utilization of information and data, coupled with the potential of people's skills, competencies, ideas, intuitions, commitments and motivations.
Terra & Angeloni 2002	Resides only in one's mind. Results from human experience and reflection based on justified set of beliefs that are at the same time individual and collective.
Webster 1961	Clear and certain perception of something; the act, fact or state of understanding.
Others:	
■ **Knowledge is equivalent to information**	
Liebeskind 1996	Information whose validity has been established through tests of proof.
Davenport 1997	Valuable information from the human mind.
Russell Ackoff	Appropriate collection of information, such that its intent is to be useful. It is a deterministic process.
Quigley & Debons 1999	Text that answers the questions why and how.
■ **Knowledge as organisational routines**	
Nelson & Winter 1982	Organisational routines.

Table 6: Definitions of Knowledge

2.2.2.2   Discussion: The Relationships Between the Definitions

The Data-Information Relationship

From the above definitions, it appears that apart from several definitions of data as being "carriers of information and knowledge and as a means through which information and knowledge can be stored" (which elicits a connotation that these two are embedded in or form part of data, and that data is a primary 'tool or mechanism' or a 'medium', through which information and knowledge is shared and stored), and "expression of feedback" (which elicits a connotation that data is a statement or view regarding an observation), the majority concur that data is distinct from information.

Hence, for purposes of this research, the author defines information as the result of 'contextualising' data- in other words, data that relates to a given condition or situation, thereby giving the data meaning: e.g. project data: size, cost, location, and context: the history/background of the project such as its purpose, progress etc.

In other words, data cannot be analysed and interpreted appropriately and accurately if its context were not attached to it, and hence given neither meaning nor purpose. For instance, a project's financial reports that just states numbers and/or words would not provide sufficient context as to what that data refers to and/or how it was derived does not indicate the progress of the project in relation to its cost nor the reasons behind its cost status.

The Information-Knowledge Relationship

In contrast, the definitions for these two terms are not as distinct. As previously identified from literature, several authors equate information with knowledge and simply as organisational routines. The majority believe knowledge is a cognitive (i.e. mental) inquiry process to organise, analyse, reflect, interpret and understand information for future application using past personal experiences that reside in individuals' minds or as true and justified beliefs.

The author believes that knowledge can only reside (i.e. is embedded) in individuals' minds (i.e. heads) while data and information may reside outside individuals' heads in verbal (e.g. dialogues between individuals) and non-verbal forms (e.g. documents

residing in organisational technological systems) as well as inside individuals' minds. The former may be known as explicit data and information while the latter as tacit data and information.

In addition, there is a 'life-cycle' between data and information as against knowledge. For instance, (tacit) knowledge residing in individuals' heads, when converted becomes explicit data and information; while explicit data and information can only become (tacit) knowledge after they have been organised, analysed, reflected, interpreted and understood using past personal knowledge and experiences, skills, competencies, commitment, and motivation that originally resided in the individuals' minds. The new and previous knowledge acquired can then be applied to new situations, instances or in the case of construction firms, projects. After these knowledge has been applied (i.e. tested, and proven or disproved), the knowledge becomes the true and justified beliefs of the individuals.

2.2.2.3 Critical Dimensions of the Data-to-Information-to-Knowledge Process

Analysing, Reflecting and Understanding
Between both the above described relationships is a very critical cognitive and analytical process of reflecting and understanding that needs to exist to enable data to become information and for information to become knowledge.

For instance, if an individual searches for and finds or receives past and present data and information, the individual needs to use the existing knowledge that he/she already has in his/her head to organise, analyse, reflect upon, interprete and understand the data and information so that it becomes new knowledge. Once that is understood, the individual should then find relevance between their new and previously existing knowledge with their work instances or problems/issues that they would like to resolve or improve.

In other words, through this process, the individual would then add or modify the previously existing knowledge that resided in their head (i.e. new knowledge is synthesized). It is pertinent to note that only people who have the ability to understand the data and information they had received or retrieved will be able to produce

knowledge to take purposeful action (application) for a particular situation, instance or problem. Some may not be able to synthesize new knowledge at all.

Therefore, a certain portion of the information-to-knowledge conversion process is dependent on the individual's inert intelligence, capability and initiative to derive as much as possible from the data and information obtained, and apply it to a situation, instance or problem. A senior management staff from a firm expressed this most clearly: "Some people can glean more from a same data or information as compared to another. That is a personal capability- which means firms need to learn how to select the right people for the right jobs." The author believes this very important inert capability is that of wisdom.

Wisdom

It is evident, from *Table 7*, that most authors define wisdom as a personal ability to discern right from wrong, and make good judgements utilising the knowledge and experience they had accumulated.

Some authors further explain that acquiring wisdom very much depends not only an individual's level of experience but also on the individual's spirituality and passion (Bierly III, Kessler and Christensen 2000), and the use of consciousness to discern or judge right from wrong (Ackoff 1989).

That may explain why some authors opine that wisdom is found more evidently in older people rather than younger people (Matthews 1998), and that it is equivalent to the knowledge regarding the meaning and conduct of life (Kunzmann & Baltes 2003).

However, the author believes that the assertion that older people are wiser does not always hold true. Matthews did not note that older and/or more experienced people do repeat their mistakes despite their past experiences. This may because the individual had earlier made a mistake and had not rectified it while some simply may not wish to learn from their past mistakes and experiences at all or may have gradually become complacent and less humble as they get more experienced; and consequently continue to make the same mistakes or even aggravate them over the years.

The author believes that wisdom is a personal ability (skills, experience, spirituality and passion) and consciousness (ethics, morals and professionalism) to make judgements (discerning right from wrong, and good from bad) from the data, information and knowledge received or retrieved, and that wisdom is necessary for the processes of analysing, reflecting and understanding that occur between data, information and knowledge to effectively produce valuable information (from data) and knowledge (from information).

Authors	Definitions of Wisdom
Wisdom as an ability developed through experience, insight and reflection, to discern truth and exercise good judgment; sometimes known as a well developed form of common sense	
Webster 1961	Faculty of making best use of knowledge, experience, and understanding by exercising good judgement.
Bellinger, Castro & Mills 2004	Embodies more than an understanding of fundamental principles embodied within the knwoledge that are essentially the basis for the knowledge being what it is. Wisdom is essentially sytemic.
Bierly, Kessler & Christensen 2000	The ability to best use knowledge for establishing and achieving desired goals and learning about wisdom as the process of discerning judgements and action based on knowledge.
Beck 1999	The awareness used by the self to relate successfully to the environment: comprises both knowledge (understanding the truth) and action (doing what is good).
McClean & Staughton 1996	Asking the right questions
Rothberg 1993	Taking the right actions
Sternberg 1990	Reasoning ability, sagacity, learning from ideas and environment, judgement, expeditious use of information, perspicacity
Maxwell 1984	Wisdom includes not only knowledge but also 'judgement of value'…to help us devise better ways of living, better institutions, customs and social relations
Edwards 1972	A demonstration of sound and serene judgement regarding the conduct of life; includes holding justified true belief but also having the intellectual grasp and insight to practically apply it
Ackoff 1989	Process by which we use our levels of consciousness to discern or judge between right or wrong, good or bad. It has elements of human 'consciousness' such as morals, ethics etc (which also depends on our souls and what we think in our hearts and minds). Technology can never substitute humans in terms of their wisdom. Neither can machines or technology have souls.
Other definitions	
Sternberg 2004	Application of intelligence and experience as mediated by values toward the achievement of a common good through a balance among intrapersonal, interpersonal and extrapersonal interests, over the short and long terms, to achieve a balance among adaptation to existing environments, shaping of existing environments, and selection of environments.
Kunzmann & Baltes 2003	Knowledge about the meaning and conduct of life.
Matthews 1998	A matter of mindset, more likely to be found in older rather than younger people.

Table 7: Definitions of Wisdom

2.2.2.4 Summary: Key Characteristics of Data, Information, Knowledge and Wisdom

From earlier discussions, the author has posited that data is simply raw and discrete facts while information is data that has been contextualised, and knowledge is information that has been organised, analysed, reflected upon, and understood by individuals.
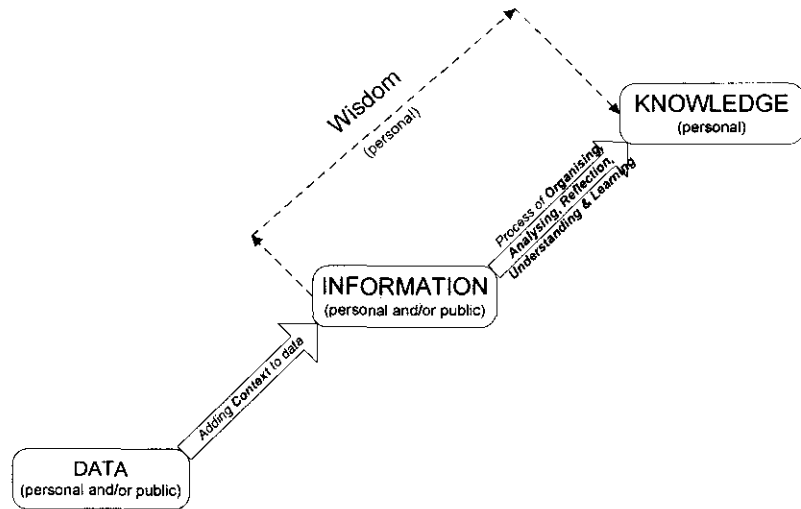
Figure 2: Relationship between Data, Information, Knowledge and Wisdom

Level:	Data	Info	Knowledge	Wisdom
Definition	Raw and discrete facts	Data that has been contextualised	Information that has been organised, analysed, reflected upon, and understood	Inert ability and consciousness of an individual to make sound and insightful judgements
Process	Accumulating truths	Providing the context: giving data its form and functions	Analysis and synthesis of information	Discerning judgements and taking appropriate action
Outcomes	Memorisation/Storage	Providing the context for Comprehension	Understanding	Better living
Characteristics	Factual without context- relates to past	Descriptive (data with context)- relates to past and present	Predictive- relates to ability to predict future with degree of certainty	Action for a common good
Level of Human Participation	Just facts- no human participation	Human participation with no clear action yet.	Human participation with action.	Personal intellectual capability (sometimes also known to be dependent on the individual's spirituality and passion)

Table 8: Key Characteristics of Data, Information, Knowledge and Wisdom

In addition, information itself is unable to provide individuals with the ability to apply in future situations/circumstances. Instead, an individual's existing knowledge aided by his/her wisdom and intellect are required to organise, analyse, reflect and understand the information, learn from it and produce/create new knowledge. This newly created knowledge when combined with the individual's existing knowledge becomes his/her current 'stock of' knowledge that can then applied to a situation or circumstance (be it to take an appropriate action or to resolve a problem).

Also, data and information relates to 'things' that had previously and/or currently occurred while knowledge aided by wisdom provides individuals with the ability to

organise, analyse, reflect, understand, and learn from past and present situations/circumstances, and then make intellectual and discerning assessments and judgements for application in future situations/circumstances with a degree of certainty.

2.2.3 Information Management and Knowledge Management: Are they the same?

Having 'clarified' the terms data, information and knowledge, it is now logical to define the terms information management and knowledge management. This is because in the past most firms had adopted the management of information as a mode of managing the 'valuable' information they had at the advent of the computer age. It is necessary to clarify the terms to ensure that they are not used interchangeably.

2.2.3.1 Definitions

Information Management

Most literature defined information management as the organised and systematic management of an organisation's information resources; usually with the use of information technology (or system). However, some authors still synonymously associate information management with knowledge management (Nonaka and Takeuchi 1995; KM4DevWiki 2008; Choo *et al.* 1998). This relationship is further discussed in *section 2.2.3.2*.

Authors	Definition of IM	Characteristics
KM4DEV	Interdisciplinary field that focuses on information as a resource with an emphasis on collection.	Provides transparent and standardised access to information. Focuses more on tools and technologies to share knowledge.
Bouthillier & Shearer 2002	To implement and maintain information systems and places strong emphasis on information resources and technology.	Information management synonymous with the use of information technology.
Nonaka and Takeuchi 1995	Implies "explicit knowledge" as synonymous to "information".	Knowledge synonymous with information
Wilson 1989	Management of the information resources of an organization and involves the management of information technology.	Information management synonymous with the use of information technology.
Cronin 1985	To control systematically recorded information......	-
Choo, C.W. 1998	A key for sustaining knowledge creation and application in organizations, and should lead to the 'intelligent organization'.	-
Place & Hyslop 1982	Plans and activities that need to be performed to control an organization's records.	-

Table 9: Definitions and Characteristics of Information Management

Knowledge Management

Most of the literature defined knowledge management as either an entire process (or lifecycle) of managing knowledge ((e.g. creating, finding, using, sharing and organising knowledge (Payne and Sheehan 2004); creating, capturing, using knowledge (Davenport & Prusak 1998)) or a part of the process (e.g. capturing (Kontzer 2002); capturing and sharing (Burk 1999); sharing and using (KM4DEV 2008); and gaining (Wenig 2002) knowledge.

Some others defined it as the ability to manage (Serhius 2002), the management and flow of (O'Dell *et. al.* 2003; Tiwana 2001; Sveiby 2002), and quality of (Terra & Angeloni 2002) information while others defined it as the process of converting data to information to knowledge (Kanter 1999), the facilitation of communication between people via verbal dialogue instead of technology (Krogh, Ichijo & Nonaka 2000), and the infrastructure for managing databases (Anthes 1999).

Authors	Definition of KM
Predominant:	
Knowledge Management as a process of capturing, sharing, creation and utilising of knowledge to sustain an organisation's competitive advantage and/or improve its performance	
Palmer & Platt 2005; 10	"harnessing and applying all the knowledge in an organization which describes the process of creating, finding, using, organizing and sharing knowledge; supporting learning.
Payne and Sheehan 2004	The way in which organizations create, find, use, share and organize knowledge.
CE 2004	processes which enable an organization to exploit the knowledge and learning of its people'.
Bouthillier & Shearer 2002	Focus of KM is neither on the distribution nor dissemination of knowledge but on its sharing.
ISC 2001	Explains that KM takes three forms: where it is results-oriented- "to have the right knowledge at the right place, at the right time, in the right format; where it is process-oriented- "the systematic management of processes by which knowledge is identified, created, gathered, shared and applied."; where it is technology-oriented- "business intelligence + collaboration + search engines + intelligent agents." - Level of emphasis/importance given to each of the 3 forms is different for different organizations. E.g. CPG- process, people, technology.
O'Leary 2001	Capture, access and reuse of information and knowledge using information technology.
Bassi 1997; Lank 1997; Zack 1999	Process of identifying/creating, capturing, and applying organizational knowledge to exploit new opportunities and enhance performance.
KPMG 1998	A systematic and organised attempt to use knowledge within an organisation to transform its ability to store and use knowledge to improve performance.
Broadbent 1998	KM is about enhancing the use of organizational knowledge through sound practices of information management and organizational learning; with the purpose of delivering value to the business.
Birket 1995	Bringing tacit knowledge to surface, consolidating it in forms by which it is more widely accessible, and promoting its continuing creation.
KM4DEVWiki 2008	Makes sense of information in the context of its users, and is concerned with the social interactions around the share and use of knowledge.
	About the way organizations create, capture, share, re-use knowledge to achieve organizational objectives. It is created in the heads of people, captured by putting on paper, into a computer system or simply being remembered. It is shared and then used, which then leads to more knowledge creation.
Swan, Scarbrough & Preston 1999	"...any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organizations."
	Knowledge management is not just/simply about developing, selecting, buying new tools and technology. It is about the processes in a company- it is about how information and knowledge flow within the company and how it can or will ultimately be used effectively and efficiently.
Newman 1991	'a collection of processes that govern creation, dissemination, and utilization of knowledge'.
Murray 2002	'the process by which knowledge seekers are linked with knowledge sources, and knowledge transferred'.
Bertels 1996	'the management of the organization towards the continuous renewal of the organizational

	knowledge base- this means e.g. creation of supportive organizational structures, facilitation of organizational members, putting IT instruments with emphasis on teamwork and diffusion of knowledge (as e.g. groupware) into place'.
Grey 2002	An audit of "intellectual assets" that highlights unique sources, critical functions and potential bottlenecks which hinder knowledge flows to the point of use; protects intellectual assets from decay, seeks opportunities to enhance decisions, services and products through adding intelligence, increasing value and providing flexibility.
Wenig 2002	Consists of activities focused on the organization gaining knowledge from its own experience and from the experience of others, as well as on the judicious application of that knowledge in order to fulfill the mission of the organization. These activities are executed by marrying technology, organizational structures and cognitive based strategies to raise the yield of existing knowledge and produce new knowledge. These activities concentrate on how to enhance the cognitive system (organization, human, computer, group, or community) in acquiring , storing, and utilizing knowledge for learning, problem solving, and decision making
Davenport & Prusak 1998	Process of creating, capturing, using knowledge to enhance organizational performance.
Davenport 1997	Process of capturing, distributing and effectively using knowledge."
Hibbard 1997	Process of capturing a company's collective expertise wherever it resides- in databases, on paper, or in people's heads- and distributing it to wherever it can help produce the biggest payoff. Knowledge management is getting the right knowledge to the right person at the right time.
CE 2004	as "the way in which organizations create, find, use and organize knowledge. The purpose of KM is to improve performance by making sure people can access and apply the right knowledge, at the right time and at the right place.
Burk 1999	Process of capturing and sharing a community's collective expertise to fulfil its mission."
BSI 2003	Creation and subsequent management of an environment which encourages knowledge to be created, shared, learnt, enhanced, organized, and utilized for the benefit of the organization and is customers."
Alavi & Lediner 1999	Systemic and organizationally specified process for acquiring, organizing, and communicating knowledge of employees so that other employees may make use of it to be more effective and productive in their work.
Newman 1991	Collection of processes that govern the creation, dissemination and utilization of knowledge.
Newman & Conrad 1999	"...a discipline that seeks to improve the performance of individuals and organizations by maintaining and leveraging the present and future value of knowledge assets."
Mahadevan, Braun & Chaczko 2002	A set of systematic and disciplined actions that an organization can take to obtain the greatest value from the knowledge available to it.
Bertels 1996	"management of the organization towards the continuous renewal of the organizational knowledge base- this means e.g. creation of supportive organizational structures, facilitation of organizational members, putting IT-instruments with emphasis on teamwork and diffusion of knowledge (as e.g. groupware) into place."
Birkett 1995	Bringing tacit knowledge to the surface, consolidating it in forms by which it is more widely accessible, and promoting its continuing creation."

Knowledge Management includes the management, flow and quality of information

O'Dell et. al. 2003	Emphasized that the focus of KM should be on getting the right information to the right people at the right time.
Tiwana 2001	Process of managing knowledge for creating business values and sustaining competitive advantage, and as a process of making creative, effective and efficient use of all the knowledge and information available to an organization for the benefit of its customers and thus the organization as a whole.
Holsapple & Singh 2001	Suggested a knowledge chain model that identifies and characterises KM activities for competitiveness.
Sveiby, K. 2001	'the management of information and of people'
Terra & Angeloni 2002	Focus should be on the richness and quality of the available information sources and the interpretive capacity of the employees, instead of increasing the quantity of information available. Two main concerns: provision of context for and validation of available information & increasing connections among people. KM is defined by the identification of peoples' expertise and the interplay of people with people (tacit knowledge sharing) and people with information systems (two way road of knowledge cpture, reuse and re-creation)
Sierhuis 2002	'the ability and the ways to manage knowledge'

Others:

Knowledge Management as the process of converting data to information, and from information to knowledge

Kanter 1999	Turning data (raw material) into information and from there into knowledge (actionable finished goods).

Knowledge Management as the facilitation of communication between people via verbal dialogue instead of technology

Krogh, Ichijo & Nonaka 2000	The facilitation of conversations locally and increasingly among people in different locations, and not the deployment of sophisticated technology. KM is about supporting conversations and supporting a humanistic perspective of work. Deeply ingrained in the values of the organization since knowledge in their opinion is justified true belief.

Knowledge Management as the infrastructure for managing databases

Anthes 1991	Policies, procedures, technologies employed for operating a continuously updated linked pair of networked databases."

Table 10: Definitions and Characteristics of Knowledge Management

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2.2.3.2 Discussion: The Information and Knowledge Management Relationship

Defining the Relationship Between Information Management and Knowledge Management

As previously mentioned, some authors associate 'knowledge management' closely with 'information management'. For instance, Nonaka and Takeuchi (1995), in the author's opinion, do not clearly differentiate between information and knowledge, and appear to regard "explicit knowledge" as synonymous with "information". In contrast, Krogh, Ichijo and Nonaka (2000) offered an interesting perspective (obviously built upon Nonaka's initial notion) that it is impossible to manage knowledge, and that the focus of knowledge management should not be the use of sophisticated information technology but supporting the facilitation of conversations and humanistic perspective of work.

The author believes that knowledge management is more encompassing than information management. While information management primarily focuses on the management of an organisation's information resources (and usually aided by information technology/systems), knowledge management takes a more holistic approach of managing what the organisation has with various initiatives (which includes information management, organisational structure/design and strategies, culture, communications, human resources as well as the alignment of organisational strategies with the KM initiatives). Hence, the former is more 'static' while the latter is more 'organic' and never-ending.

Modes of Managing Knowledge

KM may be perceived to be managed primarily in two modes. The first is that of the humanistic view which focuses on sharing, learning from and reusing of the experiences that lie in the brains of individuals in their field of expertise and practice through the use of tools such as communities of practice and post-project discussions-thereby connecting people-to-people. The second view places the emphasis on converting, encoding and capturing the knowledge residing in individuals' heads into organizational processes, procedures, documents, manuals for future reuse (via both information technology and non information technology means which obviously

includes the dependency of a robust information technology/system and/or infrastructure)- thereby connecting people-to-organisation.

The author believes that it is the first mode of managing knowledge that is harder or more difficult to manage as it often only surfaces through interaction between people at meetings and informal events (which requires people to meet face-to-face or virtually to discuss, and its dependence on the willingness of individuals to share what they know with others). However, both forms of KM are not mutually exclusive. Instead, different levels of emphasis on either or a combination of both modes would lead to the use of different tools, methods, and mechanisms to realise their benefits. For instance, where the emphasis is on connecting people-to-people via 'free-flow' exchange of ideas, knowledge and experiences between individuals, tools such as project-team meetings, informal discussions, and brainstorming sessions would be used. In contrast, if the aim is on connecting individuals to what the organisation has or 'knows', tools such as information technology/systems, procedures, manuals, standards would be employed to support the capturing of what the organisation and its individuals know. These modes of managing knowledge are consistent with the classification of KM approaches which recognize two broad classes of strategies: personalization and codification (Hansen et al. 1999). The personalization strategy, in recognizing the tacit dimension of knowledge, assumes that knowledge is shared mainly through direct interpersonal communication while the codification strategy assumes that knowledge can be effectively extracted, codified, stored and indexed in databases that allow easy retrieval of knowledge artefacts.

Regardless of the mode of managing knowledge chosen, for any tools, methods and mechanisms employed to manage knowledge to be effective in an organisation, it is pertinent that apart from a culture of openness, cooperation and willingness amongst staff to share what they know exists. It is also necessary to note that having a great variety of data, information and knowledge existing in an organization is useless if they are not of high quality, provide no added value to the organisation, and poorly structured and organised.

2.2.3.3 Summary: Key Characteristics of IM and KM
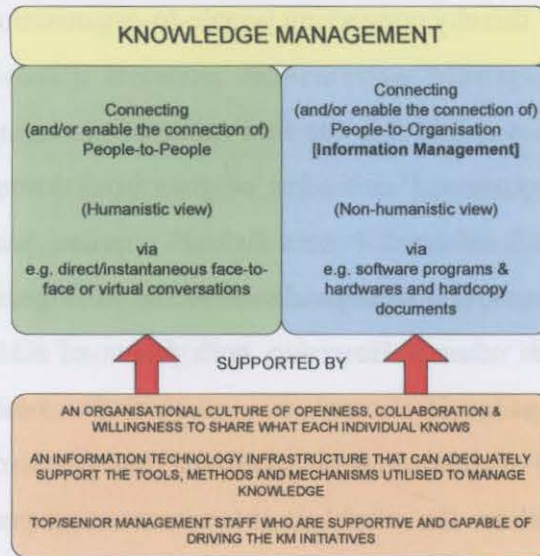
Figure 3: Relationship between Information Management and Knowledge Management

Essentially, while IM is primarily concerned with the retention and retrieval of data and information in an organisation utilising tools, methods and mechanisms that connect individuals to what the organisation has (non-humanistic view: aided by software programs, hardwares, and hardcopy documents etc. such as architectural and project management softwares and hardcopies of contractual documents), KM is more holistic in that it also considers and utilises tools, methods and mechanisms that connect individuals to what other individuals know in their heads/minds (humanistic view: aided by direct conversations between individuals such as informal or formal discussions and project meetings).

In addition, the author posits that the tools, methods and mechanisms employed by the organisation has to be supported by an organisational culture of openness, collaboration and willingness to share what each individual has and knows at all levels of the organisation, an information technology infrastructure that is adequately capable of serving as a 'platform' on which the tools, methods and mechanisms could be established, and a board level and senior management staff who are supportive to the KM initiatives.

2.2.4 Knowledge Management in Construction Organisations

2.2.4.1 A Review of Literature

Research into KM has grown significantly since its inception in the 1990s (Maqsood et al. 2007), and has been increasing steadily over the past 15 years (Loermans 2002-1990-1998; Wilson 2002). Since then, there has been an array of research areas or topics pertaining to KM across various industry sectors. They include discussions on whether KM is a new concept (Spiegler 2000); examining issues, challenges and benefits (Alavi & Leidener 1999); knowledge barriers (Nambisan & Wang 2000); strategies for KM (Earl 2001; Hansen, Nohria & Tierney 1999); integrating KM with information services (IS) strategies (King 1999) and business strategy (Drew 1999); factors influencing KM (Holsapple & Joshi 2000); best practices (O'Dell et. al. 2003); leveraging knowledge capabilities (Barquin, Bennet & Remez 2001; Gold, Malhotra & Segars 2001); technology support for KM (Bolloju, Khalifa & Turban 2002; Nemati et. al. 2002; Tiwana 2001).

Some of the authors have gone slightly further by identifying the key knowledge system elements of generic business enterprises (Chesebrough 2006); identified and divided knowledge tools into information, technology, and culture based tools, and the percentage of KM system with specific types of tools via a questionnaire survey at an executive development program held at a university (Alavi and Leidner 1999), and identifying the tools used and their objectives via a literature search on published materials of various organisations (agricultural and chemical products, pharmaceutical, computer, petroleum, agricultural and construction equipment products) that undertook KM projects (Bouthillier and Shearer 2002).

Generally, there appears to be a limited number of empirical studies in KM within the context of construction (Egbu et al., 2003). In addition, there is a lack of pragmatic work on KM in small to medium enterprises (SMEs) in the construction industry (Hari *et al.*, 2005).

Some of the journals and books that exist for KM for the construction industry include the compendium of papers written by various authors related to KM in construction by Anumba, Egbu and Carillo (2005); conceptual development of a methodology for

assessing whether construction knowledge processes are in place and the degree to which best practices are used as well as a framework for measuring knowledge management by Kululanga and McCaffer (2001); development of a prototype knowledge management model using case-based reasoning approach and a mechanism for the retrieval and reuse of knowledge for guiding CPS decisions by Ng, Luu and Skitmore (2005); a conceptual guide providing a step-by-step description on developing a structured argument for persuading senior decision-makers for the development of KM by Palmer and Platt (2005); how quantity surveying practices in Hong Kong and UK manage knowledge, and the processes and their inter-relationships in knowledge creation in multidisciplinary project teams (Fong in Love, Fong, and Irani 2005); knowledge management system for construction projects in Finland (Chong, Uden and Naaranoja 2007); knowledge management in construction: drivers, resources and barriers (2004); information technology perspective of KM for construction industry (Christiansson 2003; Lee, Lee, and Kim 2007); and the impacts of knowledge management initiatives in a Taiwanese construction firm via an in-depth case study (Kuo and Wu 2007); development of a conceptual framework for the analysis of deficiencies in contracting and the future of contracting (Hamzah and Berawi 2001); perception of KM in regards to the reasons for motivating staff to share knowledge generally and the percentage of staff acknowledging that KM as a potential to provide benefits to the organisation and the percentage of firms that currently have (or in future intending to have) a KM strategy, and the barriers to implementing KM via a generic survey questionnaire to 170 construction firms with an estimated turnover of over £50million (Robinson, Carrillo, Anumba, and Al-Ghassani 2001); development of a 'four-quadrant' knowledge management versus information technology framework eliciting the KM-IT type of Malaysian construction consultants, and identifying that the majority preferred the 'exclusive' information technology and 'explorative' knowledge to use specialised knowledge to support their highly technical IT skills (Amran et al. 2006); suggested the importance and potential of new advanced ICT and how the tools will in general support and influence building process models and its organisation (Christiansson 2003); the tools and techniques available for knowledge management (Al-Ghassani et al. 2005); and tools available for capturing and reusing of project knowledge (Kamara, Anumba & Carrillo 2005); inductive development of a framework for knowledge management systems, that claims to provide a means to explore issues related to KMS and unifying dimensions underlying

different types of KMS (such as balancing information overload and potentially useful content, balancing additional workload and accurate content, and balancing exploitation and exploration, examined the importance of KM to UK construction organisations, and identify the some of the resources used (but not exhaustively) and the main barriers to implement KM strategies (Carrillo *et al.* 2004).

However, none of the references above appear to have provided an in-depth study that could provide an organisation and its staff (who may either be intending to develop and implement knowledge management initiatives or improve their existing initiatives) with insights to identify and understand the specific tools, methods and mechanisms and their effectiveness (such as to learn across projects or across phases in a project, to resolve generic and recurrent versus specific and less-recurrent problems, the level of the organisation at which learning had been enabled to occur as a result of the tools, methods and mechanisms implemented) to manage what they have accumulated (be it data, information and knowledge).

2.2.4.2 Prevalence and Importance of KM in Construction Organisations

A multi-sectorial survey (with organisations from manufacturing, retail/wholesale, utilities and telecommunication, financial services and other sectors) conducted by KPMG Consultants 1998 revealed that 43% of organisations have a KM initiative in place, and one in ten considered knowledge management to be transforming the way they do business.

Similarly, a KM Research Report by KPMG in 2000 conducted with 423 organisations in the UK, mainland Europe and the US revealed that over 81% said they had or were considering a KM programme, 38% had a KM programme in place, 30% were currently setting one up, and 13% were examining the need for one.

The state of KM was, however, different in Australia. The majority of interest in KM is targeted towards large multinational organisations which only contributes 0.1% of total construction businesses employing significant numbers of staff in Australia (Abs, 2007). The remaining 99.9% of employing construction businesses in Australia is made up of small and medium enterprises (SMEs) (Abs, 2007) where Lee et al. (2005)

found there was little interest towards KM from SMEs in most industries, and even much less from construction-related SMEs.

These findings were consistent with the Australian Bureau of Statistics 2005-2006 reports which showed that on average only 13.4% of organisations in Australia had some form of organisational/managerial process innovation which included knowledge management processes to better use or exchange information, knowledge and skills.

	Employment size				
	0-4 persons %	5-19 persons %	20-199 persons %	200 or more persons %	Total %
- Organisational/managerial process innovation	9	20.1	26.4	^38.1	13.4
Knowledge management processes to better use or exchange information, knowledge and skills					
- Major changes to the organisation of work within the business (e.g. changes to the management structure or integrating different departments or activities)	3.8	13.6	22.8	^37.5	8
- Changes in relations with other businesses or public institutions (e.g. through alliances, partnerships, outsourcing or sub-contracting)	4.3	6.9	6.8	^19.4	5.3
- Other new or improved organisational/managerial processes	1.3	1.4	2.3	1.1	1.4
- Any organisational/managerial process innovation	14.3	29.6	42.3	^55.0	20.7
- No organisational/managerial process innovation	85.7	70.4	57.7	^45.0	79.3

^estimate has a relative standard error of 10% to less than 25% and should be used with caution

Table 11: Implementation of Knowledge Management Processes in Organisations [Source: (ABS, 2005-06)]

Furthermore, although KM has been recognised by the construction industry, in general, for its reward on organisational success (since receiving increased attention in the 1990s)- in particular for its ability for leveraging organisational knowledge in order to deliver long-term competitive advantages (Chen and Mohamed, 2007), the existence of KM initiatives was still much less prevalent in construction firms (compared with the other industries) as they were often reluctant to invest in new initiatives or innovative approaches citing low profit margins often militating against investment in research and development as well as their strong resistance due to a variety of factors including its cultural practices. For instance, an earlier study of major construction contractors shows a disappointing low proportion of firms have or plan to implement knowledge management systems (McConalogue 1999).

Nevertheless, the need for the adoption of KM practices or initiatives is even more so important and true in the construction industry which is known for its highly competitive nature, primarily because building projects are becoming increasingly complex, with budget and time constraint. This is further exacerbated by the reduction in the size of the work force, early retirements and increasing mobility of work force (e.g. increasing staff turnover) in an organization. This often led to the loss of valuable knowledge residing in individuals, and hence the need to search for new ways to retain that knowledge residing in the individuals' heads within an organisation via technological means.

These advantages have been attested to by various authors. For instance, Marques and Simon (2006) found that firms which adopted knowledge management practices obtained better results than their competitors while the KMPG KM research report 2000 showed that improving competitive advantage was the most significant role of KM. In addition, construction organisations are more likely to be successful in implementing KM practices when consideration is provided towards strategy formulation, implementation issues and the link between KM and business strategy (Robinson *et al.* 2005).

Hence, the author believes that there is a need to adopt knowledge management practices to not only ensure that knowledge and experiences accumulated by individuals within the organization are retained, shared, learnt and utilised within the organization (and to prevent what the individuals know from being lost from the organization) but, in particular, to enable its staff to learn (between each other) from their past projects and apply the lessons to future ones (cross-project learning). It is foreseeable that learning from each others' past successes and failures, and applying them to future projects would reduce or eliminate mistakes made in the past when managing new projects, and enable staff to improve what they had previously done, and improve their performances (i.e. it prohibits organisations from "re-inventing the wheel" which commonly occurs when members of an organisation are unable to refer to each other's work and subsequently, do not retain knowledge from previous experiences in order to prevent making the same errors on the next project (Boyd *et al.* 2004)).

For instance, when individuals make fewer mistakes or improve what they had previously done, they thereby improve their productivity and performances as well as their projects (e.g. less change orders made in the design and construction phases thereby reduces the cost of managing the projects or completing projects before or on the scheduled completion date). The improvement of the organisation's overall individual staff and project performances (in terms of profit and productivity) and their reputation would potentially provide them with a competitive advantage.

2.2.4.3 KM in Large Versus Small-to-Medium Construction Organisations

Furthermore, research in KM has predominately been directed towards very large multinational organisations with little involvement of SMEs, and much less towards construction-related organisations (Boyd *et al.* 2004).

The low prevalence of KM in construction SMEs may be due to several reasons.

Hari *et al.*(2005) found, via a pilot study, that SMEs generally have fewer resources, especially financial resources to contribute towards knowledge management initiatives while Carrillo and Chinowsky (2006) explained that it may be due to the poor awareness of the terminology 'knowledge management' and what constitutes 'knowledge' within SMEs, and Siemieniuch and Sinclair (2004) believed that it may be because organisations rarely take the time to evaluate whether they are in fact in a position to implement KM policies and procedures to manage knowledge adequately.

Irrespective of the problems above, SMEs represent a major business sector (99.9% of Australian construction businesses are SMEs (ABS, 2007)) in the industrial world, and it is recognised that they make a significant contribution to an economy's well being (Love and Irani, 2004).

Therefore, the author believes that there is as much or even greater need (than their larger counterparts) for SMEs to adopt KM practices or initiatives to ensure their competitiveness.

2.2.4.4 Need for Knowledge Management Transfer Between Projects

Knowledge that is not shared will neither be fully used nor applied, and may eventually be lost. Mistakes will endlessly recur because the company as a whole does not learn from them and the same problems have to be solved from scratch over and over again. Not sharing knowledge could mean continually 'reinventing the wheel' (ECKM 2008).

Learning past successes and failures is even more difficult for construction firms than those in other industries as construction firms differ from those in other sectors in several ways:

Firstly, construction firms are project-based and projects done are often unique in that each new development project done consists of different stakeholder requirements, specifications, contractual conditions, designs, construction methodologies which are dependent on site conditions, government legislative requirements- i.e. the perceived 'uniqueness' and complexity of construction projects.

Secondly, a traditional culture tends to dominate construction companies (which is 'not necessarily renowned for its quick uptake of new ideas (IKMC 2005; p.2) whereby some companies and individuals may be reluctant to take advice from outside, and may view their knowledge as something to be guarded rather than shared (Palmer and Platt 2005; p.7)- i.e. the 'protective' nature and lack of willingness of construction firms to share what they know with others.

Thirdly, often, an organization may or would be engaged in many projects simultaneously. Remembering everything that has been done and who has done what is not always possible. Furthermore, when an individual leaves the organization, he/she takes away a host of knowledge accumulated from their job and the projects which they had done/managed (i.e. the author believes that personal knowledge can walk out of the office door if not managed properly and adequately). Many experienced construction professionals also see knowledge as power and authority, and are reluctant to share it. People are also reluctant to learn from others as they may feel 'shameful' or embarrassed about revealing to others what they do not know. If

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these problems are not solved, firms risk losing knowledge as experienced individuals retire without passing on what they know.

Fourthly, construction projects are usually made up of teams which are often disbanded at the end of the project. Hence, project members have to constantly reinvent the wheel, constantly repeating 'similar' discussions and decisions. Also, constraints with human resources and cost have often forced employees to move straight from one project to the next, leaving no time to record, share and/or evaluate projects either during or upon completion of the projects. Especially where such tasks could not or are not charged/billed to the client, they were often sacrificed irregardless of how important they were to the organization (Palmer and Platt 2005; 8).

Therefore, if an organisation could capture or retrieve, share, reflect upon, learn from and reuse/apply their employees' knowledge and experience (and even create new knowledge), then the reciprocal relationship between employee and employer could be properly effected once a new person takes over from the person who had left the organisation or moved on to another project. For instance, taking the humanistic view, if an organisation could improve direct communication (be it face-to-face or virtually) between its employees, it would enable knowledge to flow freely between them and enable them to learn from each other's past knowledge and experience, and thereby improve their ability to manage projects.

2.2.5 KM Systems Versus KM Infrastructures

2.2.5.1 Definitions

The term knowledge management system is sometimes used narrowly to mean the information technology used in managing knowledge and even information (Davenport *et al.* 1998; Malhotra 2002; Alavi & Leidner 1999) (sometimes also known as information management systems) while some others consider knowledge management to include both knowledge and information (Huber 1991; Zack 1999), and that it is an information system designed to manage knowledge (notice the misnomer) (Alavi and Leidner 1999).

Hence, it is necessary to define the terms information management systems (IMS), knowledge management systems (KMS), and knowledge management infrastructures (KMI).

2.2.5.2 IM System versus KM System: A Discussion

Some authors defined KMS by eliciting the processes (acquisition, storage, distribution, and retrieval (Huber (1991); Zack (1999)); codifying, collecting, integrating and disseminating (Alavi and Leidner (1999)) involved in managing knowledge.

Others, however, took a different approach of defining KMS: Terra and Angeloni (2002) defined KMS as being more involved with the humanistic aspects of managing knowledge as well as focusing more on quality and richness, instead of information system which is regarded as being less involved with human aspects of managing knowledge and more about focusing on the quantity of information while Newman and Conrad (1999) regards it as tools that enable people to have access to tacit and explicit forms of knowledge.

Author	Definitions	
	Information Management System	Knowledge Management System
Malhotra 2002	-	Defined in terms of input such as data, information technology, and best practices etc.
Alavi & Leidner 2001	Processes information without engaging users	Helps users understand and assign meaning to the information- includes user participation.
Stenmark 2002	Dealing with information	-
Terra & Angeloni 2002	Less human centric	More human centric; focus more on quality and richness of information than on quantity.
Alavi & Leidner 1999	-	An information system designed to facilitate codifying, collecting, integrating and disseminating of knowledge.
Newman & Conrad 1999	-	Tools that would allow people to have access to both tacit and explicit knowledge of an organisation.
Huber 1991; Zack 1999	Hardware, software and processes that organisations utilise to facilitate communication and information processing	Firm-based network that enables acquisition, storage, distribution, and retrieval of knowledge and information.
Country Monitor 1998	-	Networked systems that show information and leverage knowledge throughout the enterprise and provide internet based access to customers and suppliers worldwide.
Davenport et al. 1998	-	The effect of knowledge management and manifested in a variety of implementations such as document repositories, expertise databases, discussion lists, and context specific retrieval systems incorporating filtering technologies.

Table 12: Definitions of Information Management System and Knowledge Management System

This appears, however, to be far from reality. The author believes that the word 'system' gives the impression that both the KMS and IMS are technology-centric. The only distinct difference is that the former 'system' is perceived to manage knowledge

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while the latter 'system' is perceived to manage information. However, technologically-speaking, a KMS cannot manage knowledge because knowledge has a personal connotation to it and (as earlier discussed) can only reside within individuals' heads/minds. Hence, a KMS (if regarded as technology centric) should either not have existed in the first place or had simply been inaptly named.

2.2.5.3 KM System versus KM Infrastructure: A Discussion

Having defined the difference between knowledge management systems and information management systems it is now necessary to a define knowledge management infrastructure from a knowledge management system.

As previously discussed, a knowledge management system infers that technological support serves as a primary basis for managing knowledge (as it had been used as the primary basis for information management). Hence, the author suggests that it is necessary to 'redefine' such a holistic 'system' of managing knowledge and call it Knowledge Management Infrastructure which includes management of not only the data and information resources that the organisation and its staff has via both non-technological (e.g. human centric means such as verbal communication and collaboration via meetings, informal discussions, and communities-of-practice) with the support of appropriate policies and procedures, as well as technological (e.g. information technology or systems which may include software programs such as project management, architectural drafting, and engineering softwares, and hardwares such as servers and computers) which provide the platform for the facilitation of converting tacit knowledge to explicit information and vice versa.

This infers a shift from a technology-centric system of managing just data and information (as earlier discussed, knowledge cannot realistically be managed technologically) to a combined and more 'balanced' non technology (e.g. verbal communication such as meetings, informal discussions, communities-of-practice) cum technology-centric infrastructure of managing data, information and knowledge that the organisation and its staff have accumulated- thereby eliminating the misconception that knowledge must always or is primarily managed via technological means.

2.2.6 Other Aspects of Knowledge Management

2.2.6.1 Types/dimensions of knowledge

Knowledge is generally taken to encompass both **tacit** knowledge and **explicit** knowledge.

Tacit knowledge is normally understood as that which resides in people's heads/minds; one that has a personal quality that makes it hard to articulate or communicate (or analogously, the knowing or deeply rooted know-how that emerges from action in a particular context). Marwick (2001) defines it as the knowledge of the knower derived from his/her experience and embodied beliefs and values.

Explicit knowledge, on the other hand, refers to the component that can disembodied, transmitted, codified and expressed as data and information (and represented by some form of artifact) in non-verbal forms such as databases, documents, video (which may be retained in technological and non-technological systems), and even verbally etc. (what we tell others). It is those which can be extracted from the knowledge holder and shared with other individuals- i.e. created with the goal of communicating with another person. In other words, explicit knowledge is somewhat a misnomer because once tacit knowledge has been converted to an explicit form, it becomes explicit information.

Therefore, the author believes that tacit knowledge that has been converted to an explicit form should not be called explicit knowledge but (at best) explicit information. Such explicit information once retrieved (from a technological system) by an individual or received verbally between individuals would require him/her to process (organise, analyse, reflect and understand) that information with his/her head/mind using his/her past knowledge and experiences to become new tacit knowledge once again. This newly accumulated tacit knowledge combined with his/her past knowledge becomes his/her current knowledge that resides once again in his/her mind.

2.2.6.2 Processes of Managing Knowledge

Predominant Typologies

It appears that there are two predominant typologies of defining the processes of managing knowledge in literature.

The first 'typology' appears to be that of a more simplified form of an act of 'doing' while the second appears to be that of using the mind to understand what has been found or shared.

In the first 'typology', for instance, within an information technology context, the focus would be on the use of the term 'store' and 'retrieve' to depict the act of 'retaining' something in and 'obtaining' something from an organisation's centralised technological repository while within a humanised context, the focus would be on the use of the term 'sharing' to depict the same act of 'obtaining' something from another individual.

In the second 'typology', information or knowledge is further processed: such as interpreted- through which information is given meaning and of translating events and developing shared understandings (Daft and Weick 1984), articulated- learning occurs by thinking, reflecting, discussing and confronting to produce symbolic representations and communication, understanding of action-performance (Prencipe and Tell 2001), codified- learning occurs by writing, implementing, replicating, adapting to produce codified manuals, procedures, processes (Prencipe and Tell 2001) or by organising, classifying, ordering, storing) (Boff *et al.* 2008), appropriation- by obtaining, interpreting, assimilation, internalisation, utilising to make a decision or resolve a problem or specific situation) (Boff *et al.* 2008).

Despite different authors defining the processes of managing knowledge in different ways, they are relatively similar. Each author simply uses slightly different or additional steps in the processes to explain what they mean by managing knowledge depending on the context of their discussion.

Huber 1991	Wiig 1993	Van der Spek & Spijkervet 1995	Alavi 1997	Holsapple & Joshi 1999	Burke 1999	Mercier-Laurent, Jakubczyc & Owoc 1999	Prencipe 2001	Boff 2000	BSI 2003	Sheehan & Payne 2004	Construction Excellence (CE) Apr 2004
Knowledge Acquisition	Create and source	Create	Create/Acquire	Acquire	Find/Create	Accumulating	Experience Accumulation	Generation	Create	Create/Find	Search
		Secure	Organize/Store	Select	Organize	Creating		Codification	Capture/Harvest	Organize/Store	Capture
Information Distribution	Compile and transform	Distribute	Distribute	Internalize	Share	Sharing	Knowledge Articulation	Dissemination	Prepare	Share	Articulate
Information Interpretation	Disseminate	Retrieve	Apply (Last item	Use	Use/Reuse	Application	Knowledge Codification	Appropriation	Share	Use	Apply
	Apply and		loops back to	Generate					Maintain		Learn
Organizational	Value		the first item)								
Memory	realisation			Externalise					Purge		

Table 13: Processes of Managing Knowledge

The author suggests that these processes be synthesised to those of acquiring: finding or searching, retrieving, and creating; codifying and memorisation: interpreting, organising and capturing/storing/retaining; articulation: sharing or transferring, disseminating or distributing or diffusing; and application: using or reusing. The author does not purport this process to be absolute but sufficient for the purposes of this research. However, for purposes of this research (especially for the survey questionnaires), the processes of 'capturing', 'sharing', 'applying', and 'creating' will be used.

The Knowledge Management Process: A Summary

Acquiring: Finding or Searching, Retrieving, and Creating

Finding or Searching, and Retrieving: These activities enable individuals to search for, or retrieve the knowledge they require to improve their work (e.g. reduce repeated mistakes made by others and oneself and reduces duplication of work)- i.e. learning from experiences and knowledge acquired from past projects etc.

However, because knowledge is tacit and resides in individuals' heads/minds, it has to be converted to explicit information for others to retrieve and obtain. Once the information has been obtained by an individual, the individual has to organise, analyse, understand and learn from it to become new knowledge. The success of this is dependent on the inert ability of individuals to develop new insights through the recognition of patterns between what they had retrieved and what (say a problem or situation) they need to resolve or apply to.

Creating: These activities are associated with the entry of new knowledge (e.g. principles and ideas) into the individuals' heads or technological system. It involves finding ways of generating new ideas and developing these ideas into workable solutions to problems. Knowledge is usually created by applying tacit knowledge into people's minds. The tools and techniques that support knowledge creation are usually ways of managing people and the way in which they react.

However, it is important to note that learning is not just a question of creating and/or acquiring more knowledge. It is both about taking a critical approach to the knowledge already possessed within the organization and about extending the knowledge base to what is currently not possessed by the organization.

Codifying and Memorisation: *Interpreting*, Organising, and Capturing/Storing/Retaining (*institutionalising*)

Interpreting: Understanding the tacit knowledge and converting it into explicit information using metaphors, analogies, examples and storylines.

Organizing: The activities involved in organizing the explicit information earlier converted from the tacit knowledge created by individuals. It includes filtering, cataloguing and creating links to the outside.

Capturing/storing/retaining: The explicit information are then stored in organisations using technological and non-technological tools, methods and mechanisms while tacit knowledge is stored in individuals' heads, so that they are preserved and allowed to remain within the organisation that is accessible and understandable to individuals.

Articulation: sharing or transferring, disseminating or distributing or diffusing, and learning- *integrating*

Sharing or transferring, disseminating or distributing or diffusing: This refers to the sharing or dissemination of individuals' knowledge for wide availability. These activities involve the flow of knowledge from one party to another (be it between individuals, groups or organizations). To ensure that knowledge is available to be re-used in an organization, individuals and project teams have to share what they know with others.

Learning: These include activities which can enable individuals, groups and the organization to understand, reflect or review the processes and experiences, and assess which parts could be better managed.

Application: Utilize (Use/Re-use)

This involves activities and events related to harnessing and applying the information and knowledge to address business problems and processes. Information and knowledge has no value unless it is consistently used in the right way, at the right place and at the right time.

Therefore, effective knowledge management is about the ability to not just harness information and knowledge, but also to organise, analyse, share and disseminate, create, and apply them, so that it can be used for future decision-making.

2.3   Knowledge Management (KM) versus Organizational Learning (OL)

2.3.1   The Confusion

According to Swan et al 1999, there has been an apparent decline in interest in the concept of OL since 1995, being offset by a sharp increase in enquires into KM. Some researchers believe that the concept of OL is not only being consumed or overtaken by KM (e.g. Davenport 1999) but also other emerging concepts such as business and customer intelligence, while others (e.g. Swan *et. al.* 1999) argue that the shift is linked to a sharp decrease in people management and development-related themes, and an increase in articles addressing information technology or systems and intellectual capital.

This segregation of OL & KM is apparent in the literature of OL & KM. Some literature on OL do not mention knowledge at all (e.g. Senge 1990; Malhotra 1996; Santosus 1996) while some only briefly mentions knowledge in passing but does not expand on the relationship (e.g. Addleson 1999; Schein 1997). On the other hand, some literature on KM do not mention learning at all (e.g. Davenport and Prusak 1998; Sveiby 1997) while some identify close relationships between the theories and practice of knowledge generation and learning (e.g. Allee 1997; Nonaka and Takeuchi 1995; Leonard 1998; Sierhuis and Clancey 1997).

Hence, some writers do recognise that there is critical significance in the relationship between learning and management of knowledge in an organisation while others do not

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seem to make any apparent attempt to link (or relate) them to each other. This could be due to the difference in origins of both concepts as well as the lack of literature on the synergies between the two. For instance, as previously mentioned, knowledge management is often associated with KM systems which gives a connotation that knowledge is managed via technological means while organisational learning is often associated with the process by which the organisation and its individuals learn how to improve their future actions using their past knowledge and experiences.

However, before an attempt is made to synthesize the concepts of KM and OL, it is necessary to first define individual from group and organisational learning.

2.3.2 The Need to Define and Delineate Individual Learning from Group as well as Organisational learning

Logically, we acquire or create new knowledge as a result of what we have learnt from what we have done. This is in line with Allee's (1997) view that each aspect of knowledge has a corresponding activity that supports it, and Wikstrom and Norman's (1994) view that knowledge (and competence) is acquired through learning, and that everyday learning is a natural and continuous process and often leads to the acquisition of tacit knowledge.

Conversely, after individuals have organised, analysed, reflected upon and understood what (data and information) they have found or obtained (converted from tacit forms (in the heads) to explicit forms (data and information), learning occurs. This is in line with Brown and Woodland's 1999 claim that learning is the process of acquiring knowledge. This means that at the individual level, the link between learning and knowledge processes are clear- they are cyclic in nature.

However, the OL and KM relationship between the individual, group (department or division) and organisational levels does not appear as clear. Von Krogh & Roos (1996) observed that "a firm's knowledge system consists of several levels being individual, group, department, division and corporate." while Sandelands (1999) and Prusak (1999) indicate that no matter how pervasive individual learning occurs in an organization, it is insufficient to constitute a learning organization.

The author believes that as individuals learn from their past experiences and create knowledge, the organization also needs to create a corporate architecture (or infrastructure) to not just facilitate learning at the organization level but also to develop knowledge retention, sharing and dissemination mechanisms across the organization. Essentially, at the division and organisational levels, the organization only becomes a learning organization when knowledge acquired or created by individuals have been captured/retained, systemised and utilised to the benefit of the entire organization and other individuals in the organisation.

Hence, an organization is a learning organisation if it is shows that it is characterised by generative learning tools and processes, and building and maintaining a climate that encourages everyday learning at all levels of the organisation as well as with formal education, as well as the management of knowledge (acquiring, sharing, creating, and applying) harnessed towards achieving organizational goals is the factors that gives an organisation the sustained and competitive advantage over their peers.

2.3.3   The KM and OL Relationship

Some authors believe that organizational learning is the process of gaining knowledge (Wilstrom and Norman (1994); Collier *et al.* 2005) and developing skills to empower organizational members to understand and thus act effectively within social institutions. Collier *et al.* 2005) further explains that KM is about ensuring that what is learnt by individuals within organizations is shared and utilised, and that processes exist to prevent knowledge from being lost to the organization. For instance, as an individual, everyday learning is a natural and continuous process that often leads to the acquisition of tacit knowledge (i.e. our knowledge is an accumulation of our experiences and what we have learnt from what we have done). Both, however, are concerned with the flow of knowledge (which is distinct from intellectual capital which is more concerned with reporting this stock of knowledge).

However, an organization that is effective in learning and managing knowledge must also consistently create knowledge and disseminate it widely throughout the organization, and also embody it in new technologies and products. Hence, organizational learning is more

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broadly based than intellectual capital as it focuses on the knowledge and understanding of cause-effect or action-outcome relationships, and sees the environment as a stimulus for learning.

For instance, creating knowledge, in particular, is a very critical process of knowledge management. It is not a matter of simply processing objective data or information. Rather, it takes into consideration and the importance of individuals 'tapping' the tacit knowledge of other individuals and often highly subjective insights, intuitions and hunches that resides in the heads of individual organizational members, and making the insights available for testing and use by the company as a whole (that is assuming individuals in the organization are willing to share what they know with each other).

In other words, there is a need to also examine the tacit element and the more often human resource aspects of KM that facilitate the willingness and openness of sharing knowledge between individuals (Davenport (1997). The human side of information and knowledge has largely been ignored due to a common assumption that all data, information and knowledge related problems could/would be solved by placing greater emphasis in IS/IT systems and the more prevalent focus on technological tools, techniques systems for managing knowledge (e.g. Sandelands (1999) reckons that capturing knowledge in a database or network around the organization would provide the rudiments of a knowledge creation and dissemination system (i.e. the KM process), and that the creation of in-company OL structures that build on or share this knowledge forms the beginning of a LO).

The author, however, believes that such a database or technological network system within the organization can only provide elements of knowledge capturing, storing, dissemination and sharing. It does not necessarily support nor are they relevant to the creation/generation and use of knowledge. In addition, it also does not necessarily support the occurrence of a learning culture within the organization. Swan *et al.* (1999) also identified this 'predicament' in that many articles continue to focus on developing and implementing KM databases, tools, methods and mechanisms with the basis of KM being the implementation of IT/IS for knowledge capture and sharing. By packaging KM as a

technology or as a data or information management system, it results in a loss of the richness of human relations. This view is also supported by Kleiner and Roth (1998) who believe that technology is not a critical factor to KM and that technology is the "easy bit" Macleod (1999) in the KMS development.

All in all, the author does not purport that technology is unnecessary but that the technological and non-technological (i.e. human 'relations') aspects to managing knowledge should be examined in tandem with each other, and that technology should be viewed as a supporter and enabler to better knowledge management (i.e. means to an end), and not as an end in itself.

2.4 The Theoretical Construct for the Research: Applying the Organisational Learning Framework to Understand Construction Organisations

2.4.1 Theoretical Grounding for the Research: Selection and Justification

The organizational learning framework proposed by Crossan, Lane and White (1999) has been selected as the theoretical grounding of this research for the following reasons:

First, it attempts to integrate the essence of the various forms of learning. It not only takes into account strategic renewal via the exploration (feed-forward flow of learning) of new ways of doing things resulting in organizational learning and knowledge generation but also the exploitation (feed-back flow of learning) of what the organization already knows or has already learnt. In other words, it acknowledges the tension between assimilating new learning (exploration) and using what has already been learnt (exploitation).

Second, the framework takes into account the interactions of individuals and the collective levels (individual, group, organization) of the organization in relation to the four inter-related learning processes (intuiting, interpreting, integrating, institutionalizing) through the feed-forward and feed-back flows of learning.

Third, it takes into account the mechanisms or repositories of learning in which stocks of learning reside (whereby the management of these stocks of learning in a firm is the

domain of knowledge management). It is necessary to differentiate organizational learning from knowledge management because 'organizational learning broadens the discussion to incorporate behaviours as well as knowledge and provides a means to understand how the 'stocks' change over time' (Bontis, Crossan and Hulland 2002; p. 440).

Lastly, the four learning processes of intuiting, interpreting, integrating, institutionalizing are based on multiple interactions of tacit and explicit knowledge.

2.4.2 Gaps in the Theoretical Framework

Despite having described many of the predominant concepts espoused in the earlier sections, there are still several inadequacies inherent in Crossan, Lane and White's (1999) framework that need to be addressed prior to its application in this research study.

First, the interactions of tacit and explicit knowledge as the basis of the four processes of learning are suggested by implication only. It is necessary to place these interactions into the theoretical construct.

Second, Crossan, Lane and White's (1999) construct does not elaborate how different project teams within an organization share their knowledge and experiences with each other. This may be because the framework was not originally developed with project-based organizations in mind as observed in: 'we use the term group learning to represent this process rather than the more commonly used term of team learning. In many cases, there are no teams but simply a group of individuals who struggle to develop a shared understanding' (Bontis, Crossan and Hulland 2002; p. 443).

Taking the context (project-based nature) of construction organizations into consideration, the author will attempt to address these two concerns by developing the following extensions to the theoretical construct. On the same note, the term 'project-team' will be used instead of 'group'.

2.4.3 Extending the Theoretical Framework: Placing Tacit and Explicit Knowledge into the Construct

In order to account for all factors that may affect an organization's learning environment in terms of the interaction between the individual and the collective levels of the organization, the author has attempted to account for tacit and explicit contributions by placing them into the theoretical construct (see *Figure 4*)

Intuiting- Tacit (Individual)

Intuiting relies on the process of developing new insights through the recognition of patterns based on an individual's competence and capability (i.e. technical expertise). For instance, an expert may be able to foresee a pattern in a problem (due to their experiential knowledge) that a novice may not. Therefore, the process of intuiting at the individual level primarily recognises tacit knowledge and expertise.

Interpreting- Explicit (Individual)

Interpreting is the explanation of individuals' insights through their words and actions by developing cognitive maps on the basis of each of their own technical expertise. The explanation may be in the form of metaphors, analogies, concepts, hypothesis or models. Since the process goes from the preverbal to the verbal, this process primarily exhibits explicit knowledge creation. This process however requires both motivation, and direction or focus for it to be effective.

Integrating- Tacit (Collective)

Integrating is the process of developing shared or common understanding amongst individuals, and taking coordinated action through mutual adjustments. Knowledge is shared via social interaction (such as via dialogue and story-telling) between individuals. Hence, this process is primarily associated with the creation of tacit knowledge such as shared mental models and technical skills. At the beginning, this process is usually ad-hoc and informal between individuals as they communicate their assumptions freely. However, the process becomes institutionalized once such collective actions that are (preferred by the group) taken recurs (i.e. becomes a routine).

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Institutionalizing- Explicit (Collective)

Institutionalizing involves the process of converting concepts into system knowledge by ensuring that routines are 'formally' embedded in the organization and where routine actions occur. It is where learning that has occurred in individuals and project teams become embedded into organizational institutions such as strategies, procedures, instructions, rules, structures, guidelines and systems (written and unwritten). As a result, tasks become defined, actions specified and organizational mechanisms put in place to ensure that certain actions occur; thereby exhibiting the conversion of tacit knowledge (from the integrating process) into explicit knowledge.
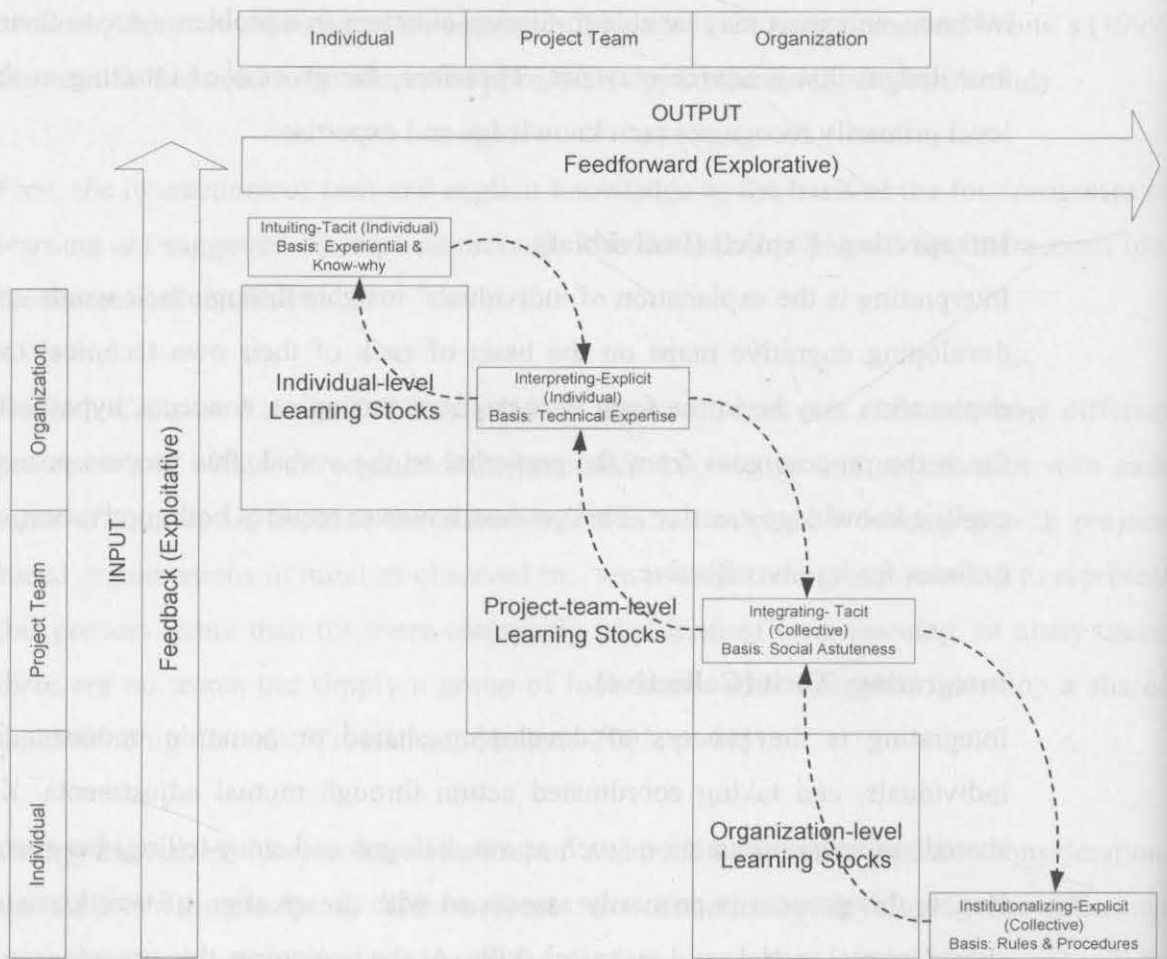
Figure 4: Extended Organizational Learning Framework
(adapted from Crossan, Lane & White 1999, and Bontis, Crossan & Hulland 2002)

2.4.4 Extending the Theoretical Framework: Adding a 'Horizontal' Dimension to the Construct

As previously highlighted, Crossan, Lane and White's (1999) framework may have been developed for application to non project-based organizations, and has to be further extended to be appropriately applied to the context (project-based nature) of construction organizations.

Based on Crossan, Lane and White (1999)'s original framework, the 'flow' of learning would be 'vertical'; where for learning to occur, knowledge would have to flow from one level of the organization to the next (see *Figure 5*). In other words, for knowledge to flow from one level to the next, the previous level is a prerequisite. For instance, for knowledge to feed-forward from the individual level to the project-team level, it is a prerequisite for learning to have occurred at the individual level. Likewise, for learning to flow from the project-team level to the organization level, learning at the project-team level must have occurred. Based on the same principles, for knowledge to feed-back from the organization level to the project-team level, learning at the organization level is a prerequisite; and for learning at the project-team level to flow to the individual level, learning at the project-team level is a prerequisite.

The author is not suggesting that this process is inappropriate but rather able to be improved; particularly at the project-team level. For instance, based on Crossan, Lane and White's (1999) framework and due to the contemporary perspective of managing projects, tacit knowledge acquired at the project-team level (through the process of integrating) would only be shared between individuals within that particular project-team. This tacit knowledge would then be converted into explicit knowledge at the organization level through mechanisms such as information systems and subsequently becoming embedded and 'routinized' as part of the organization's culture. Consequently, a project-team may learn from the explicit knowledge that had been captured at the organization level by other project teams, and applying what they had drawn (and learnt) from the organization's explicit knowledge at the project-team level. The shortcomings to this process are that it is time-consuming as the knowledge shared with a project-team at the project-level has to be converted to explicit knowledge at the organizational level before it

can be 'retrieved' by another project-team and shared within that project-team. Furthermore, in construction, this process of learning is made even harder as project members are almost immediately 'transferred' to another project upon its completion, resulting in the formation of a new project-team for a new project (often) consisting of a different set of individuals. Project team members not only have to constantly draw (and learn) from the explicit knowledge at the organizational level but also to learn how to share this knowledge with different individuals as they move from project to project.
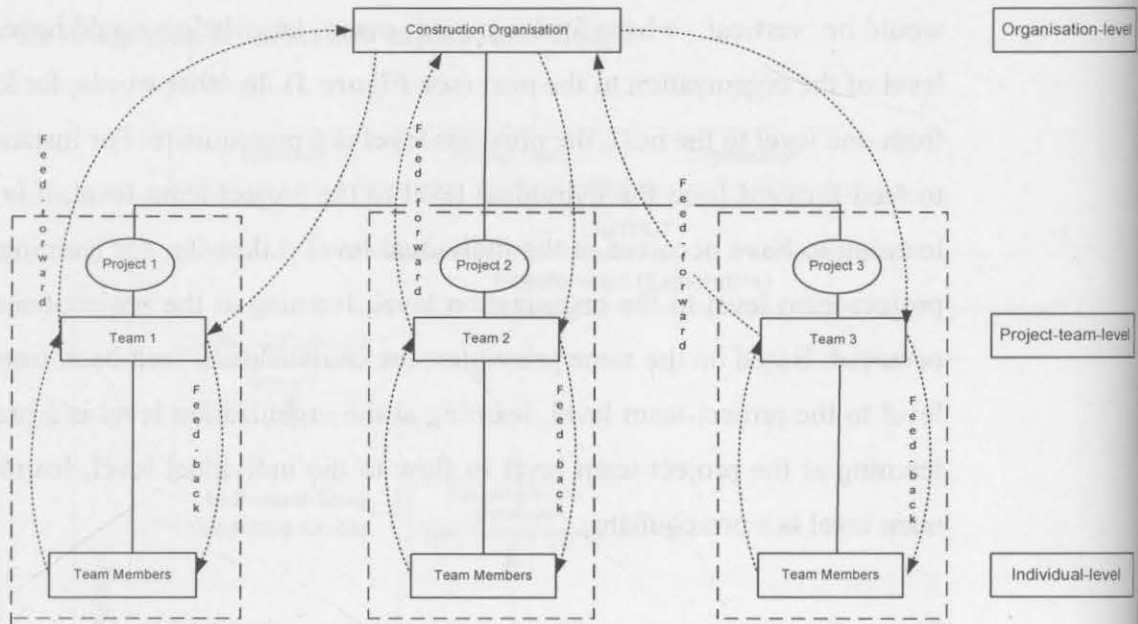
Figure 5: 'Vertical' Organizational Learning Based on Crossan *et al.*'s (1999) Framework
in the Context of Contemporary Perspectives of Project Management

This gap in the effectiveness and efficiency in the flow of knowledge can be narrowed by extending the construct to include a 'horizontal' dimension to the learning process (see *Figure 6*). For instance, when individuals from different project-teams are brought together, they share insights which they have developed based on each of their past experiences (tacit), form cognitive maps about the domains which each operate (explicit), share their interpretations with each other (tacit) to develop an understanding of the way each other operates (and in the process, identifying best or worst practices and its reasons), and converting what they have learnt tacitly into explicit knowledge through organizational mechanisms (e.g. information systems). In doing so, the 'horizontal'

dimension does not only facilitate the sharing of knowledge between members from different project teams more efficiently from each other but also attempts to break the contemporary mainstream perspective where projects are managed as distinct individuals. This implies that a project-team does not only have one route ('vertical') of 'drawing from' the knowledge of a different project-team (by 'retrieving' explicit knowledge at the organization level and converting it into tacit knowledge when members within a project-team share the knowledge amongst themselves) but would also be able to learn across different project-teams ('horizontal' route) at the project-team level.

The author suggests that the use of the extended organizational learning framework would assist in a better and more in-depth understanding of how learning along both these two dimensions ('vertical' and 'horizontal') of learning (instead of just one of either) would enable an organization to improve their learning capability and subsequently their project and organizational performances.
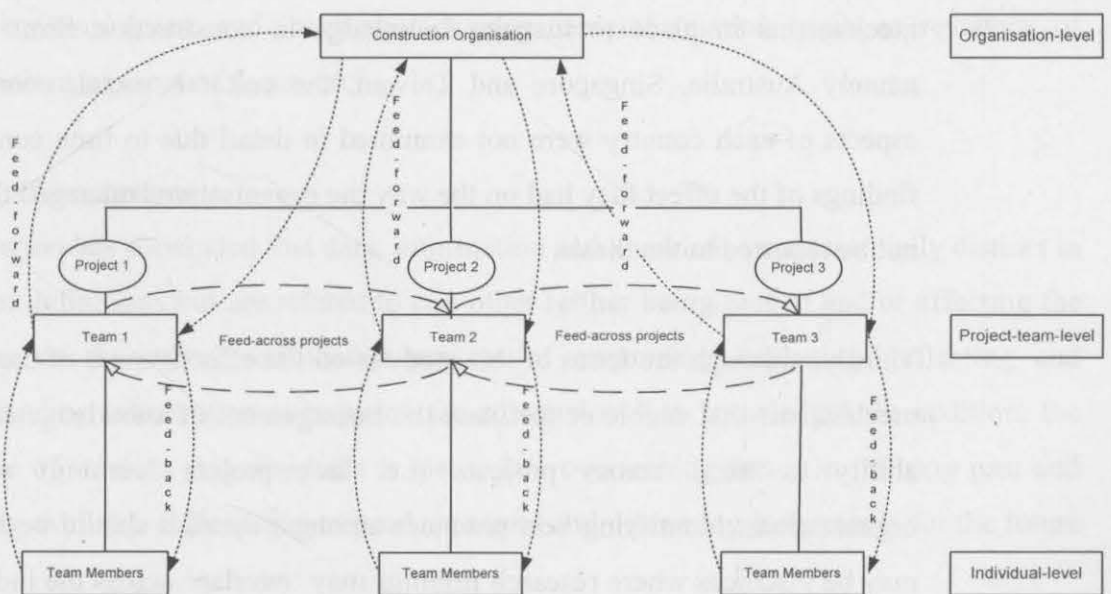
Figure 6: 'Vertical' and 'Horizontal' Dimensions of Organizational Learning

The proposed organizational learning framework (*Figure 6*) not only shifts the heavy emphasis of current literature on the learning of individuals towards a more balanced and holistic view of understanding and implementing learning practices at the individual, team

and organization levels ('vertical' dimension) but also provides a more efficient and effective route for enabling learning to occur across projects ('horizontal' dimension). It is hoped that the framework may serve as a platform for guiding project management researchers and practitioners to better conceptualize the true nature of organizational learning, and subsequently provide them with a clearer understanding of how the learning could be effected in their organization.

2.5 Limitations in Scope and Key Assumptions

The limitations of this research study are outlined below:

Firstly, due to the time and resource constraints of a PhD study, this study shall only focus on and address contemporary perspective no.1: **Individualistic (Unique and Temporal) Nature of Projects and Organizations (see *Section 1.1.2.1*).**

Secondly, although the primary aim of this research is to examine the tools, methods and mechanisms in place to manage knowledge in construction firms in three countries, namely Australia, Singapore and Taiwan, the cultural, social, economic and political aspects of each country were not examined in detail due to time constraints. Hence, the findings of the effect they had on the way the organisations managed their knowledge will not be reported in the thesis.

Thirdly, although the focus of this study is on the effectiveness of the tools, methods and mechanisms that enable or facilitate the management of knowledge and in particular, the ability to learn across projects (i.e. cross-project learning) within construction organizations, identifying best practices amongst them, it should be noted that that there may be instances where research findings may 'overlap' across the individual, project and organizational levels due to new issues or factors emerging during data collection from unexpected patterns or features which become evident only during the research.

The fourth limitation is concerned with the qualitative aspects of this research, in particular:

o The researcher needs to adopt a stance of neutrality with respect to the phenomenon under study in order to reduce or eliminate any bias towards the research findings. Hence, it is pertinent that the researcher does not influence the discussions or results. For instance, the researcher will only be an observer at project meetings and not as an active participant.

o Although the research enables the in-depth understanding of several cases and situations studied, it may result in generalization. It is therefore important to identify generic and/or specific themes, processes, procedures, categories that can be applied to other organizational settings.

o In order to avoid accusations of qualitative research being subjective, it is necessary to ensure that there is trustworthiness in the research through the use of audit trails, member checks and peer examination. For instance, the use of procedures to keep track of the research process which include process notes, methodological notes, observation notes, and instrument development information (such as revisions of questions or areas of focus, etc).

2.6   Conclusions

This section has concluded that data, information and knowledge are essentially distinct in terms of definitions but are related to one other (either being part of and/or affecting the outcome of the other, and that a process of organising, analysing, reflecting and understanding information is required for conversion into knowledge). In addition, the presence of wisdom in individuals is also a key overarching factor in utilising past and currently available information to produce sound and discerning judgements for the future.

The sometimes confusing and conflicting definitions of and distinction between information management and knowledge management as well as that between information management systems and knowledge management systems, and between knowledge management systems and knowledge management infrastructures have also been highlighted.

Essentially, IM only manages information resources thereby focusing on explicit information while KM is more encompassing as it manages what the organisation and its employees have (both explicit information and tacit knowledge) with various initiatives (which also includes IM, organisational structure/design and strategies, culture, communications, human resources and alignment of organisational strategies with KM initiatives). Furthermore, the use of the term 'system' in IM system and KM system gives an impression that they are both technology-centric where the only difference is that the former is perceived to manage information while the latter is perceived to manage knowledge- to which the author refutes that since knowledge only resides in individuals' heads/minds and is therefore personal, a KM system cannot manage knowledge (it can at best manage information). Hence, the term 'KM system' should either not have existed in the first place or it had simply been inaptly named. Instead, a more aptly appointed name for a 'holistic system' of managing knowledge would be 'KM infrastructure' which does not just include the tools, methods and mechanisms that enable the effective management of explicit information residing in the organisation but also those which effectively facilitate the conversion of tacit knowledge to explicit information and vice-versa.

Finally, this sections ends by asserting that although KM and OL are distinct in terms of definitions, there is a need for both to coexist and work hand-in-hand to ensure that organisations become learning organisations; and that although technology is a 'necessary evil' to support the management of information and knowledge, one should not neglect the non-technological (e.g. people-to-people/'humanistic') aspects.

3.0 RESEARCH METHODOLOGY AND PLAN

3.1 The Research Process

The purpose of the research process is to:

- Define the research strategy of this study in detail.
- Support the identification of issues underlying the selection of data collection methods.

The research process for this study has been outlined as follows:

- Research Philosophy
- Research Approach
- Research Strategy/Methodology
- Modes of data collection

3.1.1 Research Philosophy

This study aims to achieve a deeper understanding of the tools, methods and mechanisms and the complexity of their relationship in facilitating or enabling learning within a project and between projects in an organization. This involves an understanding of how individuals recognise patterns or possibilities (by *intuiting*), refine and develop intuitive insights (by *interpreting*), develop shared understandings through mutual adjustment within groups (by *integrating*), and establish formal rules, procedures, systems, structure and strategy within the organization (by *institutionalising*), and also how this process of learning 'feeds back' the other way around: from institutionalising at the organizational level down (through integrating and interpreting) to intuiting at the individual level.

Due to the nature of this research, the approach taken is both qualitative and quantitative. The qualitative aspect of the study lies primarily with the case studies to be conducted via direct observations and examining documentary materials (including knowledge management systems). The author was embedded in each firm for a period of two to three months in order to understand how knowledge and experiences are transferred between individuals in a project and between projects. The ontological and epistemological issues of this study can best be classified as an overlap between the positivism/post-positivism

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and interpretive/constructivist views. This is because, on one hand, when examining the organizational learning systems, structures, methodologies, and procedures in selected organizations to identify the better or best practices, it adopts an ontology that there are certain realities out there that can be known (for e.g. whether organizations have 'learning systems' or not, what types, how it functions). This affects the epistemology- since to obtain such information from organisations, it is necessary to develop and build a rapport with organizational members to gain their trust that the research data collected will be used in confidentiality and for the benefit of the field of project management. On the other hand, the study also attempts to understand how organizational members interact with one another within their project-based groups and the organization which includes: gaining an in-depth understanding of the organization's learning capacity- for e.g. how learning is transferred between/across projects within an organization. This adopts an ontology that there are socially constructed realities and one which values the participants' (i.e. the individuals and groups) interpretations of reality which is embedded in their rich context (e.g. the organization's ethnographic variables- such as organizational structure, social, political and cultural environments) that cannot be simply separated and generalised out to some mass population. This, however, does not mean that generic frameworks cannot be elicited from the various organizational contexts. Also, this ontology invariably affects the epistemology of this study (since knowledge emerges from achieving a deep understanding of the data and information and the context it is embedded in) by recognising the importance of objectivity (where the researcher needs to conduct the research in an objective manner) when conducting this part of the study.

Meanwhile, the quantitative aspects of this study lies in the analysis of numerical data collected via survey questionnaires from the potential respondents in the organizations completed by participating in the case studies.

Since data analysis might be able to deal with situations where behaviour is homogeneous and routine while observations are required to deal with creativity, innovation and context which may produce much more detailed information than what is available through data analysis, utilizing both case studies and statistical analysis would provide a more 'balanced' approach to the research.

3.1.2　Research Approach

The purpose of selecting an appropriate research approach is to enable the researcher to ensure that theory is aligned with the arguments in the research. The research approach taken for this research is primarily a combination of deductive and inductive reasoning as well as scientific methods and critical thinking.

This research follows a combination of deductive and inductive reasoning (i.e. a top-down and bottom-up approach). The deductive approach began when the researcher 'thought up' a theory about the topic of interest based on past practical experiences in the author's career as a project manager and quantity surveying manager as well as from an in-depth study of organizational learning and project management literature. Various hypotheses are identified and narrowed down to more specific hypotheses which the author believes would be reasonably possible to be tested during the course of a PhD study. This not only provides the researcher with a more specific focus but also as a guide to tackling the research problems. At the same time, in order to be careful not to be entirely 'tied-down' to the specific hypotheses that have been identified for examination, it is necessary to use specific instances or occurrences (e.g. from observations in case studies) to draw conclusions (patterns and/or regularities) about entire classes of objects or events where a sample (or samples) is/are observed and conclusions drawn about the population(s) from which the sample(s) comes (i.e. the inductive approach). These will be used to validate the hypotheses developed via the deductive approach. Should the hypotheses be found to be invalid, new hypotheses may be developed as attested by the research findings. This will be achieved via case studies (e.g. attending company, project and/or site meetings and analysis of documentary materials) as well as data collected from survey questionnaires.

It is also evident that the deductive and inductive approach has included the scientific method which allows the researcher to draw insight into the unknown by (a) identifying the problem that defines the goal of one's quest (b) positing a hypothesis, that if confirmed, resolves the problem (c) gathering data relevant to the hypothesis, and (d) analysing and interpreting the data to see whether they support the hypothesis and attempt to resolve the question that initiated the research.

The critical thinking method involves evaluating information or arguments in terms of their accuracy and worth. This involves in-depth studies through the following means: (a) evaluating past literature on the value of data and results achieved in terms of the methods used to obtain them and their relevance to particular conclusions (i.e. critical analysis of prior research) (b) assessing and identifying the various tools, methods and mechanisms identified in literature or used by organizations to manage what they know, and (c) determining whether and which of the tools, methods and mechanisms can be best used to manage what organisations know.

3.1.3 Research Strategy/Methodology

The research strategy is a general plan of how to go about answering the research questions that have been set. This study will begin with an in-depth study of the literature in project management, organizational learning and knowledge management in order to obtain a deeper understanding of the phenomena at play. Thereafter, a pilot survey is used to elicit perspectives from project management professionals in construction organizations to ascertain the need for such a research. Results from the survey will subsequently be used to develop protocols for case studies to be carried out in construction organizations which includes several different sources of information such as attending meetings (e.g. project or site meetings and an analysis of documentary materials (archival and current)) in order to gain an in-depth understanding (or 'workings') of how (and whether) learning occurs within a project and between projects as well as to determine if knowledge can be 'objectified' and 'grouped'. From results of case studies, an organizational learning development framework for knowledge management infrastructure for construction organisations will be developed and validated through surveys (questionnaires). Utilizing data from several or multiple sources allows 'cross-checking' and triangulation of data to provide a multi-dimensional profile of composing activities in a particular setting, and ensure that the research results are trustworthy. However, in the process of doing so, it is also important to check, verify, test, probe and confirm the collected data.

A summary of the research strategy (*Table 14*) has been formulated in accordance with the following perspectives in mind: research strategy; data collection methods; data collection instruments or processes; data sources; timing in terms of when the instrument

is administered; qualitative versus quantitative nature of data; and trustworthiness and continuity of data.

3.1.4   Modes of Empirical Data Collection

This research will involve not just one but several (i.e. multiple or collective) case studies. Case studies are well-suited for this research since the object of this study is the knowledge management and organizational learning 'systems' in construction organizations where interests are primarily in the organizational issues (e.g. the ability of organizations to learn, and the transfer of experiences or knowledge between individuals and group within an organization).

The research tools utilised for the empirical data collection in these case studies include survey questionnaires, personal interviews, direct observations (e.g. experience in organisational environments such as company and project meetings and discussions), and analysis of documentation materials (i.e. content analysis).

3.1.4.1 Survey Questionnaires and Personal Interviews

The purpose of survey questionnaires was two-fold. The first was to conduct a pilot study to elicit perspectives from project management professionals in construction organizations to ascertain the need for such a research. The pilot study concluded that there was a lack of cross project learning and hence an impending need to develop more robust infrastructures to support and enable learning to occur within project organisations. These results subsequently directed the development of the second survey questionnaires to address the above concerns. The second survey not only provided a substantial level of understanding of the context of each of the case study organizations (Robinson *et al.* (2005) found, but also identified and highlighted the strategies construction organisations could take to develop more robust infrastructures to manage their vast project knowledge and prevent "re-invention of the wheel". In addition, the survey enabled an in-depth understanding of the various dimensions of knowledge and its business context as well as addressed the questions listed in *Section 1.2.2* prior to the in-depth personal interviews/discussions.

Table 15 has been prepared to not only depict how questions in part one and two of the main survey questionnaires relate to and integrate with each other, but also to define the sequence of reporting the comparative analysis, findings and discussions of the three case studies' in *Section 4.0*.

Personal interviews/discussions, however, enable further or more in-depth information to be elicited from individual respondents which they may have withheld in written forms (as it may have been more 'formal' and hence the fear of repercussions) as well as further enhance, improve or include issues which have been missed out and 'discovered' during the survey questionnaire. On this note, it is pertinent to note that personal interviews/discussions provide the flexibility to elicit information which structured questionnaires often do not. A brief outline of the interview/discussion questions are in Appendix I.

3.1.4.2 Direct Observations and Documentation Analysis

As earlier highlighted, this study looks at construction organizations where the focus is the organizational learning aspects of the organizations in their natural environment (i.e. social, culture and politics of the organization). However, it does not involve in-depth ethnographic studies such as 'determining the culture of a group of people' nor to tell the whole story of a group's daily life or to identify its cultural meanings, beliefs and patterns of the group (which are the essential foundations of ethnographic studies). This study only seeks to take into the account the fact that when studying organizational learning aspects of organizations, one has to take into consideration these ethnographic 'variables' (i.e. social, culture and politics) which the organizations are in, as these variables may have an effect on the learning capability of organizations.

Hence, direct observations of the organisational environments of the case studies are employed to understand the context of the organisation; for instance, whether the organisation is collegial in nature (e.g. level of collaboration between divisions and between individuals), the perception of staff with regards to their work environment (e.g. whether they are satisfied with their work environment, welfare, and job security), the

level of communication and workflow between divisions and staff (e.g. whether staff are able to communicate freely with each other).

On the other hand, documentation analysis enables an in-depth study of the materials (whether hardcopies (e.g. documents in paper form) or softcopies (e.g. electronic documents existing in information technology softwares and hardwares) in order to not only corroborate the findings from the survey questionnaires and personal interviews but also become part of the overall research findings.

RESEARCH STRATEGY	QUALITATIVE & QUANTITATIVE STUDIES			
Main Hypothesis	Identification of the knowledge management tools, methods and mechanisms that are capable of enabling learning within and across projects within construction organizations, and whether it is more appropriate to standardise or customise the implementation of knowledge management tools, methods and mechanisms in different construction organisations			
Sub Hypothesis	The most regularly and effectively used tools in the case study construction organisations. The types of problems the various tools, methods and mechanisms have enabled organisations to resolve. Level of the organisation at which learning had occurred as a result of the use of the various tools, methods and mechanisms.			
Variables	Knowledge management tools, methods, and mechanisms. Regularity and effectiveness of use of the tools, methods, and mechanisms used Ability to learn within and across projects Ability to resolve different types of problems (generic and recurrent versus specific and less-recurrent) Level of organisation (individual, division/department, corporate)			
Construct	Theoretical Construct developed from literature review: Extension of theoretical construct first developed by Crossan, Lane and White (1999).			
Data Collection	**Case Studies**			
Methods/Instruments	Surveys	Interviews	Direct Observations	Documentary Materials (archival and current)
	Questionnaires	One-to-one interview and discussion	Systemic Inquiry Process / Observation Reports	Analysis of data and information relevant to study
Data Source	Survey returns from key organizational personnel	Transcripts of interviews and discussions	Embedment in case study organisations Informal discussions with organisational personnel Attend company, project and site meetings etc.	Collection of individual, project, and organizational material (e.g. project manuals and files, minutes of meetings etc.) - may exist in hardcopies (e.g. paper documents) or softcopies (electronic documents stored using information technology via mediums (softwares) within repositories (hardwares)
Research Questions proposed to be addressed in Section 1.2.2	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18	Q3, Q4, Q5, Q6, Q7, Q14, Q15, Q16, Q17, Q18	Q1, Q2, Q3, Q4, Q7, Q8, Q15
Purpose	**Pilot Survey:** Elicit preliminary data to support need for and protocols of case studies. **In-depth Survey:** As the primary mode of addressing the research questions.	As the secondary mode of addressing research questions in order to support and validate the findings of the survey questionnaire, and to elicit more in-depth perspectives from the respondents regarding some of their responds to the questionnaires.	▪ As the secondary mode of understanding the organisational environments of the case studies (e.g. whether the organisation is collegial in nature (e.g. level of collaboration between divisions and between individuals), the perception of staff with regards to their work environment (e.g. whether they are satisfied with their work environment, welfare, and job security), the level of communication and workflow between divisions and staff (e.g. whether staff are able to communicate freely with each other). ▪ To identify, validate and understand the tools, methods, and mechanism currently used in the case study organisations that enable/facilitate/support learning within a project and across projects as well as identify best/better practices.	
Content of data: Quantitative versus Qualitative	Primary: Quantitative Secondary: Qualitative	Primary: Qualitative Secondary: Quantitative	Primary: Qualitative Secondary: Quantitative	Primary: Qualitative Secondary: Quantitative
Data Analysis Tool	Quantitative Analysis using Microsoft Excel and Word, and systematically organising and analysing findings to identify and categorize specific observable characteristics and/or features.	Qualitative Analysis using by study the transcripts of the interviews.	Qualitative Analysis by systematically searching and analysing data (through inductive reasoning) to identify and categorize specific observable characteristics and/or features.	
When Administered	Pilot Survey: before final survey, direct observations, and documentation analysis In-depth Survey: after pilot survey, and during embedment in case study organisations	After In-depth Survey	After Pilot Survey	
			Before and during collection of documentary materials and in-depth survey	Before and during the course of direct observations and in-depth survey
Trustworthiness and Continuity	Triangulation Member Checks Peer Consultations/Examinations		Triangulation / Member Checks Audit Trails / Peer Consultations/Examinations	Triangulation Audit Trails Member Checks

Table 14: Summary of Research Design

Mapping of Specific Questions between Part One and Part Two of the Survey Questionnaires			
Part One (Overall)		**Part 2 (Detailed)**	

Part One (Overall)		Part 2 (Detailed)	
(A) Assessing the Context of Each Case Study Organisation and the Strategic Objectives of Each Organisation's Knowledge Management Initiatives			
Q.1 to 4	Understanding the Organisational Context	-	
Q.6	Purpose of the KM initiatives	-	
Q.7	Existence of Board-level Representation for KM	-	
Q.8	Substantial Top/Senior Management Encourage of KM initiatives	-	
Q.9	Initiators of KM Initiatives	-	
Q.10 & 11	Receptiveness of Staff to KM Initiatives & whether it is a key factor for the success for KM Initiatives	-	
(B) Effectiveness, and Performance Outcomes of the Tools, Methods and Mechanisms Currently Existing within Each Case Study Organisation to Manage Knowledge			
(B1) Tools, Methods and Mechanisms Currently Existing in Each Organisation for Managing Knowledge			
Q.5	3 Main Tools , Methods and Mechanisms currently existing in each organisation	Q.1	Specific Tools, Methods and Mechanisms currently in each organisation
(B2) Regularity of Use and Effectiveness of the Tools, Methods and Mechanisms Used for Managing Knowledge			
		Q.2 & 3	Regularity of use and effectiveness of specific tools, methods and mechanisms currently existing in the organisation that had enabled learning from one project for application in another
Q.12	Overall effectiveness of the KM initiatives in the organisation		
		Q.7 to 9	Perceived effectiveness of specific tools, methods and mechanisms which currently did not exist in organisation to enable improved sharing of past project knowledge and experiences
(B3) Performance Outcomes of the Tools, Methods and Mechanisms Used for Managing Knowledge			
		Q.4 to 6	Specific performance outcomes of the tools, methods and mechanisms currently existing in each organisation
Q.13	Performance Outcomes of the KM Initiatives (Improving performances at the individual, project and division levels) by examining the effect of the KM processes	▪ Q.4	Types of learning the tools, methods, and mechanisms had enabled respondents to experience: between projects within the organisation and/or between project phases within a project.
		▪ Q.5	Types of problems the tools, methods, and mechanisms had enabled respondents to resolve: generic and recurrent and/or specific and less-recurrent problems
		▪ Q.6	Level/s of the organisation at which learning had been experienced by the respondents

Table 15: Mapping of Specific Questions between Part One and Two of the Survey Questionnaire

3.2   Establishing Trustworthiness

Dependability

For case studies, protocols will be standardised so that the researcher goes into an organization looking out for the information he wants according to the protocol. However, it is necessary to note that often other data may arrive fortuitously. In order to ensure the dependability of the research method, specific criteria should be set out so that whenever subjective judgements are made, these criteria dictate what the researcher makes (Leedy and Ormond 1999).

An initial pilot survey is done to ensure that 'issues' or 'questions' that form the basis of subsequent case studies has taken the findings from the initial survey into consideration. This will progressively assure that 'issues' or 'questions' raised and results found from the case studies conducted will be aligned with findings of the surveys. *[See 3.1.4.1 regarding the influence the pilot survey had on the second survey]*

Credibility

In order to ensure that the research findings are the most likely ones for the observations they have made, the triangulation research strategy is used. Multiple sources of data are collected: from surveys, case studies, and documentary materials. This is to enable the identification of common themes from data collected via the various modes of data collection. These methods are meant to improve the credibility of the research. Also, to ensure confirmability, replicability, and reliability, audit trail categories would be used in the research. These include raw data, data analysis, data reconstruction and synthesis, structuring of categories and themes, and process notes. Findings from the study will also be validated via peer consultation (academics in this field of research) and member checks (key staff of case study organizations). Other strategies not employed in this research include prolonged data gathering in the field where the researcher will spend between one to one-and-a-half years in the case study organizations.

Transferability

To ensure that results from the research may be applied to situations beyond the context of the study itself and that the research findings can be drawn and generalized to other contexts, the research will utilise the following three strategies:

o The studies will be conducted in construction organizations. Studies of 'real-life' situations would be more valid in the sense that they yield better results with broader applicability to other real-world contexts' (Leedy and Ormond 1999). In addition, the methods of data collection would involve the participation of the researcher to observe and understand the organizations of study in their real-life contexts (e.g. in their own cultural, political and structural context).

o From the results of the pilot survey, organizations will be carefully selected for subsequent case studies in order to ensure that these organizations are representative of the construction organizations as a whole. For instance, depending on the results of the surveys, a few organizations may be selectively chosen from a list of organizations who claim that they do enable organizational learning to occur and a few organizations may be chosen from those who claim that they do not enable learning.

o The same set of surveys and case studies will be used in all organizations involved in the study. For example, the same set of 'questions' will be used for case studies in the different organizations (supposedly all with different cultural, social and political contexts). In order to ensure transferability of data, results from initial case studies would be recorded systematically and used to adjust (i.e. set up and refine) the protocols and 'issues' or 'queries' to be raised for subsequent case studies in different organizational contexts.

3.3 Ethical Considerations

The author's supervisor had been consulted on the ethical considerations in regards to the case studies to be conducted in the construction firms and it was affirmed that there was no involvement of ethical issues because the research conducted at the case study firms had been obtained through the author's own construction industry affiliations and contacts. The firms involved had accepted and adopted the questionnaires as part of their internal HR management systems in order to maximise the effectiveness of their own KM systems, and saw this as a way to improve their business performance. Thus the ethical responsibilities transferred to the firms. Furthermore, the author, being the only person able to identify respondents acts as a buffer between subjects and their employer ensuring respondents' anonymity.

Prior to the commencement of the case studies, senior management respondents (including the Chief Executive Officers, Presidents and Executive Directors of the firms etc.) had been made aware of the purpose and objectives of and consent obtained for the case studies to be conducted in their firms as well as the intentions and potential uses of the research analysis and findings. All respondents had also been assured that no information of a personal nature would be requested from respondents.

Furthermore, all respondents were given the option as to whether they wish to complete the survey questionnaires or not and to be interviewed (all questionnaires had been approved by the firms prior the commencement of the research) or not as well as whether they would like their interviews/discussions to be recorded or not. All who were surveyed and interviewed gave consent for the data collected in the case studies to be used as a consultancy for the benefit of helping their firms improve their current KM infrastructure and consequently their organisational performance.

In addition, the author had also signed confidentiality agreements with the firms affirming that any research findings arising from these case studies collected may be published on the condition of assuring the anonymity of the firms.

3.4 Summary

This section has detailed the methodology and plan for this research study where the primary mode of empirical data collection will be conducted via questionnaire surveys

and aided by informal interviews/discussions with respondents, direct observations and documentation analysis in order to triangulate the research data and findings.

4   Comparative Study of the Three Case Studies

The three case study firms were carefully selected by the author because of their repute in the industry and in accordance to their organisational sizes (small, medium, and large). The author had tapped onto his previous industry experience and network to contact the firms for potential collaborations on the research. In addition, the organisations believed that the research could potentially improve the way projects and project knowledge were managed in their organisations to better the strategic management of company operations. Hence, no major difficulties were experienced in obtaining the consent of the case study firms to conduct the study.

4.1   Structure of Reporting the Research Analysis, Findings and Discussions

The writer spent a considerable period of time (2 to 3 months) embedded in each of the case study firms as a member and observer of the management team. The data and information gathered and presented here was collected on behalf of the managements of the organisations involved who understood that the information was to be used in this study.

The research analysis and findings of the individual case studies utilised the survey questionnaires as the primary platform for eliciting responses while the personal interviews were used to verify the findings of the questionnaires. Whilst all of the questions have been analysed and discussed in detail, only the significant responses that assist the cross-cultural and cross-size comparison of the organisations are reported in this section. The bulk of the reporting, including statistical data, appears as *Appendix I* on the compact disc attached.

This section provides a comparative study of the three case studies firms. The comparison has been organised to relate the importance and effectiveness of the KM tools, methods and mechanisms utilised within the case study organisations (which includes their existence, regularity of use and effectiveness, and performance outcomes) to the context of the organisations as well as the impact of the KM initiatives employed by the firms on their ability to deliver projects, portfolios and programs, and the identification of the critical success factors of KM initiative and measures (key performance indicators) of knowledge management.

These are followed by *Section 5.0* which includes an assessment of each of the case study firm's current KM infrastructure and recommendations for improvement for each firm, as well as the provision of guidelines (based on lessons-learnt from the case studies) as to how a firm should develop, maintain and maintain a KM infrastructure which may potentially be applied to organisations that may already have a KM infrastructure or those who are intending to develop and implement one.

4.2   Context of the Organisations (refer to *Appendix A*)

Prior to a detailed comparative analysis of the results from the case studies in the following sections, provided below is a brief background of the case study organisations and the contribution of the construction industry to the Gross Domestic Product (GDP) in each the countries where the companies are located. The case study firms will be referred to as S (a small company), M (medium), and L (large).

Background of the Case Study Organisations

The small-sized Taiwanese construction company (Company S) with a staff size of approximately 50 (approximately half are professional staff and the remaining half administrative staff) has an annual turnover of approximately NT50 billion. Since its inception approximately 14 years ago, it has built an extremely strong local repute and is progressively building its base internationally. In terms of turnover (earnings), it is currently within the 'Top 50 list' of construction organisations in Taiwan. The average years of employment of the respondents in the construction industry was 13.62 years, and the average years of employment in this company was 4.84 years.

The medium-sized American multi-national construction consultancy company, on the other hand, has a staff size of approximately 17000 worldwide- of which the Singapore office comprises approximately 230 personnel and Australian office has 50 personnel. Both offices are primarily made up of most forms of engineering, project management, and finance professionals. The average years of employment of the respondents in the construction industry was 17.47 years, and the average years of employment in this company was 5.89 years.

Lastly, the largest firm (Company L) is a large private construction consultant corporation with a staff size of approximately 2000 (used to number 3000 several years ago) based in Singapore. The organisation has been in operation for more than 100 years and is primarily made up of 17 divisions- each division comprising staff from each different field of construction (E.g. Architectural division, Mechanical division, Electrical division, Civil and Structural Engineering division, Quantity Surveying division, Project Management division, and Facilities Management division). The average years of employment in the construction industry for all respondents was 30.71 years, and the average years of employment in this company was 9.4 years.

Construction Industry's Contribution to GDP in Taiwan, Australia and Singapore

The Taiwanese construction industry's average contribution to its GDP of NT$12,635,768 million was 2.25% (284,393 million) in year 2007 [based on current prices] (*NS-ROC 2008*). On the other hand, the Australian construction industry's contribution to its GDP of AUD 921,747 million in 2005/2006 (ABS 2008a) was approximately 6.7% (AUD 61,644 million) [no GDP data could be found for 2006/2007] while the Singaporean construction industry's contribution to GDP of S$243,168.8 million was 3.74% (S$9,083.9 million) in year 2007 (*SDS 2008*). As at May 2007, the Australian construction industry was the fifth largest employing industry and 9% (918,000 people) for year 2006/2007 of the total workforce (previous employment for year 2005/2006 was 876,000 people) (*ABS 2008b*). However, despite the comparatively much smaller contribution of the Taiwanese construction industry to its GDP against that of the construction industries in Australia and Singapore, it is evident that the construction industry plays a critical role in supporting and maintaining the economic stability of these countries.

4.2.1   Business Type

Analysis & Findings

Although engaged in the management of construction projects, all three firms were of different business types and size. The only distinct similarity between them was that they were largely productivity focused rather than creativity focused.

Discussions

It was interesting to discover that the firms were primarily productivity focused. Given the importance of project delivery in this industry, this could well be a generic trait of most project management organisations.

4.2.2   Business Priorities

Analysis & Findings

Five business objectives were identified by all three firms as their primary emphasis:

- cost of running either the project or firm;
- quality of product and services;
- client satisfaction and support;
- staff's work productivity; and
- sales and turnover

In addition, two firms (S and M) mutually included technological capability as their primary emphasis while only firm S included job security and business processes. Firm M included staff development, while only firm L included market share as their primary emphasis.

Amongst the business objectives that were identified by each firm as their secondary emphasis, staff creativity and innovation, staff satisfaction, and comfortable work environment were mutually selected by all three firms. In addition, firms S and M identified market share, firms S and M identified staff development, and firms M and L identified business processes and job security while only firm M identified cost to run the firm and only firm L identified technological capability as their secondary emphasis.

Furthermore, within firm L, senior management and professional staff only mutually agreed that cost to run the firm, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, and market share were their primary emphasis. They also only mutually agreed that staff creativity and innovation, staff

satisfaction and support, comfortable work environment, business processes, staff development, and job security were their secondary emphasis.

Hence, in firm L, there is a mismatch between perceptions of senior management and professional staff in regards to technological capability and cost of projects. Senior management believed that the organisation's technological capability was their primary emphasis and cost of projects was their secondary emphasis while professional staff believed that the reverse was true (i.e. this concurred with findings from personal interviews and discussions with professional staff who felt that the firm had insufficiently focused on the technological capabilities of the firm while senior management felt that they had sufficiently done so. In contrast, the former felt that the firm had sufficiently focused on cost of projects while the latter felt that the firm had not).

Discussions

It would appear that the primary foci of the firms were directed at the more 'tangible' aspects (i.e. on the outputs and 'external' aspects) of the firm such as productivity and client satisfaction rather than the internal aspects of the firm such as their staff, their development and 'welfare'.

However, there is a sub-theme of continuity of work-load in order to maintain the staff. This may be related to size of the organisations; the smaller firm appears to be taking a more 'paternalistic' view of their employees than the larger firms.

This was evident from the fact that firms S and M appear similar in largely focusing on the outputs and 'external' aspects of the organisation with a slight ('tinge' of) focus on their staff. Each had one people or 'internal' aspect as part of their primary focus: firm S had a primary focus on job security while firm M had a primary focus on staff development (these concurred with the general perspective or expression of 'happiness' with the majority of their staff as elicited via discussions). Both, however, did not place any primary focus on all the other internal aspects.

In contrast, firm L had placed their primary emphasis solely/entirely on outputs and no (not even one) primary focus on any one of the people or internal aspects. This

concurred with the perspectives of most staff that they were generally unsatisfied with the 'welfare' provided by the firm (in particular, job security).

Recommendations

It was clear that all three firms were seriously lacking in the people or 'internal' aspects and primarily focused on the outputs and 'external' aspects of the firm. Instead, firms need to be aware of the consequences for the lack of focus on the 'welfare' or well-being of their staff and what they would potential lose should they not find the appropriate balance between both aspects of the firm (e.g. staff turnover may be high, poor retention rates, and poor staff motivation and performance). Comparatively, of the three firms, the author predicts that firm L may have a much higher percentage of staff turnover than the other two firms.

More specifically, it appears that firm S needs to decide if they should focus on market share (the president believes, at the moment, that it is only necessary for the firm to strengthen their current market share), while firm M should consider if they should focus on building their market share (unclear on the different staff's position on this), business processes and secure work environment. It also appears that firm L needs to reassess their current position in regards to whether people aspects or the operational aspects are more important to them (and appropriately balance them) and the priorities of the objectives in both aspects of the firms and subsequently set goals to achieve them.

4.2.3 Views on the Strategic Role of KM in the Organisation

Analysis & Findings

The majority of the respondents in the three firms believed that KM is regarded in their organisations as a vital part of business strategy and that knowledge is widely recognised as the basis for the company's competitive position, and that it also acts a platform to enable staff to share knowledge gained from projects done by different staff, and not just as a tool for sharing knowledge.

It was also clear that since all respondents in this firm expressed their mutual belief in the above statement, firm M was the most collegial and clear in their understanding of the above,

Discussions

The author asserts that for KM initiatives to be successful, they must not 'stand-alone' from the business strategies of the organisation. The initiatives must not just be aligned with and form part of, but also drive the organisation's business strategy.

4.2.4 Views on the Existence of Tools, Methods, Mechanisms to Manage Knowledge

Analysis and Findings

The majority of the staff from all three firms believed that tools, methods or mechanisms currently exist in the firms to manage knowledge.

Discussions

The tools, methods or mechanisms used by organisations to manage knowledge come in various forms. It may be technologically or non-technologically orientated.

Furthermore, in discussions with respondents, there appears to be no consensus to the meaning of the term 'knowledge'. Some respondents equate knowledge with data and information. However, as previously asserted by the author, knowledge is different from data and information, and that tools, methods and mechanisms are only able to manipulate data and information. Fundamentally, knowledge can only reside in

individuals' heads. Data and information can only 'become' knowledge if they have been processed (organised, analysed, reflected upon, understood and learnt from). Even written accounts of things that had happened (i.e. experiences) in projects are only (explicit) data and information that had been converted from the knowledge that had (tacitly) resided within individuals.

4.2.5   Overall Purposes of the KM Initiatives

Analysis and Findings

The purpose of the KM initiatives in firms S and L are aimed at the centralisation of the pool of knowledge and experiences (although from discussions with respondents, it appears that what had been stored centrally were only data and information) while firm M appears equally split on the centralisation of the pool of knowledge and experiences and the facilitation of a sharing culture in the firm.

Discussions

It is surprising to find that the primary purpose of KM initiatives is largely the act of centralising what 'knowledge' the firm has, and not on all the other processes of knowledge management such as sharing/dissemination, retrieving, creation and application of 'knowledge' as well as the process of organising, reflecting, understanding and learning from the 'knowledge' that had been retrieved by individuals or shared between individuals. In addition, respondents expressed during discussions that they felt that often what was being centralised in the organisation (primarily via information technology tools) were simply data and information (at best project data and information), and not knowledge. They also reckoned that lessons-learnt accounts or stories within the context of a project (which often did not exist in the 'centralised pool') as being most potentially useful.

4.2.6   Existence of Board-level Representation for KM and Substantial Top/senior Management Encouragement

Analysis and Findings

The majority of respondents in firms S and M believed that although board level representation does not exist in the firms, there was substantial senior management

encouragement for KM initiatives. However, responses in firm L appear mixed: the majority of top management appears to believe that there was a board-level representation and that there was substantial top management encouragement while the majority of professional staff believed otherwise.

Discussions

In reality, there are no official Board level KM representations in firms S and M but does exists at the Vice-President (KM) level for firm L.

It was discovered that the majority of the professional staff in firm L were unaware of the existence of a board level representation. The author suggests that this could be due to the lack of awareness and/or 'promotion' of the existence and potential benefits of utilising staff initiatives or that the firm was simply too large and segregated (or 'fragmented') such that any 'awareness'/'promotion' programs could not be proliferated effectively.

4.2.7 Initiator of KM Initiatives

Analysis and Findings

It was clear that the KM initiatives in all three firms had largely been initiated by senior management (and at most, equally initiated by middle management).

Discussions

It appears that KM initiatives were usually top-down driven, and at best includes middle management. Professional staff usually followed the initiatives or orders given by higher management. This does not strike the author as unusual, as senior management (usually) has a responsibility to generate and administer internal routines and procedures in their company- of which KM would be one.

The author suggests that, most often, professional staff would not have the authority to initiate such a move because most official KM initiatives cost money (hence would require senior management to sanction such a cause), and senior management would usually equate such initiatives as issues that affect the management, costs, and finances of the firm.

4.2.8   Receptivity to KM Initiatives

Analysis and Findings

All three levels of the organisations have been relatively receptive to the KM initiatives: it was generally most receptive at senior management, and subsequently followed by middle and professional staff.

Discussions

The author believes that for any KM initiatives to be successful, all staff in the organisation must not only be receptive to the initiatives but also actively participate in them.

4.3   Regularity of Use and Effectiveness of the Tools, Methods and Mechanisms in Enabling Learning from One Project for Application in Another (see *Appendix B*)

Discussion tools

Analysis and Findings

Overall, *regular and irregular (ad-hoc) discussions between superior and subordinate* appear to have been most regularly used and effective in enabling learning to occur from one project for application in another. These were followed by *irregular (ad-hoc) and regular discussions between peers within the organisation.*

The regularity of use and effectiveness of formal (regular) discussions appears to exhibit a decreasing trend with size of firm, while ad-hoc (irregular) discussions appears to have been second most regularly used and effective in the small and large firms, and third most in the large firm.

The least regularly used and effective tool appears to be *discussion forums/boards placed on the intranet/extranet or another program*. This appears to contradict the norm that such tools would often form a critical part of an organisation's information technology systems and softwares (e.g. intranets) to propagate knowledge sharing between staff and projects.

Discussions

Respondents from the small-sized firm indicated (via informal discussions with the author) that *regular discussions between superior and subordinate* had been the most regularly used and effective tool in the firm because they were free to communicate directly with their superiors (in particular the President) regarding any issues (be it company, project and/or personal related); while those from the medium-sized firm indicated that although they prefer regular discussions with their superiors, it was often more convenient for them to have regular discussions with their peers as it was often difficult for them to 'reach' their superiors who were often difficult to 'locate'.

On the other hand, respondents in the large firm indicated that *irregular (ad-hoc) discussions between their peers*, as well as *between superiors and subordinates*, had been most regularly used and effective in their organisation because the firm was too large to the extent that it was often impossible to 'reach' someone or get everyone to meet on a fixed/scheduled basis for regular discussions to occur (i.e. the size of the firm was a hindrance to formal discussions occurring within the firm). Furthermore, there were approximately seventeen different divisions/departments within the firm with most divisions located on different levels/floors of the office building (there were, at most, only two to three divisions co-existing on a same level of the building) as compared to staff from the small and medium firms where all staff were located on a single level. This made communication between staff on a scheduled basis even more difficult because each division usually operated within their own 'domain'/'territory'.

During discussions, the majority of the staff also claimed they would like to use discussion forums/boards placed on the intranet to communicate with others. However, they were unable to use it regularly and effectively because they were often based on project sites or constantly on the move between sites. Many respondents indicated that if they ran into any problems on site, it would be much quicker (i.e. more convenient) for them to call someone whom they believed could promptly help them (instead of sitting down in front of a computer and putting up questions onto the firm's discussion forums/boards and waiting for an answer as most often people do not answer at all or take too long to answer as they are also very busy).

Meeting tools

Overall, *formal project-team meetings* appear to be the most regularly used and effective tool in enabling learning to occur from one project for application in another, followed by *management meetings,* and *directors' only meetings*.

Respondents in the medium and large firms felt that the most regularly used and effective tool had been *formal project-team meetings,* and followed by *management meetings,* and *directors' only meetings*; while those in the small firm felt that the most regularly use and effective tool had been *management meetings,* followed by *formal project-team meetings* and *director's only meetings*.

It was also clear that *directors' only meetings* had been the least regularly used and effective of the tools for all three organisations.

Discussions

From discussions with respondents and on personal observation, it was clear that the small firm had most regularly used *management meetings,* in preference to *formal project-team meetings*. This may be due to the earlier mentioned 'compact' structure/nature of the firm which allowed staff in the firm to directly communicate with their boss without any barriers.

Respondents from the medium and large firms also expressed in personal discussions that since it was often difficult to reach senior management or their bosses in their firms, they felt that it was easier, and more convenient and effective to use 'formal project-team meetings' since staff who were officially part of a project had an 'obligatory' requirement to attend such meetings.

Sessions/forums tools

Analysis and Findings

Overall, *brainstorming sessions* had been most regularly used and effective in enabling learning to occur from one project for application in another, followed by *information*

sessions, seminars, forums, talks, expert panels, project lessons-learnt sharing sessions, and *team building activities*.

Brainstorming sessions had been most regularly used and effective by respondents of the small and medium sized firms while it had been the second least regularly used and effective tool by those from the large firm.

Information sessions, seminars, forums, talks, expert panels had been the second least regularly used and effective tool in the small and medium firms, and the second most regularly used and effective tool in the large firm while the *project lessons learnt sharing sessions* exhibited an upward trend of having been the least, second most, and most regularly used and effective tool in the small, medium and large firms respectively.

Team building activities had been the least regularly used and effective tool in the medium and large firms, and the second least regularly used and effective tool in the small firm.

Discussions

The author suggests that staff operating in smaller firms may have more opportunities for staff to meet each other to brainstorm for ideas (e.g. for design and construction reviews).

From discussions with respondents in the firms, it was also apparent that *information sessions, seminars, forums, talks, and expert panels* had been much more regularly used and effective in the large firm than the small and medium firms.

Furthermore, staff of larger firms with more projects to be managed by each individual may have found it more difficult to meet up for *brainstorming sessions* due to their heavier workloads. Instead, *lessons-learnt sharing sessions* provided staff with the flexibility to attend them as and when they wish (i.e. scheduled in accordance with their availability).

Although *team building activities* were usually part of the human resource management's initiatives to build up rapport between staff, it was the least regularly

used and effective tool in enabling learning to occur from one project for application to another.

Project Review tools

Analysis and Findings

Overall, it appears that *informal verbal reportback/feedback sessions by employees to superiors* were the most regularly used and effective tools in the three firms. This was followed by formal post-project reviews (*project-reviews at the end of each phase of a project*, and then *formal post-project reviews*), and *meetings to discuss/evaluate completed project reviews*. Only the respondents from the largest firm had indicated that *formal post-project review*s had been least regularly used and effective.

Informal verbal reportback/feedback sessions by employees to superiors had been most regularly used and effective in the small and large firms while it had been the second least regularly used and effective tool in the medium firm. *Formal project-reviews at the end of each phases of a project* had been second most regularly used and effective in the medium and large firms, and second least regularly used and effective in the small firm .

On the other hand, while *formal post-project reviews* had been least regularly used and effective in the large firm, it had been second most regularly used and effective in the small and medium firms.

Clearly, the least regularly used and effective tool appears to be *meetings to discuss/evaluate completed project reviews*. It had been least regularly used and effective in the small and medium sized firm, and second least regularly used and effective in the large firm.

Discussions

The small and large firms preferred *informal verbal reportback/feedback sessions by employees to superiors* as compared to the medium firm which preferred *formal post-project reviews*.

Furthermore, those in the medium firm indicated the importance of both *formal post-project reviews* and *project-reviews at the end of each phase of a project* prior to that of *informal verbal reportback/feedback sessions by employees to superiors* while those in the small firm indicated the reverse. However, those in the large firm indicated the importance of the *informal verbal reportback/feedback sessions by employees to superiors* and *project-reviews at the end of each phases of a project* whereas *formal post-project reviews* were least important.

Manuals/Guidelines/Standards tools

Analysis and Findings

Overall, respondents from all three firms indicated that *project management manuals* and *quality assurance manuals* were the most regularly used and effective tools in enabling learning from one project for application in another while *best practices guides* and *lessons-learnt manuals* were the least regularly used and effective tools.

Respondents from the small and medium firms indicated that *project management and quality assurance manuals* were the most and second most regularly used and effective tools respectively while the large firm indicated the reverse.

All three firms believed that *best practices guides* and *lessons-learnt manuals* had been the second least and least regularly used and effective tools respectively.

Discussions

It is perverse to find that *lessons-learnt manuals* had been the least regularly used and effective tool in all three firms. By definition, these manuals are dedicated to knowledge proliferation within the organisation. One would wonder what the reasons are for the respondents' 'low regard' of *lessons-learnt manuals* (i.e. what is it that makes them so shunned?) as one would logically surmise that organisations and their staff would be most eager to learn from their past successes and failures to improve their future performances.

Human Resource tools

Findings and Analysis

Overall, it appears that *mentoring and apprenticeships* was the most regularly used and effective tool in enabling learning from one project for application in another. This was subsequently followed by *formal and informal rotation of people around projects*, and *work induction for new staff*.

Mentoring and apprenticeship had been the most regularly used and effective tool in the small and medium firms, and the second most regularly used and effective tool in the large firm. *Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc* showed an increasing trend from the small to medium to large firms in having least, second least, and most enabled learning from one project for application to occur in the respective firms.

Formal rotation of people around projects, functional departments, different job scopes etc had been second most, least, and second least regularly used and effective in the small, medium and large firms respectively while *work induction for new staff* had been second least, second most and least regularly used and effective in the small, medium and large firms respectively.

Discussions

It appears that *mentoring and apprenticeship* was more important in the small and medium sized firm than the large firm. Respondents from the large firm indicated that *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc* was most important to them but amongst the least important in the small and medium sized firm.

Formal rotation of people around projects, functional departments, different job scopes etc appears to have been much more regularly used and effective (second most and second least) in the small and large firms than the medium firm (least) while *work induction for new staff* had been much more regularly used and effective (second least and second most) in the small and medium firms than the small firm (least).

Computing tools

Analysis and Findings

Electronic message exchange and *intranets* had been the most and second most regularly used and effective tools in enabling learning from one project for application in another in all three organisations.

This was followed by *computer aided design programs, extranet, electronic document management system, electronic contract/procurement system, expertise locator, and electronic tender document management system.*

Although *computer aided design programs* had been the least regularly and effective tool in the large firm, it had been the third most regularly used and effective tool in the small and medium firms. *Extranet* exhibited an increasing trend in having been third least, fourth most and third most regularly used and effective while *electronic document management system* exhibited a decreasing trend in having been fourth most, fourth least, and third least regularly used and effective from the small to medium to large firms respectively.

Electronic contract/procurement management system appears to have been the second least regularly used and effective tool for the small and medium sized firm, and the fourth most regularly used and effective tool for the large firm while *expertise locator/people finder* exhibited an increasing trend in having been the least, third least, and fourth least regularly used and effective from the smallest to medium to large firm.

It was also apparent that *electronic tender document management system* had been the least regularly used and effective of the tools in having been fourth least, least, and second least regularly used and effective in the small, medium and large firms respectively.

Discussions

The author recommends that *electronic message exchange* and *intranets* be applied as the standard in construction organisations. Although *computer aided design programs* appears to be highly important in the small and medium firms but least important in

the large firm, they are often (still) necessities for most architecture, building and construction related organisations.

All the other tools should be applied (using the above findings as a platform) according to the context of each organisation by taking into consideration and conducting an analysis of the way the organisation works or is being run (e.g. its culture- collegiality and culture of sharing, structure, characteristics of people employed, and even the spatial and physical layout of the organisation).

4.4 Performance Outcomes

4.4.1 General Performance Outcomes

4.4.1.1 Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge as Measured by the KM 'Process'

KM 'process'	Firm S (Taiwanese)	Firm M (American)	Firm L (Singaporean)	Average
Capture	76.92%	61.90%	76.04%	71.62%
Share	73.08%	78.57%	71.88%	74.51%
Apply	63.46%	64.29%	44.79%	57.52%
Create	61.54%	39.29%	33.34%	44.72%
Average	68.75%	61.01%	56.51%	

Effectiveness of the KM Initiatives
by KM 'process' for each Firm

Most

↕

Legend   Least
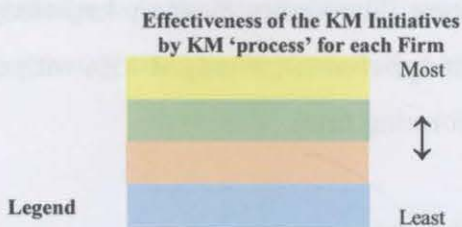
Table 16: Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge as Measured by the KM 'Process'

Method of Measuring the Effectiveness of the KM Initiatives
in Managing Knowledge

For each firm, the response rates for the effectiveness of the KM initiatives employed to manage (capture, share, apply and create) knowledge at each level of the organisation (individual, project, division, corporation) were first tabulated from the survey responses- these are available in the detailed analysis in *Appendix I*.

These were then averaged to derive the overall response rates for each of the process (capturing, sharing, application and creation) of managing knowledge.

These were then tabulated into *Table 16* which depicts the effectiveness of each firm to capture, share, apply and create knowledge respectively, and the overall effectiveness to manage knowledge as an organisational entity (averages on the x-axis) as well as the effectiveness of the initiatives to capture, share, apply and create knowledge in each firm (averages on the y-axis).

It is also important to note that these tools can not only be used to measure the effectiveness of firms to manage knowledge, but also as benchmarks from which a firm could constantly monitor and improve its own performance (internal benchmarking) as well as in comparison with other firms (external benchmarking)- provided all firms are subjected to the same measures and that they are comparatively monitored.

Analysis and Findings

All three firms rate well in their ability to *share* knowledge with around an average of 75% with only small variances between them: i.e. a mere 6% between best and worst performing. Whilst the average for *capturing* knowledge was high (72%), there is a 15% variance between the best and worst. The ability to *apply* knowledge averaged 58% with a variance of 20%, and knowledge *creation* averaged 45% with a variance of 29%. Overall, there is no clear best performing firm.

Discussions

As previously mentioned, all three firms appear to indicate that the KM initiatives employed in the firms had been consistently and substantially effective in enabling the respondents to *share* knowledge (73.08%, 78.57%, and 71.88% in the small, medium and large firms respectively).

However, respondents in the small and large firms indicated that the initiatives had been much more effective in enabling them to *capture* knowledge in the small and large firms (76.92% and 76.04%) than the medium firm (61.90%). It also appears that

respondents in the small and medium sized firms indicated their KM initiatives had been much more effective in enabling them to *apply* knowledge (63.46% and 64.29% respectively) than the large sized firm (44.79%). Furthermore, those in the small firm had been much more effective in *creating* knowledge (61.54%) than those in the medium and large sized firms (39.29% and 33.34% respectively).

All in all, in terms of managing the knowledge lifecycle of *capturing, sharing, applying and creating*, respondents appear to mutually concur that the KM initiatives currently in place in the three firms had most enabled the *capturing and sharing* of knowledge than *applying and creating* knowledge (apart from a slight weakness of the medium firm to capture as compared to its application of knowledge).

In terms of the ability of the individual firms to manage knowledge, it appears that the only firm that had a KM infrastructure which had been most holistically and substantially capable of capturing, sharing, applying and creating knowledge was firm S, the Taiwanese firm. However, it is important to note that in firm S, although respondents reported that the KM initiatives had enabled them to apply and create knowledge, there were fewer responses to this question.

On the other hand, firm M had generally been capable of *capturing, sharing, and applying* knowledge but not *creating* knowledge while the least effective in managing knowledge was the Singaporean firm which had generally been (much more) effective in *capturing and sharing* knowledge but not *applying and creating* them.

4.4.1.2 Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge at Various Levels of Each Firm

Various Levels of the Firm	Company S (Taiwanese firm)	Company M (American firm)	Company L (Singaporean firm)	Average
Individual	76.92%	80.95%	59.38%	72.42%
Project	59.62%	60.71%	55.47%	58.60%
Division/Department	67.31%	57.14%	58.60%	61.01%
Corporate	71.16%	50.00%	55.47%	58.88%
Average	68.75%	62.20%	57.23%	

Effectiveness of KM
Initiatives at various levels
of the Firm

Most

↕

Legend   Least
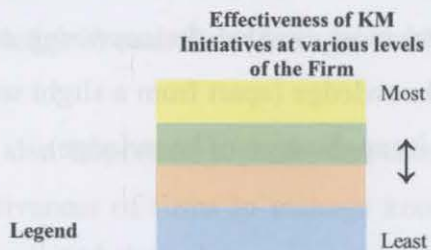
Table 17: Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge at Various Levels of each Firm

Method of Measuring the Effectiveness of the KM Initiatives in Managing Knowledge

For each firm, the response rates for the effectiveness of the KM initiatives employed to manage (capture, share, apply and create) knowledge at each level of the organisation (individual, project, division, corporation) were first tabulated from the survey responses- these are available in the detailed analysis in *Appendix I*.

These were then averaged to derive the overall response rates for the effectiveness of the initiatives to manage knowledge at each level of the organisation.

These were then tabulated into Table which depicts the effectiveness of each firm to manage knowledge at each level of the organisation, and the overall effectiveness to manage knowledge as an organisational entity (averages on the x-axis) as well as the effectiveness of the initiatives to capture, share, apply and create knowledge respectively in each firm and in all three firms overall (averages on the y-axis).

Again, as mentioned earlier, it is also important to note that these tools can not only be used to measure the effectiveness of firms to manage knowledge, but also as

benchmarks from which a firm could constantly monitor and improve its own performance (internal benchmarking) as well as in comparison with other firms (external benchmarking)- provided all firms are subjected to the same measures and comparatively monitored.

Analysis and Findings

Overall, it appears that the KM initiatives had been most effective in enabling respondents to manage knowledge at the individual level for all three firms (72.42%) but with 21% variance. This was then followed by the division/department level (61.01%) with 10% variance, corporate level (58.88%) with 21% variance, and project level (58.60%) with 4% variance.

In comparing the firms, the effectiveness of the KM initiatives in enabling respondents to manage knowledge was clearly the highest at the individual level in all three firms (76.92%, 80.95%, and 59.38% in the small, medium and large firms respectively) while the effectiveness of the KM initiatives in enabling respondents to manage knowledge at each of the other levels differed from each other.

At the small firm, respondents indicated that their initiatives had been second most effective in enabling them to manage knowledge at the corporate level (71.16%), and closely followed by division level (67.31%). The initiatives had been least effective in managing knowledge at the project level (59.62%). At the medium firm, the initiatives had been second most effective in managing knowledge at the project level (60.71%), followed by division (57.14%) and corporate level (50%). At the large firm, the initiatives had been second most effective in managing knowledge at the division level, and followed closely by corporate and project levels.

Discussions

It appears that the initiatives in the small and medium firms had been (substantially) much more effective than the large firm in managing knowledge at the individual level. Although the initiatives in the three firms do not appear substantially effective in managing knowledge at the project level, the initiatives in the small firm had generally been (substantially) much more effective in managing knowledge than the medium and large firms.

Overall, the effectiveness of the initiatives employed in a firm to manage knowledge (be it measured by processes of managing knowledge or the level of the organisation at which the knowledge was managed) seems to be related to the size of the organisation. It appears that, firm S had been the most effective in managing knowledge in both 'forms of measure', followed by firm M, and lastly by firm L.

Furthermore, apart from the deviation of the effectiveness of the initiatives employed in the large firm from the small and medium firms to manage knowledge at the individual level, in general the firms had (only) been substantially more capable of managing knowledge at the individual level than at the project, division and corporate levels. This appears to infer that the organisations' KM infrastructure (or systems as these firms call it) was essentially incapable of managing project and corporate knowledge, and that it was more (and most) capable of managing individual knowledge.

4.4.2   Specific Performance Outcomes

4.4.2.1 Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Enable Learning Between Projects Within the Firm and/or between the Project Phases of a Project (see *Appendix C*)

Discussion tools

Between Projects within the Organisation

Overall, *regular discussions between superior and subordinates* appears most effective in enabling learning to occur between projects within the organisation, followed in descending order by *irregular (ad-hoc) discussions between peers, irregular (ad-hoc) discussions between superior and subordinate, discussions forums/boards placed on the intranet/extranet or another program, and regular discussion between peers.*

In regards to the firms individually, *regular discussions between superior and subordinate* had been most effective in enabling learning to occur between projects in the small firm, and the second most effective tool in the medium and large firms.

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Irregular (ad-hoc) discussions between superior and subordinate appears to be the third most effective tool for the small and large firms but the second least effective tool for the medium firm. *Discussion forums/board placed on the intranet or another program* had been the second least effective tool for the small and large firms, and the least effective tool for the medium firm.

Regular discussions between peers had been the least effective tool for the small and large firms but the most regularly used tool for the medium firm.

Between Project Phases within a Project

Overall, it appears that *irregular (ad-hoc) discussions between peers, and irregular (ad-hoc) discussions between superior and subordinate* had been most effective in enabling learning to occur between project phases within a project, and subsequently followed by *regular discussions between superior and subordinate, regular discussions between peers,* and *discussion forums/boards*. Also, irregular discussions appear to have generally been more effective in enabling learning to occur between project phases in the small and medium firms than the large firm.

In particular, in regards to the firms individually, *irregular (ad-hoc) discussions between peers* exhibited a decreasing importance (most, second most, and third most effective) from the small to medium to large firm respectively.

Regular discussions between superior and subordinate exhibited an increasing importance (second least, third most, and most effective) from the small to medium to large firms respectively, while *regular discussions between peers* had been least effective in enabling learning in the small firm, and second least effective in the medium and large sized firms.

Discussion forums/boards had been the second most effective tool for doing so in the small firm but the least effective tool in the medium and large sized firms.

Meeting tools

Between Projects within the Organisation

Overall, it appears that *management meetings* had been most effective in enabling learning to occur between projects within the organisation, followed by *formal project-team meetings*, and then *directors' only meetings*.

The least effective tool appears to be *directors' only meetings* in the small and medium sized firms, and the second most effective tool in the medium sized firm.

Between Project Phases within a Project

All three firms agree that *formal project-team meetings* had been most effective in enabling them to learn between project phases within a project, followed by *management meetings*, and *directors' meetings*.

It was evident that *directors' only meetings* had been the least effective meeting tool in enabling both learning between projects and between project phases.

Sessions/forums tools

Between Projects within the Organisation

Overall, *brainstorming sessions* and *project lessons-learnt sharing sessions* appear to have been most effective in enabling learning to occur between projects within the organisation, and subsequently followed by *information sessions, seminars, forums, talks, expert panels,* and *team building activities.*

Brainstorming sessions exhibited a trend of decreasing importance from the small to medium to large firm in having most, second most, and second least enabled learning to occur between projects within the organisations while *project lessons-learnt sharing sessions* had been least, most and second most effective in the small, medium, and firms respectively.

Between Project Phases within a Project

Similar to the above findings, *brainstorming sessions* appear to have been most effective in enabling learning to occur between projects within the organisation, and subsequently, followed by *project lessons-learnt sharing sessions, information sessions, seminars, forums, talks, expert panels*, and *team building activities*.

Brainstorming sessions had been most effective in enabling all three firms to learn between project phases within a project. *Project lessons-learnt sharing sessions* had been least effective in the small firm, and second most effective in the medium and large firms.

Project Review tools

Between Projects within the Organisation

Overall, *informal verbal reportback/feedback sessions by employees to superiors* had been most effective in enabling learning to occur between projects within the organisation, and followed in effectiveness by *formal post-project reviews, meetings to discuss/evaluate completed projects*, and *formal post-project reviews at the end of each phase of a project*.

Informal verbal reportback/feedback sessions by employees to superiors had been most effective in the small firm, and the second most effective tool in the medium and large firms. *Formal post-project reviews* had been second most, most and second least effective in the small, medium, and large firms respectively.

Meetings to discuss/evaluate completed project reviews had been the least effective tool for the small and medium sized firm but conversely the most important tool for the large firm. *Formal post-project reviews at the end of each phase of a project* was agreed by all to be one of the most ineffective (second least effective in the small and medium firms, and least effective in the large firm) project review tool.

Between Project Phases within a Project

Overall, *informal verbal reportback/feedback sessions by employees to superiors* had also been most effective in enabling learning to occur between project phases within a

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project. Of lesser effectiveness are *formal post-project reviews at the end of each phases of a project, formal post-project reviews,* and *meetings to discuss/evaluate completed project reviews.*

Again, *informal verbal reportback/feedback sessions by employees to superiors* had been most effective in enabling learning to occur between project phases in the small firm, and second most effective of doing so in the other firms. *Formal post-project reviews at the end of each phase of a project* had been most effective in the medium and large sized firms.

Manuals/Guidelines/Standards tools

Between Projects within the Organisation

Overall, *project management manuals* had been most effective in enabling learning to occur between projects within the organisation, and subsequently followed by *quality assurance manuals, best practices guides, and lesson-learnt manuals.*

Project management manuals had been most effective in enabling learning to occur between projects within the organisation in the small and medium sized firms and second most effective in the large size firm while *quality assurance manuals* had been second most effective in the small firm but most effective in the medium and large firms.

Best practices guides were deemed second least, second most, and least effective in the small, medium and large firms respectively while *lessons-learnt manuals* were generally the least effective in the small and medium firms, and second least effective in the large firm.

Between Project Phases within a Project

Overall, *project management manuals* had also been most effective in enabling learning to occur between projects within the organisation, and subsequently followed by *quality assurance manuals, best practices guides, and lesson-learnt manual.*

Project management manuals had been most effective in enabling learning between project phases in the small and medium firms, and second most effective in the large firm while *quality assurance manuals* had been more effective of enabling learning in the medium and large sized firm (most effective) than the small sized firm (second most effective).

Best practices guides appear to have been more effective in enabling learning in the small and medium firms (second least and second most effective) than the large firm (least effective). *Lessons-learnt manuals* appear to have been least and second least effective in enabling learning to occur in the medium and large sized firms respectively while no responses were received from the respondents in the small firm.

Human Resource tools

Between Projects within the Organisation

Overall, *mentoring and apprenticeship* had been most effective in enabling learning to occur between projects within the organisation. In descending order, formal and *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc.*, and *work induction for new staff* were of lesser effectiveness.

Mentoring and apprenticeship appears to have been more (and most) effective in enabling learning to occur between projects within the organisation in the medium firm than the small and large sized firms (second most effective).

Formal rotation of people around projects, functional departments, different job scopes had been most, least and second least effective in the small, medium and large firms respectively while *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes* exhibited an increasing effectiveness in having least and second least effective in the small and medium firms respectively but most effective in the large firm.

Work induction for new staff had been second least, second most and least effective in the small, medium and large firms respectively.

Between Project Phases within a Project

Overall, the ranking of effectiveness of the human resource tools in enabling learning between project phases within a project was the same as that between projects within the organisation.

Mentoring and apprenticeship had been more (and most) effective in the medium firm than the small (second most) and large (second least) firms.

Formal procedures for rotating people around projects, functional departments, different job scopes had been second most effective in the large firm but second least effective in the small and medium firms while *informal (ad-hoc) rotation for rotating people around projects, functional departments, different job scopes* had been most effective in the small and large firms but least effective in the medium firm.

Work induction for new staff had been second most effective in the small medium firm but least effective in the small and large firm.

Computing tools

Between Projects within the Organisation

Overall, *intranets* had been most effective of enabling learning to occur between projects within the organisation. This was followed by *electronic message exchange, expertise locator/people finder and electronic document management system, computer aided design programs, extranet, electronic tender document management system, and electronic contract/procurement system.*

The *intranet* had been most effective in enabling learning to occur between projects in all three firms while *electronic message exchange* had been fourth most effective in the small firm but second most effective in the medium and large firms.

Expertise locator had been third least and fourth least effective in the small and large firms but third most effective tool in the medium firm while *electronic document management systems* exhibited a decreasing effectiveness (third most, fourth most, and third least) by size of firm (small, medium and large).

Computer aided design programs had been second most effective in the small firm but fourth least and fourth most effective in the medium and large firms respectively while *extranet* exhibited an increasing effectiveness (second least, third least, and third most effective) by size of firm (small, medium, and large).

Electronic tender document management system had been fourth least, least, and second least effective in the small, medium and large firms respectively.

Lastly, *electronic procurement/contract system* had been least effective in the small and large firms respectively and second least effective in the medium firm.

Between Project Phases within a Project

Overall, three tools appear to have most effective in enabling respondents to learn between project phases: *electronic message exchange, electronic document management system, and intranets.* These were followed by *computer aided design programs, extranet, expertise locator, electronic tender document management system, and electronic contract/procurement system.*

Electronic message exchange had been second most effective in the small firm and most effective learning to occur in the medium and large firms. *Electronic document management systems* exhibited a decreasing effectiveness in being rated most, second most, and fourth most effective in enabling learning with increasing firm size.

Intranet exhibited increasing effectiveness in having fourth, third and second most enabled learning to occur in the small, medium, and large firms respectively while *computer aided design programs* had been third most effective in the small and large firms respectively but fourth least effective in the medium firm.

Extranet had been second least effective in the small firm, and third least effective in the medium and large firms while *expertise locator* had been least effective in the small firm (no responses) but fourth most and fourth least effective in the medium and large firms respectively.

Electronic tender document management system and *electronic procurement/contract system* appears to be have been least effective in enabling respondents to learn between project phases within a project. The former had been fourth least, least and second least effective in the small, medium and large firms respectively while *electronic procurement/contract system* exhibited a decreasing effectiveness (third least, second least, and least effective) in the small, medium and large firms respectively (no responses from large firm).

4.4.2.2 Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms in Resolving Different Types of Problems (see *Appendix D*)

Discussion tools

Resolving Generic and Recurrent Problems

It appears that *irregular (ad-hoc) discussions between peers* had been most effective in resolving generic and recurrent problems. This was subsequently followed by *regular discussions between superior and subordinate, irregular (ad-hoc) discussions between superior and subordinate, and regular discussions between peers and discussion forums/boards placed on the intranet/extranet or another program.*

Irregular (ad-hoc) discussions between peers appear to have most effective in enabling respondents to resolve generic and recurrent problems in the small firm and second most effective in enabling respondents to do so in the medium and large firms, while *regular discussions between superior and subordinate* had been third most effective in resolving generic and recurrent problems in the small firm but most effective in doing so in the medium and large firms.

Irregular (ad-hoc) discussions between superior and subordinate had been second least effective in the small firm but second and third most effective in the medium and large firms respectively while *regular discissions between peers* had been least and second least effective in the small and large firm respectively but most effective in the medium firm.

Discussion forums/boards placed on the intranet/extranet or another program exhibited decreasing effectiveness (second most, third most and least effective) by the size of the firm (small, medium and large).

Resolving Specific and Less-recurrent Problems

In contrast, it appears that *irregular (ad-hoc) discussions between superior and subordinate* had been most effective in enabling respondents to resolve specific and less-recurrent problems. This was followed by *regular discussions between superior and subordinate, irregular (ad-hoc) discussions between peers, regular discussions between peers, and discussion forums/boards placed on the intranet/extranet or another program.*

Irregular (ad-hoc) discussions between superior and subordinate had been most effective in enabling respondents in resolving specific and less-recurrent problems in all three firms while *regular discussions between superior and subordinate* had been second most effective in the small and medium firm, and third most effective in the large firm.

Irregular (ad-hoc) discussions between peers had third most, most, and second most effective in the small, medium and large firms in resolving specific and less-recurrent problems respectively while *regular discussions between peers* had been least, most, and second least effective in the small, medium and large firms respectively.

Again, *discussion forums/boards placed on the intranet/extranet or another program* had been least effective in enabling resolving specific and recurrent problems in having second least effective in the small firm, and least effective in the medium and large firms.

Meeting tools

Resolving Generic and Recurrent Problems

Clearly, respondents from all firms appear to agree that *formal project-team meetings* had been most effective in enabling them to resolve generic and recurrent problems, followed by *management meetings, and directors' only meetings.*

Resolving Specific and Less-recurrent Problems

Overall, *management meetings* had most effective in enabling respondents to resolve specific and less-recurrent problems, followed by *formal project-team meetings, and directors' only meetings*.

Management meetings had been most effective in enabling respondents to resolve specific and recurrent problems in the small and large firms, and second most effective in the medium firm while *formal project-team meetings* had been most effective in the medium firm, and second most effective in the small and large firms.

It was also clear that *directors' only meetings* had been the least effective meeting tool in resolving both generic and recurrent problems, and specific and less-recurrent problems.

Sessions/forums tools

Resolving Generic and Recurrent Problems

Overall, *brainstorming sessions and information sessions, seminars, forums, talks and expert panels* had most enabled respondents to resolve generic and recurrent problems. This was followed by *project lessons-learnt sharing sessions and team building activities*.

Brainstorming sessions exhibited a decreasing effectiveness in having most, second most, and second least enabled respondents in the small, medium and large firms respectively to resolve generic and recurrent problems while *information sessions, seminars, forums, talks and expert panels* had second most effective in the small and large firms, and second least effective in the medium firm.

Project lessons-learnt sharing sessions had been most effective in enabling respondents in the medium and large firms but least effective in the small firm while *team building activities* have been least effective in the medium and large firms, and second least effective in the small firm.

Resolving Specific and Less-recurrent Problems

Overall, it appears that *brainstorming sessions* had most enabled respondents to resolve generic and recurrent problems. This was followed by *project lessons-learnt sharing sessions, information sessions, seminars, forums, talks and expert panels, and team building activities.*

Brainstorming sessions had been the most effective in the small firm and second most effective in the medium and large firms while *project lessons-learnt sharing sessions* had most effective in the medium and large firms, and second least effective in the small firm.

Information sessions, seminars, forums, talks, expert panels had been second most effective in the small firm, and second least effective in the medium and large firms while *team building activities* had clearly been least effective in all three firms.

Project Review tools

Resolving Generic and Recurrent Problems

Overall, *informal verbal reportback/feedback by employees to superiors* had been most effective in enabling respondents to resolve generic and recurrent problems. This was followed by *formal project reviews at the end of each phase of a project, formal post-project reviews and meetings to discuss/evaluate completed project reviews.*

Informal verbal reportback/feedback by employees to superiors had been most effective in the small and large firms but second least effective in the medium firm.

Formal project reviews at the end of each phase of a project had been second least, most and second most effective in the small, medium and large firms respectively while *formal post-project reviews* had been second most effective in the small and medium firms but second least effective in the large firm.

Meetings to discuss/evaluate completed project reviews had been third least effective in the small and large firm but least effective in the medium firm.

The author believes that at least one form of formal project review (be it *formal post-project reviews or formal project reviews at the end of each phases of a project*) should be implemented in any project-based organisation. Also, formal post-project reviews appears to have been more important than formal post-project reviews at the end of each phase of a project in the small firm while the reverse was true for the medium and large firms.

Resolving Specific and Less-recurrent Problems

The ranking of effectiveness for the tools to resolve specific and less-recurrent problems was the same to that for generic and recurrent problems.

Informal verbal reportback/feedback by employees to superiors had been most effective in the small and large firms but second least effective in the medium firm.

Formal project reviews at the end of each phase of a project exhibited an increasing effectiveness (least, second most and most effective) by the size of the firm (small, medium and large firms respectively) while *formal post-project reviews* had been least effective in the small firm but second least effective in the medium and large firms respectively.

Meetings to discuss/evaluate completed project reviews had been least effective in all three firms (no responses in the small firm).

Manuals/Guidelines/Standards tools

Resolving Generic and Recurrent Problems

Generally, all three firms indicated that *quality assurance manuals and project management manuals* had most enabled respondents to resolve generic and recurrent problems (apart from respondents in the medium firm who indicated that *project management manuals* were as equally effective as *quality assurance manuals*). This was followed by *best practices guides and lessons-learnt manual.*

Resolving Specific and Less-recurrent Problems

Quality assurance manuals and project management manuals had most enabled respondents to resolve generic and recurrent problems. These were, however, followed by *lessons-learnt manuals, and then best practices guides.*

Quality assurance manuals had been second most effective in the small and medium firms, and second least effective in the large firm while *project management manuals* had been most effective in the small and medium firms but least effective (no responses) in the large firm.

Lessons-learnt manuals had been second least effective, least (no responses), and most effective in the small, medium and large firms respectively while *best practices guides* had been second least effective in the small and medium firms, and second most effective in the large firm.

Human Resource tools

Resolving Generic and Recurrent Problems

Mentoring and apprenticeship had been most effective of enabling respondents to resolve generic and recurrent problems. This was followed by *formal and informal rotation of people around projects, functional departments, different job scopes, and work induction for new staff.*

Mentoring and apprenticeship had been second most effective in the small and large firms, and most effective in the medium firm.

Formal rotation of people around projects, functional departments, different job scopes had been most effective in the small firm but least and second least effective in the medium and large firms while *informal rotation of people around projects, functional departments, different job scopes* exhibited increasing effectiveness (least, second least and most effective) by size of firm (small, medium and large respectively).

Work induction for new staff had been second least, second most and least effective in the small, medium and large firms respectively.

Resolving Specific and Less-recurrent Problems

Again, *mentoring and apprenticeship* appears to have been the most effective tool in resolving specific and less-recurrent problems. This was followed by *work induction for new staff, informal (ad-hoc) rotation of people around projects, functional departments, different job scopes, and formal procedures for rotating people around projects, functional departments, different job scopes.*

Mentoring and apprenticeship had been most effective in the small and medium firms, and second most effective in the large firm while *work induction for new staff* second least effective in the small and large firms but second most effective in the medium firm.

Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes exhibited increasing effective (least, second least, and most effective) by size of firm (small, medium and large respectively) while *formal procedures for rotating people around projects, functional departments, different job scopes* had been second most effective in the small firm but least effective in the medium and large firms respectively.

Computing tools

Resolving Generic and Recurrent Problems

The tools that had been most effective of resolving generic and recurrent problems were *intranets, computer aided design program, and electronic message exchange.* This was followed by *extranet, electronic document management system, expertise locator, electronic contract/procurement system, and electronic tender document management system.*

Intranets had been third most, most and second most effective in the small, medium and large firms respectively while *computer aided design programs* had been second most effective in the small firm, and third most effective in the medium and large firms. *Electronic message exchange* exhibited increasing effective (fourth least, fourth most, and most effective) by size of firm (small, medium and large respectively).

Extranet had been second least effective in the small firm but second most and third most effective in the medium and large firms respectively while electronic document management system exhibited decreasing effectiveness (fourth most, fourth least, and third least effective) by size of firm (small, medium and large respectively).

Expertise locator exhibited increasing effectiveness (least, third least, and fourth most effective) by size of firm (small, medium and large respectively) while *electronic contract/procurement system* had been third least effective in the small firm and second least effective in the medium and large firms respectively.

Lastly, although *electronic tender document management system* had been most effective in the small firm but least and fourth least effective in the medium and large firms respectively.

Resolving Specific and Less-recurrent Problems

The tools that appear to have been most effective of resolving generic and recurrent problems are *electronic message exchange and intranets*. This was followed by *expertise locator, computer aided design programs, electronic document management system, extranet, electronic contract/procurement system, and electronic tender document management system.*

Clearly, *electronic message exchange* had been most effective in enabling respondents in all three firms to resolve specific and less-recurrent problems. This was followed by *intranets* which had been third most, fourth most and second most effective in the small, medium and large firms respectively while *expertise locator* had been fourth most effective in the small and large firms, second most effective in the medium firm.

Computer aided design programs had been second most effective in the small firm but third least and fourth least effective in doing so in the medium and large firms while *electronic document management system* had third most effective in the small and medium firms but third least effective in the large firm.

Electronic contract/procurement system exhibited a decreasing trend of effectiveness (fourth least, second least, and least effective) by firm's size (small, medium and large respectively- no responses in large firm) while *electronic tender document*

management systems was generally (again) the least effective of the tools in having been third least effective in the small firm, and least effective in the medium and large firms (no responses for large firm).

4.4.2.3 Effectiveness of the Tools, Methods and Mechanisms Used by the Three Case Study Firms in Enabling Staff to Experience Learning at Various Levels of the Organisation (see *Appendix E*)

Discussion tools

Individual level

Overall, it appears that *irregular (ad-hoc) discussions between superior and subordinate* had been most effective of enabling respondents to experience learning at the individual level. This was followed by *irregular (ad-hoc) discussions between peers, regular discussions between superior and subordinate, regular discussions between peers, and discussion forums/boards placed on the intranet/extranet or another program.*

Irregular (ad-hoc) discussions between superior and subordinate had been most effective in the small and medium firms, and second most effective in the large firm while *irregular (ad-hoc) discussions between peers* exhibited increasing effectiveness (third most, second most, and most effective) by size of firm (small, medium and large respectively).

Regular discussions between superior and subordinate had been second least, second most, and third most effective in the small, medium and large firms respectively while *regular discussions between peers* exhibited increasing effectiveness (least, second most, and most effective) by size of firm (small, medium and large respectively).

The least effective tool was *discussion forums/boards placed on the intranet/extranet or another program* which exhibited a decreasing trend of effectiveness (second most, third most, and least effective) by size of firm.

Division-level

Overall, it appears that *regular discussions between superior and subordinate* had been most effective of enabling respondents to experience learning at the individual level. This was followed by *irregular (ad-hoc) discussions between peers and irregular (ad-hoc) discussions between superior and subordinate, regular discussions between peers, and discussion forums/boards placed on the intranet/extranet or another program.*

It appears that *regular discussions between superior and subordinate* had been most effective in the small and medium firms, and second most effective in the large firm.

Irregular (ad-hoc) discussions between peers had second most, most effective in the small and medium firms but second least effective in the large firm while *irregular (ad-hoc) discussions between superior and subordinate* exhibited an increasing trend in having been second least, second most, and most effective in the small, medium, and large firms respectively.

Although *regular discussions between peers* had been least effective in the small firm, it had most and third most effective in the medium and large firms respectively.

Again, *discussion forums/boards* appears to be the least effective tool in enabling respondents to experience learning at the division level. It had been third most effective in the small and medium firms but least effective in the large firm.

Corporate-level

Overall, it appears that *discussion forums/boards* had been most effective of enabling respondents to experience learning at the individual level. This was followed by *regular discussions between superior and subordinate, regular discussions between peers, by irregular (ad-hoc) discussions between superior and subordinate, and irregular (ad-hoc) discussions between peers.*

Discussion forums/boards appeared to have been most effective of enabling respondents in the small and large firms to experience learning at the corporate level, and second most enabled those in the medium firm.

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Regular discussions between superior and subordinate had third most, least, and second most enabled respondents in the small, medium and large firms respectively while *regular discussions between peers* had least, most, and third most enabled respondents in the small, medium and large firms respectively.

*Irregular (ad-hoc) discussions between superior and subordinat*e had been second most effective in the small firm but least and second least effective in the medium and large firms respectively while *irregular (ad-hoc) discussions between peers* had third most, most effective in the small and medium firms but least effective in the large firm respectively.

Meeting tools

Individual level

It was clear that respondents from all three firms agree that the tool that had most enabled them to experience learning at the individual level was *formal project-team meetings*, followed by *management meetings and directors' meetings*.

Division-level

It appears that respondents from all three firms also agree that *management meetings* had been most effective in enabling respondents to experience learning at the individual level, followed by *formal project team meetings and directors' only meetings*.

Corporate-level

Overall, it appears that *management meetings* had been most effective in enabling respondents to experience learning at the corporate level, followed by *directors' only meetings and formal project-team meetings*.

However, on closer examination, the importance of the tools at the corporate level appears to be mixed.

Management meetings had been most effective in the small and large firms, and second most enabled those in the medium sized firm while *directors' meetings* had been most effective in the medium and large firms but least effective in the small firm.

Formal project-team meetings had been second least effective in the small firm, and least effective in the medium and large firms (no responses were received for the large firm).

Sessions/forums tools

Individual level

Overall, *information sessions, seminars, forums, talks and expert panels and brainstorming sessions* had been most effective of enabling respondents to experience learning at the individual level. This was followed by *project lessons-learnt sharing sessions and team building activities*.

Information sessions, seminars, forums, talks and expert panels had been most effective in the small and large firms but least effective in the medium firm while *brainstorming sessions* had been deemed second most and most effective in the small and medium firms but second least effective in the large firm.

Project lessons-learnt sharing sessions had been second least effective in the small firm but most and second most effective in the medium and large firms while *team building activities* appears to have been the least effective in the small and large firms but second most effective in the medium firm.

Division-level

Brainstorming sessions and project lessons-learnt sharing sessions had been most effective in enabling respondents to experience learning at the division level. This was followed by *information sessions, seminars, forums, talks and expert panels and team building activities*.

Brainstorming sessions had been most effective in the small firm, and second most effective in the medium and large firms while *project lessons-learnt sharing sessions*

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had been third least effective in the small firm but most effective in the medium and large firms.

Information sessions, seminars, forums, talks and expert panels exhibited decreasing trend of effectiveness (second most, second least and least effective) by firm's size (small, medium and large respectively) while *team building activities* had been least effective in the small and medium firms, and second least effective in the large firm.

Corporate level

Information sessions, seminars, forums, talks and expert panels and *project lessons-learnt sharing sessions* had been most effective of enabling respondents to experience learning at the corporate level. This was followed by *brainstorming sessions* and *team building activities*.

Information sessions, seminars, forums, talks and expert panels had been most effective in the small firm and second most effective in the medium and large firms while *project-lessons-learnt sharing sessions* had been second least effective in the small firm, but most effective in the medium and large firms.

Brainstorming sessions exhibited a decreasing trend of effectiveness (second most, second least, and least effective) by size of firm (small, medium and large respectively) while *team building activities* had been least effective in the small and medium firms, and second least effective in the large firm.

Project Review tools

Individual level

Informal verbal reportback/feedback by employees to superiors had been most effective in enabling respondents to experience learning at the individual level. This was followed by *formal post-project reviews, formal project reviews at the end of each phase of a project, and meetings to discuss/evaluate completed project reviews.*

Informal verbal reportback/feedback by employees to superiors had been most effective in the small and large firms but second least effective in the medium firm.

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Formal post-project reviews had been second most, most and second least effective in the small, medium and large firms respectively while formal project reviews at the end of each phase of a project had been least effective (no responses) in the small firm but second most effective in the medium and large firms respectively.

Meetings to discuss/evaluate completed project reviews exhibited an increasing trend of effectiveness in having been least effective in the small firm but second most and most effective in the medium and large firms.

Division-level

Formal post-project reviews had been most effective in enabling respondents to experience learning at the division level. This was followed by *formal project reviews at the end of each phase of a project*, and lastly by *informal verbal reportback/feedback by employees to superiors and meetings to discuss/evaluate completed project reviews*.

Formal post-project reviews had been second most effective tool for all three firms while *formal project reviews at the end of each phase of a project* had been second least effective in the small and large firms but most effective in the medium firm.

Meetings to discuss/evaluate completed project reviews exhibited an increasing trend of effectiveness (least, second least, and most effective) by firm's size (small, medium and large respectively).

Corporate level

Formal post-project reviews had been most effective in enabling respondents to experience learning at the division level. This was followed by *meetings to discuss/evaluate completed project reviews, formal project reviews at the end of each phase of a project,* and lastly by *informal verbal reportback/feedback by employees to superiors.*

Formal post-project reviews had been least effective (no responses) in the small firm, and second least and second most effective in the medium and large firms respectively

while *informal verbal reportback/feedback by employees to superiors* had been most effective in the small firm but least effective in the medium and large firms.

Manuals/Guidelines/Standards tools

Individual level

Quality assurance manuals and *project management manuals* had been most effective of enabling respondents to experience learning at the individual level. However, the importance of *lessons-learnt manuals* and *best practices guides* appear unclear.

Quality assurance manuals had most enabled respondents in all three firms to experience learning at the individual level. *Project management manuals* had been second most effective in the small and large firms, and most effective in the medium firm. It was, however, inconclusive as to the effectiveness of *best practice guides* and *lessons-learnt manuals*.

Division-level

Overall, it appears that *project management manuals* and *quality assurance manuals* had been most effective in enabling respondents to experience learning at the individual level. These were followed by *best practices guides* and *lessons-learnt manuals*.

Project management manuals had been most effective in the small and medium firms, and second most effective in the large firm while *quality assurance manuals* had been second most effective in the small firm, and most effective in the medium and large firms.

Best practice guides had been second least effective in the small and large firms but second most effective in the medium firm while *lessons-learnt manuals* had been least effective in all three firms (no responses for small and medium firms).

Corporate-level

Overall, the importance of the tools in enabling respondents to experience learning at the corporate level was the same as that for division level.

Project management manuals had been most effective in the small and medium firms, and least effective (no responses) in the large firm while *quality assurance manuals* had been second most effective in the small and large firms, and most effective in the medium firm.

Best practice guides had been second least and least effective in the small and medium firms but most effective in the large firm while *lessons-learnt manuals* had again been least effective in all three firms (no responses for all three firms).

Human Resource tools

Individual-level

Mentoring and apprenticeship had been most effective in enabling respondents to experience learning. This was followed by *work induction for new staff, formal procedures for rotating people around projects, functional departments, different job scopes, and informal (ad-hoc) rotation of people around projects, functional departments, different job scopes*.

Mentoring and apprenticeship had been most effective in the small and medium firms but second least effective in the large firm while *work induction for new staff* had been second most effective in the small and large firms but second least effective in the medium firm.

Formal procedures for rotating people around projects, functional departments, different job scopes had been second least and least effective in the small and large firms respectively but second most effective in the medium firm while *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes* had been least effective in the small and medium firms but most effective in the large firm.

Division-level

Mentoring and apprenticeship and *work induction for new staff* appears to have been most effective in enabling respondents to experience learning at the division level.

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This was followed by *formal procedures for rotating people around projects, functional departments, different job scopes*, and *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes.*

Although *mentoring and apprenticeship* had been least effective in the small firm, it had most enabled those in the medium and large firms while *work induction for new staff* had second least effective in the small firm but second most effective in the medium and large firms.

Formal procedures for rotating people around projects, functional departments, different job scopes exhibited a decreasing trend of effectiveness (most, second least and least effective) by size of firm (small, medium and large respectively) while *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes* had been second most effective in the small and medium firms but least effective (no responses) in the large firm.

Corporate level

Overall, *formal procedures for rotating people around projects, functional departments, different job scopes* had been most effective in enabling respondents to experience learning at the corporate level. This was followed by *mentoring and apprenticeship and work induction for new staff, and informal (ad-hoc) rotation of people around projects, functional departments, different job scopes.*

Formal procedures for rotating people around projects, functional departments, different job scopes exhibited a decreasing trend effectiveness (most, second most, and least- no responses for large firm) by firm's size (small, medium and large respectively) while *mentoring and apprenticeship* had been second most effective in the small and medium firms but least effective in the large firm (no responses).

Work induction for new staff had been second least, least (no responses), and most effective in the small, medium and large firms respectively while *informal (ad-hoc) rotation of people around projects, functional departments, different job scopes* had been least effective in the small and large firms (no responses in large firm), and second most effective in the medium firm.

Computing tools

Individual-level

Intranets and *electronic message exchange* had been most effective of enabling respondents to experience learning at the individual level. These were followed by *electronic document management system, computer aided design programs, extranet, expertise locator/people finder, electronic tender document management system, and electronic contract/procurement system.*

Intranets had most enabled those in the small and medium firms to experience learning, and second most enabled those in the large firm.

Electronic message exchange exhibited an increasing trend of effectiveness (fourth most, second most and most effective) by the firm's size (small, medium and large respectively), whilst *electronic document management systems* exhibited a decreasing trend of effectiveness (second most, third most, and fourth least effective) by the firm's size (small, medium and large respectively).

Computer aided design programs had been third most effective in the small and large firms but third least effective in the medium firm while *extranet* exhibited an increasing trend of effectiveness (third least, fourth most, and third most effective) by size of firm (small, medium and large respectively).

Expertise locator also exhibited an increasing trend of effectiveness (least, fourth least, and fourth most effective) by size of firm (small, medium and large respectively).

The least effective tools appear to be *electronic tender document management system* which had been fourth least, least and third least effective in the small, medium and large firms respectively while *electronic contract/procurement system* had been second least effective in the small and medium firms, and least effective (no responses) in the large firm.

Division-level

Electronic document management systems and *electronic message exchange programs* had been most effective in enabling respondents to experience learning at the individual level. These were followed by *intranet, electronic tender document management system, expertise locator/people finder, electronic contract/procurement system, computer aided design programs, and extranet.*

Electronic document management system had second most and most effective in the small and medium firm but fourth least effective in the large firm while *electronic message exchange programs* had been fourth most effective in the small and medium firms but most effective in the large firm.

Intranets exhibited an increasing trend of effectiveness (fourth least, third most, and second most effective) by size of firm (small, medium and large respectively) while *electronic tender document management system* had been most, least (no responses), and fourth most effective in the small, medium and large firms respectively.

Expertise locator/people finder had been second least effective in the small and large firms but second most effective in the medium firm while *electronic contract/procurement system* had been third least effective in all three firms.

Computer aided design programs exhibited a decreasing trend of effectiveness (third most, fourth least, and least effective) with size of firm (small, medium and large respectively) while *extranet* had been least effective (no responses) in the small and medium firms but third most effective in the large firm.

Corporate level

Intranet and *computer aided design programs* had been most effective in enabling respondents to experience learning at the corporate level. These were followed by *electronic message exchange, extranet, expertise locator/people finder, electronic document management system, electronic tender document management system, and electronic contract/procurement system.*

Intranet had been most, fourth least, and second most effective in the small, medium and large firms respectively while *computer aided design programs* exhibited a

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decreasing trend of effectiveness (third most, fourth least, and least effective) by size of firm (small, medium and large respectively).

Electronic message exchange had been fourth most effective in the small and large firms but third most effective in the large firm while *extranet* had been second least and fourth least effective in the small and large firms but most effective in the medium firm.

Expertise locator/people finder had been least effective in the small and medium firms (no responses for medium firm) but most effective in large firm while *electronic document management system* had been second most effective in the small and medium firms but least effective (no responses) in the large firm.

The least effective tools appear to be *electronic tender document management system and electronic contract/procurement system*. The former had been fourth least and least (no responses) in the small and medium firms respectively but most effective in the large firm while the latter had been third least effective in the small and medium firms but least effective (no responses) in the large firm.

4.4.3 Impact of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge on their Capabilities to Deliver Projects, Portfolios and Programs

	Firm S (Taiwanese)	Firm M (American)	Firm L (Singaporean)	Average
Impact of KM Tools, Methods & Mechanisms on Capability to *Deliver Projects*	76.92%	42.86%	40.63%	53.47%
Impact of KM Tools, Methods & Mechanisms on Capability to *Deliver Portfolio*	46.15%	28.57%	34.38%	36.37%
Impact of KM Tools, Methods & Mechanisms on Capability to *Deliver Program*	61.54%	71.43%	18.75%	50.57%
Average	61.54%	47.62%	31.25%	

Impact of KM on Capability of Each Firm to Delivery Projects, Portfolio & Program

Most

↑
↓

Legend

Least
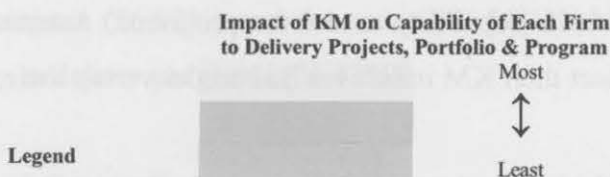
Table 18: Impact of the Tools, Methods and Mechanisms Used by the Three Case Study Firms to Manage Knowledge on their Capabilities to Deliver Projects, Portfolios and Programs

Method of Measuring the Impact of Tools, Methods and Mechanisms Used to Manage Knowledge in the Firms to Deliver Projects, Portfolios and Programs

Respondents in each firm were asked in the survey to indicate the impacts the initiatives in their firms had on their capability to delivery projects: in particular, project delivery, portfolio delivery, and program delivery. The percentage of responses received were then tabulated, and ranked from the most able in delivering projects to the least (see *Table 18* and colour coding legend above).

Subsequently, the metric for the impact of KM on the overall capability of each firm to deliver their projects (x-axis) was determined by averaging the responses received for project delivery capability, portfolio delivery capability, and program delivery capability while the overall impact of KM on the capabilities of all three firms to delivery projects, portfolios, and programs respectively (y-axis) were determined by averaging the responses received for each of delivery projects, portfolios, and programs.

Analysis and Findings

Overall (on the average), the KM initiatives in all three firms did not appear to have greatly increased their capability to deliver projects as a whole.

With the exceptions of firm S on the impact of KM on its capability to deliver projects, and firm M on the impact of KM on its capability to deliver programs, all other impacts of KM initiatives on the capability of the firms are less than 67%.

More specifically, the KM tools, methods and mechanisms in firms S and L had the greatest impact on their capability to deliver projects (although the capability of firm L was much less substantial compared to firm S) while the initiatives in firm M had the greatest impact on its capability to deliver programs. Firms S and M's KM initiatives had the least impact on their capability to deliver portfolios while firm L's initiatives had the least impact on its capability to deliver programs. Astonishingly, all firms rated poorly in the impact their KM initiatives had on delivering their portfolios.

The variance between the best and worst performance in Project Delivery is 36% while the variance between the best and worst performance in Portfolio Delivery Capability

is 18%. The variance between the best and worst performance in Program Delivery is 52%; the best performance (71.5%) is over three times better than the worst (19%).

Discussions

Overall impact of the KM tools, methods and mechanisms on each of the three firms' ability to deliver projects, portfolio and program
(see results by each firm in *Table 18* 'vertically')

It appears that the overall impact of the KM initiatives on the firms' capability to deliver projects was directly related to the size of the firm (decreasing ability from the small to medium to large firm).

More specifically, it was clear that firm S's KM initiatives had the greatest impact on its capability to deliver projects and portfolios (although its capability to deliver portfolios was below the average of 61.54%) while firm M's initiatives had the greatest impact on its capability to deliver programs (while its ability to deliver projects and portfolios were below the average of 47.62%). Firm L's KM initiatives also had the least impact on its capability to deliver projects and programs as it was below the average of 31.25%- (only portfolio delivery was above the average, even though it was unsubstantial)

Overall impact of the KM tools, methods and mechanisms on all three case study firms' ability to deliver projects, portfolio and program (see results by impacts of KM tools, methods and mechanisms to deliver projects, portfolio and program
respectively in *Table 18* 'horizontally')

Overall, all three firms appear to perform poorly in the impact their KM initiatives had on either deliver projects, portfolios or programs (ranged from 36.37% to 53.47%).

More specifically, only firm S's KM initiatives showed substantial capability to deliver projects (76.92%) and programs (61.54%) while firm M showed substantial capability to deliver programs (71.43%).

4.4.4 Comparative Study of the Critical Success Factors of the Tools, Methods and Mechanisms Used to Manage Knowledge in the Three Case Study Firms *(See Appendix II for detailed study of each firm)*
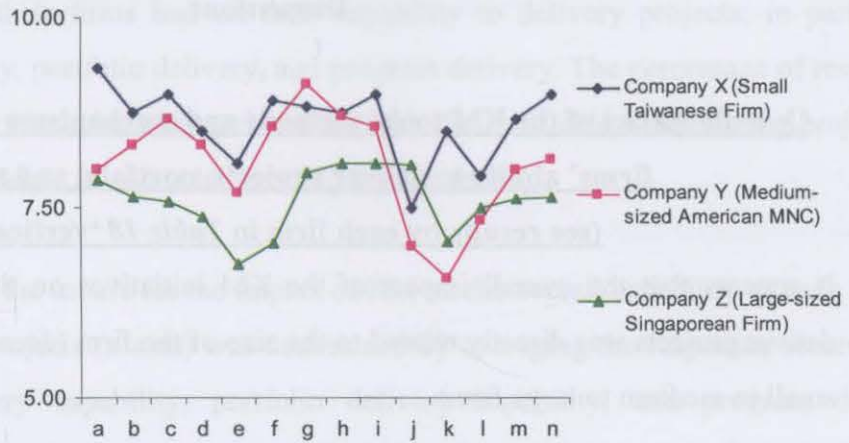
Figure 7: Comparative Analysis of the Critical Success Factors of the Tools, Methods and Mechanisms Used to Manage Knowledge in the Three Case Study Firms

		FIRM*			
	Critical Success Factors	**S**	**M**	**L**	**Average**
a.	KM initiatives must support the organization's vision/mission, and objectives.	9.33	8.00	7.87	**8.40**
b.	KM initiatives and the organization's culture must be aligned with each other.	8.75	8.33	7.65	**8.24**
c.	Explaining the purpose of the KM initiative/s clearly to all levels of staff (i.e. top/senior management, middle management, professional staff).	9.00	8.67	7.59	**8.42**
d.	Consistently promoting the awareness of the KM initiative/s at all levels of the organization.	8.50	8.33	7.38	**8.07**
e.	Involving staff in the development process of the KM initiative/s.	8.08	7.71	6.76	7.52
f.	Involving staff in the implementation process of the KM initiative/s.	8.92	8.57	7.03	**8.17**
g.	Having (consistent and continuing) full support and commitment from top/senior management.	8.83	9.14	7.97	**8.65**
h.	Having (consistent and continuing) full support and commitment from middle management.	8.75	8.71	8.09	**8.52**
i.	Having (consistent and continuing) full support and commitment from professional staff.	9.00	8.57	8.09	**8.55**
j.	Implementing good recognition/incentive/reward mechanisms to encourage contributions.	7.50	7.00	8.06	7.52
k.	Implementing a KM initiative/s in stages (e.g. starting with a pilot project and implementing the rest of the project steadily)	8.50	6.57	7.06	7.38
l.	Designing work processes in the KM system/initiatives that encourage knowledge sharing.	7.92	7.33	7.50	7.58
m.	Selecting the right person/s to manage the content of the KM system.	8.67	8.00	7.62	**8.10**
n.	Selecting person/s who are (freely) willing to manage the content of the KM system.	9.00	8.14	7.65	**8.26**
	Average	**8.63**	**8.08**	**7.59**	**8.10**

*Notes: Firm S (Taiwanese); Firm M (American); Firm L (Singaporean)

Table 19: Comparative Analysis of the Critical Success Factors of the Tools, Methods and Mechanisms Used to Manage Knowledge in the Three Case Study Firms

It appears that all the factors were significantly important to the success of KM initiatives. However, in closer examination, 10 out of 14 factors had scores that were either extremely close to (highlighted 'blue') and equal to or above the average score of 8.10 (highlighted 'red') while only 4 were way below the average score.

Of the 10 that were either extremely close to and equal to or above the average score of 8.10, it was clear that having consistent and continuing full support and commitment from all levels of staff (professional staff, middle management and top/senior management) were the most critical success factors. These were closely followed by 'explaining the purpose of the KM initiatives clearly to all levels of staff', and the 'alignment of KM initiatives to the organisation's vision/mission and objectives'.

These were then followed by the 'need to select person/s who are (freely) willing to manage the content of the KM system', 'KM initiatives and the organization's culture must be aligned with each other', 'involving staff in the implementation process of the KM initiative/s', 'Selecting the right person/s to manage the content of the KM system', and lastly 'consistently promoting the awareness of the KM initiative/s at all levels of the organization' (which scored an average of 8.07- just below the overall average of 8.10).

Those that were 'not as important' appears to be the remaining 4 that had below the average score of 8.10: 'designing work processes in the KM system/initiatives that encourage knowledge sharing', 'involving staff in the development process of the KM initiative/s', 'implementing good recognition/incentive/reward mechanisms to encourage contributions', and 'implementing a KM initiative/s in stages (e.g. starting with a pilot project and implementing the rest of the project steadily)'.

4.4.5 Comparative Study of the Measures (Key Performance Indicators) for KM in the Three Case Study Firms *(See Appendix III for detailed study of each firm)*

	Key Performance Indicators for Knowledge Management	FIRM S	FIRM M	FIRM L
a.	The uptake (receptiveness and use) of knowledge management initiatives by staff	15.38%	14.29%	28.13%
b.	Impact of knowledge management initiatives on individual, project, division/department and/or organizational performances (e.g. whether a knowledge management initiative had a positive or negative impact on individual, project and/or organizational performances)	15.38%	0%	9.38%
c.	Impact of knowledge management on organizational learning capabilities of the organization and the staff.	15.38%	0%	15.63%
d.	No measures at all.	15.38%	14.29%	0%
e.	Other measures of knowledge management:	0%	**57.14%**	6.25%
f.	Not sure if any knowledge management measures exist.	**61.54%**	14.29%	**40.63%**

*Notes: Firm S (Taiwanese); Firm M (American); Firm L (Singaporean)

Table 20: Comparative Analysis of the Measures (Key Performance Indicators) for KM in the Three Case Study Firms

It appears that respondents in firm M only indicated the existence of 'the uptake (receptiveness and use) of knowledge management initiatives' (i.e. non existence of 'impact of knowledge management initiatives on individual, project, division/department, and/or organisational performances', and 'impact of knowledge management on organisational learning capabilities of the organisation and the staff'). The other respondents from firm S and L indicated the existence of all the above initiatives (albeit the unsubstantial response rates ranging from 9.38% to 28.13%).

Apparently, a much larger percentage (57.14%) of respondents from firm M indicated the existence of other measures of KM (which they do not regard as KPIs) in their firm (such as measures for current project performances, training feedback, in-house training and evaluation of training) as compared to firm S (0%) and firm L (6.25%).

In contrast, a much larger percentage of respondents from firm S and L (61.54% and 40.63% respectively) expressed that they were unsure if any KM measures exist in their organisations as compared to firm M (14.29%).

As previously explained, it was clear that despite the above response, none of the firms had actually instituted formal or official measures for and/or methods of measuring KM in their organisations. The author again reiterates that in order for these construction organisations to constantly benchmark and continually improve themselves, they need to implement and institute official measures and methods of measuring for KM.

5.0 Identification and Recommendation of Areas of Improvement for the Three Case Study Firms

5.1 Introduction

Understanding, Ability & Experience

Knowledge of facts, tools,
processes and procedures
constitute UNDERSTANDING

AWARENESS of the discipline's
environment and the application
of Knowledge to real world
situations constitutes
EXPERIENCE

KNOWLEDGE
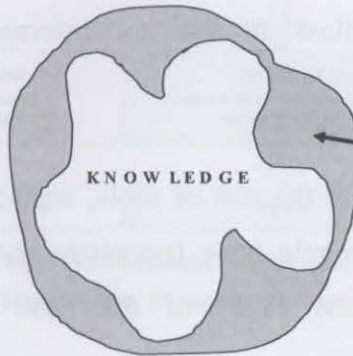
BOUNDARY
CONDITIONS

New situations (boundary
conditions) need to be analysed.
Tools, processes and procedures
then need to be modified to deal
with these new situations
constitutes ABILITY
(competency?)   6

Figure 8: Personal communication [**Source:** Personal communication based on - Leifer.D (2008) Facility Management = Business Infrastructure Management, Construction 360° Conference Proceedings, Dubai, May, 2008, Presentation #3.]

The diagram above indicates the extent of a persons' world view. Individuals have an awareness of the environment in which they exist; they have an understanding of facts, tools, processes and procedures that allow them to deal with the environment and solve problems. Often the problems are novel, and require the individual to modify tools processes and procedures in order to solve them. Their ability to do this determines their competency.

Knowledge Management's goal is to capture and disseminate individual employee's novel awareness, understanding, and experience and add it to the organisation's body of knowledge. This endeavour may be conceived as making public what knowledge "resides in peoples' heads".

5.2 Framework for the Identification of Tools, Methods and Mechanisms for Linking People to What the Firm Has (People-to-Organisation) Versus People to What Other People in the Firm Have (People-to-People)

The author has identified two approaches to the management of the data and information and knowledge that resides in the firm and its people (*Figure 9*).

Approach α emphasises the use of tools, methods and mechanisms that largely connect people to what the organisation has (people-to-organisation)- thereby supporting and/or facilitating the 'vertical flow' of data and information residing within the organisation.

Approach ß, however, emphasises the use of tools, methods and mechanisms that connect people to what other people have (people-to-people)- thereby supporting and/or facilitating the 'horizontal flow' of data and information within the organisation.

At this instance, it is pertinent to note that both approaches can only support and/or facilitate the direct conversational transference of data and information between individuals, and/or repository and retrieval of data and information to/from an institution's system. In other words, because knowledge is personal, individuals still have to process (analyse, reflect, understand and learn) the data and information they have acquired and convert them to knowledge by utilizing their personal wisdom (which includes their individual intuitive and discernment abilities) prior to applying their knowledge to a situation or problem.

Subsequently, any personal knowledge accumulated by individuals may then be further interpreted into data and information, and institutionalised within the firm (e.g. via software programs, hardwares and hardcopy documents) for future 'retrieval' by other individuals for use in future projects (i.e. utilising Approach α) or shared via communication (be it face-to-face or virtually) between individuals in the firm (utilising Approach ß). Furthermore, the conversations and its outcomes arising from communications between individuals in meetings and discussions (Approach α) may be converted, documented and institutionalised into minutes and 'lessons-learnt' stories/guides/manuals and best practices guides/manuals (Approach ß).

Figure 9

Tools, Methods & Mechanisms Available for Managing Data, Information and Knowledge in construction organisations		
Technological	Software programs (e.g. Powerpoint slides, AutoCAD, MSOffice) Company intranet Extranet Electronic document management system Electronic tender document management system Electronic contract/procurement system	Discussion forums/boards placed on the intranet/ extranet or another program Electronic message exchange Expertise locator/people finder
Non-technological	Formal project-reviews Project management manual Quality assurance manual Best practices guides	Informal and formal discussions between peers & between superior and subordinate Information sessions, seminars, forums, talks, expert panels Project lessons-learnt sharing sessions Brainstorming sessions Team building activities Directors' only meetings Management meetings Project-team meetings Meetings to discuss/evaluate completed project reviews Informal verbal reportback/feedback sessions by employees to superiors
Approach connecting: emphasis:	Approach α - people to what the organisation has - repository & retrieval	Approach ß - people to what other people in the organisation have - sharing by conversation
Business Type	Type α	Type ß

Figure 9: Relationships Between Tools, Methods and Mechanisms Available for Managing Data, Information and Knowledge, and Organisational Business Types

The author suggests that 'Approach α' is more appropriate for business types that are largely centralised, hierarchic, standardised and productivity-focused while 'Approach ß' is more appropriate for business types that are largely decentralised, open, innovative and creativity-focused (*Figure 10*).

STYLE OF OPERATION	Centralised	Decentralised
ORGANISATIONAL CULTURE	Hierarchic	Open
NATURE OF BUSINESS	Standardised	Innovative
BUSINESS FOCUS	Productivity	Creativity
Business Type	Type α	Type ß
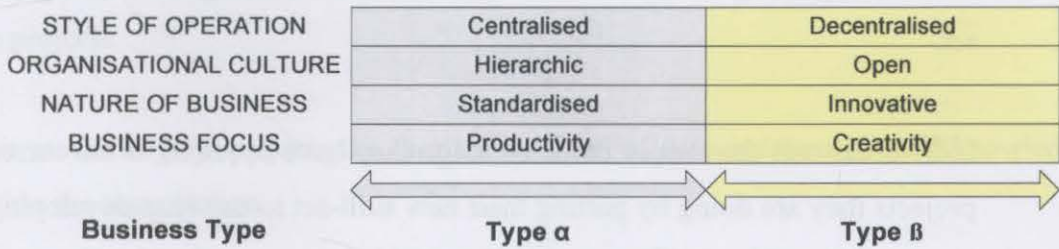
Figure 10: Business Types

5.3 Development of Data, Information and Knowledge Management Models

Utilising the basic premise of the approaches in *section 5.2*, the author has developed data, information and knowledge management infrastructure models (*Figure 11*) to assist construction firms in identifying the components of a KM infrastructure appropriate to their firm. The model is unique in that it not only includes the processes of: organising and retaining/storing, sharing (transferring or retrieving), acquiring, creating or/and utilising but also includes an emphasis on the need for individuals to

analyse, reflect, understand and learn from the data and information shared in order to derive knowledge.

The author proposes two 'models' for the acquisition, creation, and application of knowledge (Model α and Model ß).

Model α

Model α assumes a primary purpose of connecting people to what the firm has (people-to-organisation: using the tools, methods and mechanisms listed in A1 and A2) with Model ß assuming a secondary purpose of connecting people to what other people in the firm have (people-to-people: using the tools, methods and mechanisms listed in B1 and B2) (see *Appendix F, G, H*). With Model α, the firm's existing system organises and retains institutionalised explicit data and information that had been harvested from individuals' tacit knowledge that originally resided in their heads. Individuals then 'share' the data and information by retrieving them via an information system (IS) or knowledge management system (KMS).

Individuals using their existing knowledge and skills then analyse, reflect upon and draw insights from the new data and information in the KMS and subsequently learn from it, upgrading their own awareness and understanding thus adding to their skill-set.

Individuals will then apply the knowledge they have acquired to the current or future projects they are doing by putting their new skill-set to use (e.g. developing a solution to a project problem). The new insights could act as a catalyst leading to the creation of new knowledge (either in their heads (tacitly) or in written form (explicitly)), leading to further innovations.

This model largely supports the 'vertical flow' of data, information and knowledge within the organisation.

Model ß

On the other hand, Model ß serves a primary purpose of connecting people to what other people have (people-to-people: using the tools, methods and mechanisms listed

in B1 and B2) with Model α assuming a secondary purpose of connecting people to what the organization has (people-to-organisation: using the tools, methods and mechanisms listed in A1 and A2) (see *Appendix F, G, H*).

With Model α, individuals possess (tacit) data, information and knowledge in their own heads which are shared (transferred) verbally (e.g. by stories, analogies and metaphors as well as project details such as cost, duration, specifications etc.) between individuals in a group (e.g. formal and informal meetings, and/or ad-hoc discussions) to become explicit data and information.

Individuals using their existing knowledge and skills analyse, reflect upon and draw insights from the new data and information in the KMS and subsequently learn from it, upgrading their own awareness and understanding thus adding to their skill-set. Ideally, they would share what they now know with others in a group (e.g. project team or division).

Having acquired the tacit knowledge, individuals may either apply the knowledge to their projects or decide to create new knowledge. The creation of knowledge may occur tacitly in individuals' heads, or explicitly in the form of diagrams, drawings, and words (either individually or as a group), and subsequently applied the knowledge to the projects.

This model largely supports the 'horizontal flow' of data, information and knowledge within the organisation.

Only Data and Information Exist ⟷ **Data, Information and Knowledge Exist**

Focusing on connecting People-to-Organisation via Retention and Retrieval of data and information using information technology and hardcopy documentation

Data, Information and KM Model α (primarily supports & facilitates repository and retrieval of data and information via connecting people to what the firm has)

Institution	Individual	Individual	Individual	Individual	Group	Individual &/or Group
Data & Information (Explicit)	Data & Information (Explicit)	Data & Information (Tacit)	Knowledge (Tacit)	Knowledge (Tacit) / Knowledge (Explicit)	Knowledge (Explicit)	Knowledge converted to actions (Explicit)
Embedded in the institution (documents &/or technological systems)	Retrieve (physically &/or technologically)	Assisted by individual's existing knowledge & skills	Embedded in individuals' heads	Embedded in individuals' heads / Embedded in written form	Transfer (verbally) / Transfer (written form)	Assisted by individual's/group's existing, newly acquired &/or created knowledge & skills

institutionalising | intuiting & interpreting | interpreting | integrating

Organise & Retain/Store → Share → Analyse, Reflect and Understand → Learn → Acquire → Create → Share → Utilise/Apply

Data, Information and KM Model β (primarily supports & facilitates sharing of data and information via connecting people to what other people in the firm have)

Organise & Retain/Store → Share → Analyse, Reflect and Understand → Learn → Acquire → Create → Share → Utilise/Apply

integrating | intuiting & interpreting | interpreting | integrating

Embedded (in individuals' heads)	Transfer (verbally)	Assisted by individual's existing knowledge & skills	Embedded in individuals' heads	Embedded in individuals' heads / Embedded in written form	Transfer (verbally) / Transfer (written form)	Assisted by individual's existing, newly acquired &/or created knowledge & skills
Data, Information & Knowledge (Tacit)	Data & Information (Explicit)	Data & Information (Tacit)	Knowledge (Tacit)	Knowledge (Tacit) / Knowledge (Explicit)	Knowledge (Explicit)	Knowledge converted to actions (Explicit)
				Individual / Individual &/or Group:		
Individual	Group	Individual	Individual	Individual &/or Group	Group	Individual &/or Group

Focuses on connecting People-to-People via sharing of data and information using direct communication (face-to-face and/ or virtually)

Figure 11: Data, Information and KM Models

Limitations

There are, however, several limitations in both models. Generally, both models rely on the willingness of individuals to share within the 'group' in model α and the 'individual/group' in model ß. A frequent barrier to sharing is the perception that an individual's knowledge within the firm makes him/her irreplaceable, and that disclosing knowledge may adversely affect their job security. Hence, there must be a corporate culture of sharing within the firm before any sharing can realistically occur. Moreover, there is a time commitment involved for individuals to interface with KM systems. This is an increasing problem as time poverty becomes more prevalent.

5.4 Application of the Models to the Case Study Organisations

Model α

When applied to the case study organisation's structure and current KM infrastructure, this model is representative of the vertical 'flow' of data, information and knowledge within the organisation (*Figure 11*). The primary emphasis for this model is on enabling the organisation with the capability to reposit data and information centrally, and providing individuals with the ease of searching for and retrieving what they require. However, if an organisation were to solely adopt this model, individuals from different divisions/departments may only be able to search for and retrieve what they require (e.g. data and information reposited by other divisions) from the organisation's central repository.

Being project-based, this is time-consuming as most project individuals do not have the convenience of returning to their departments or main offices to retrieve (and spend time retrieving) what they require from the central repository. This would be overcome if the KM systems are implemented at the project-level or the project personnel could retrieve what they require from their main offices whilst still based on project sites (neither were implemented in the case study organisations). Also, unless organisationally sanctioned, most employees do not have the hours to spend repositing explicitly what their tacit knowledge into the organisational system. Evidently, if an organisation were to solely operate on model α, the organisational divisions/departments would largely be isolated from each other.

Model ß

When applied to the organisation's structure and current KM infrastructure, this model represents the horizontal 'flow' of data, information and knowledge within the organisation (*Figure 11*). The primary emphasis of this model is on enabling the organisation through the capability of sharing the data and information that was initially residing within individuals (individual repositories) via person to person communication (especially between individuals in a same division/department, and between individuals from different divisions/departments). This could be achieved via ad-hoc discussions, and purpose-formed groups such as communities-of-practice, focus groups, brainstorming sessions, lessons-learnt sessions, and project review meetings or even via technologically-based tools such as discussion/forums or electronic messaging system attached to an intranet. Once individuals have shared their tacit knowledge within a purpose-formed group (horizontal 'flow' via verbal means), they could then either share what they have discovered with their colleagues in their own division/department or individually reposit them into the organisation's central repository (vertical 'flow' via organisation's technological KM system).

5.5   Importance of Considering Organisational Context When Selecting the Most Appropriate KM Tools, Methods and Mechanisms

Generally, the summary of the analysis of the data collected from the research findings may be used as a reference for construction companies to develop their own knowledge management infrastructure.

However, the author recommends that each knowledge management infrastructure should be tailored to suit (each) individual construction firms once the business strategies and objectives of the firm has been mutually agreed between staff from different levels in the firms (to ensure 'buy-in' from all staff in the firm) (that is if a firm wishes to change its current strategies and objectives or develop a KM infrastructure that adapts to their current organisational context).

Moreover, it is not recommended that the organisation should simply 'follow blindly' the findings derived from the case studies to develop a knowledge management infrastructure but to use logic and common sense and holistically consider the context of the firm when doing so. This is because every organisation is unique being made up

of unique individuals with different professions, skill-sets, characteristics, habits etc.- hence the difference in organisational culture, business strategies, objectives, priorities and focus.

It would be a fallacy to simply replicate a knowledge management infrastructure currently existing in other organisations and applying them in another. Also, KM infrastructures should never be simply (and purely) regarded as technological systems (such as IT hardwares, servers, computers, or even softwares) that help manage knowledge. Since an organisation is made of people, it is 'organic' in nature. Hence, a KM infrastructure should also include 'social-enabling' tools, methods and mechanisms which enable individuals and groups to communicate and/or relate to one other.

Therefore, not knowing what each of the case study organisations would have in mind for the future business strategies and objectives of their firm, the author is able to only at best make assumptions that would appear logical for each firm to proceed with improving their current KM infrastructure.

5.6   Analysis of Current KM Infrastructure and Recommendations for Changes for Each of the Three Case Study Firms (see *Appendix F, G, H*)

5.6.1   Firm S: The Taiwanese Firm (see *Appendix F*)

5.6.1.1 Context of the Firm: Analysis and Findings of and Recommendations for the Organisation's Business Type and Priorities

Analysis of the organisation's prevailing business type and priorities (based on 1st tier analysis)

According to the 1st Tier Analysis for 'Business Type' (*Figure 12*), the majority of respondents felt that the organisation was (at time of study) a combination of both 'Type α and ß'.
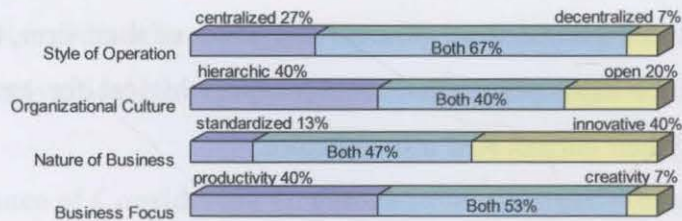
Figure 12: Firm S- Case Study Organisation's Prevailing Business Type (1st Tier Analysis)

Organisation's prevailing business type and approach to managing data, information and knowledge (based on 2nd tier analysis)

On closer examination, according to the 2nd Tier Analysis (*Figure 13*), it appears that the majority of respondents felt they were (largely) a 'Type α' business (which clearly aligns with the fact that the organisation was focusing on connecting its staff to what it has (Model α).
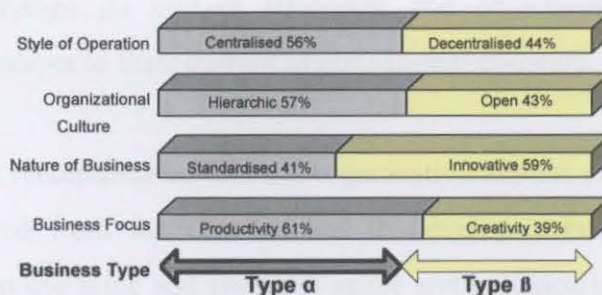
Figure 13: Firm S- Case Study Organisation's Prevailing Business Type (2nd Tier Analysis)

From the above, it is evident that the firm was largely of Type α (being centralised, hierarchic, and productivity focused) with a slight skew towards being an innovative firm rather than a standardised firm. Hence, assuming that the business strategy of the firm was decided based upon the four business types mentioned above, the firm could be considered to have an overall business type of approximately three-quarters Type α and one-quarter Type ß.

Recommendations

Hence, it appears that firm needs to utilise tools, methods and mechanisms that largely (approximately three quarters) support Type α which are tools that connect people to the organisation. The remaining one-quarter should be tools that enable the connection of people to people.

In addition, it appears that the firm's business priorities are largely focused on the operational aspects of the organisation and not its people. The author believes that should an organisation wish to retain its good staff (not just any staff), it also needs to focus on its people's (staff's) needs (e.g. welfare, health and well-being, security), and not just the external customers (i.e. the business clients). The author believes that customer satisfaction should not only refer to meeting the needs of external customers (business clients) but also that of its internal customers (staff).

5.6.1.2 Analysis and Findings of and Recommendations for the Regularity and Effectiveness of the Tools, Methods and Mechanisms Currently Used by the Firm to Manage Data, Information and Knowledge

Generally

On analysis and examination of the regularity of use and the effectiveness of the tools, methods and mechanisms identified by respondents in Appendix E, it appears that the organisation's overarching approach at time of the study was that of linking its staff to what it had in the organisation and people to people via technological tools (Grid A1 sub-total average 7.54 and 7.34, and Grid B1 sub-total average 6.90 and 6.92 respectively). This appears to be followed by the use of non-technological tools to

connect people to people and people to organisation (Grid B2 sub-total average 6.10 and 6.60, and Grid A2 sub-total average 5.50 and 6.21 respectively).

Whilst the firm had the largest emphasis on technological tools, methods and mechanisms that connected its staff to what they had in the organisation (Grid A1), it had placed least emphasis on connecting staff to their non-technological tools, methods and mechanisms (Grid A2). On the other hand, the firm had relatively strong (although lower than those in grid A1) emphasis on tools that connected people to people via both technological (Grid B1) and non-technological tools, methods and mechanisms (Grid B2).

In Detail

(Grid A1) Connecting People-to-Organisation via Technological Tools

Computing tools

Analysis & Findings

The firm had placed most focus on connecting people to what the organisation has via technological tools, methods and mechanisms.

When a comparison was made between the rankings of the tools, methods and mechanisms in terms of their regularity and use, and its various effectiveness in enabling learning between projects and phases, resolve problems, and experience learning at various levels of the firm (see Appendix F), the most important of the tools, methods and mechanisms appear to be *intranets, electronic document management system, and computer aided design programs* while the least important of the tools, methods and mechanisms appears to be *electronic tender document management system, extranet, electronic contract/procurement system.*

In addition, the findings for extranet appeared inconsistent. Although, generally, its regularity of use and effectiveness was one of the highest amongst the computing tools (7.50 and 8.25 respectively), it was amongst the four least effective tools, methods and mechanisms in specifically enabling learning between projects and phases, resolve problems, and experience learning at various levels of the firm.

Recommendations

Intranets, electronic document management system, and computer aided design programs should be given greater emphasis while the *electronic tender document management system, extranet, electronic contract/procurement system* should be given lower emphasis.

Although all the former tools had been highly effective in enabling learning from one project for application in another, *electronic document management system* had been much less regularly used than it had been effective. Hence, the firm needs to focus on encouraging its staff or providing the means of enabling staff to increase the use of this tool. On the other hand, *intranets and computer aided design programs* had been much more regularly used than they had been effective.

Of the latter tools, although they also appear to be relatively effective, they had all been much less regularly used than they had been effective.

(Grid B1) Connecting People-to-People via technological tools

Discussion tools

Analysis & Findings

It was evident that *discussions/forums placed on the intranet/extranet or another program* was not only one of the least regularly used and effective tool amongst the discussion tools but also (overall) one of the least effective of the tools. It had however been much more regularly used than it had been effective.

Recommendations

It is suggested that the firm continue using this tool but with a lower emphasis. This is because since the firm is (currently still) small and compact and all staff were located on the same level, there would be no impending need for them to communicate via discussion forums/boards on the intranet. However, it would be very beneficial for the firm to set up the *discussion forums on the intranet or another program* for the benefit of project staff located on separate project sites to enable them to input and share their queries, comments and replies between other project staff or office staff. This should

only be done provided that the project sites have available access to broadband or wireless services and information technology/systems hardware, and that the firm has and is willing to provide the funds to support such initiatives.

Computing tools

Analysis & Findings

When a comparison was made between the general assessment of the tools, methods and mechanisms in terms of their regularity and use, and its more specific effectiveness in enabling learning between projects and phases, resolve problems, and experience learning at various levels of the firm, it appears that *electronic message exchange* was not only one of the most regularly used and effective of the computing tools while *expertise locator appears* to be the one of the least regularly used and effective tools.

Recommendations

Despite the importance of the former tool, it is suggested that it be given lower emphasis. This is because logically the small, compact and cohesive nature of the firm does not require individuals in the firm to communicate with electronic tools. It is recommended, however, that the firm emphasises the use of this tool more when it gets larger or becomes more fragmented (i.e. when staff are unable to reach each other in person). And when it does so, it needs to encourage its staff to use it more regularly as it is currently much less regularly used than it is effective.

However, it would be certainly be more beneficial to project staff located on different project sites who would like to communicate with one other and/or their office staff. The firm should therefore continue with the provision of *electronic message exchange* as long as it is willing to support (and the proliferation of) its use by project staff located in different project sites and that funds are available to support that function.

As for the latter, it is suggested that the firm shelve *expertise locator* since it was clearly the least regularly used and effective as well as effective of the tools. Again, this may be due to the small, compact and cohesive nature of the firm (i.e. staff could easily communicate with each other), thereby making it easy for staff to locate each

other. However, the author suggests that it would be more useful if such a tool was made available on the company's website for its external customers to locate the firm's professionals when they need to.

(B2) Connecting People-to-People via Non Technological Tools

Discussion tools

Analysis & Findings

When a comparison was made between the general assessment of the tools, methods and mechanisms in terms of their regularity and use, and its more specific effectiveness in enabling learning between projects and phases, resolve problems, and experience learning at various levels of the firm, *regular and irregular (ad-hoc) discussions between superior and subordinate, and irregular (ad-hoc) discussions between employees of same or similar standings or position appears to have been much more regularly used and effective* than regular (ad-hoc) discussions between employees of same or similar standings or position appears (which also appears to have largely been the least regularly used and effective of the tools).

Recommendations

The firm should place greater emphasis on *regular and irregular (ad-hoc) discussions between superior and subordinate*, and *irregular (ad-hoc) discussions between employees of same or similar standings or position in the firm* as well as encourage or enable its staff to have more opportunities for discussions (since they appear to be much less regularly used than they had been effective) while lower emphasis should be given to *regular discussions between employees of same or similar standings or position in the firm*.

Sessions/forums tools

Analysis & Findings

Brainstorming sessions and information sessions, seminars, forums, talks, expert panel appears to have the one of the most capable tools in enabling learning between projects and between phases while *project lessons-learnt sharing sessions and team building*

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activities had been the one of the least capable. However, generally, *brainstorming sessions and team building activities* had been one of the most regularly used and effective tool while *information sessions, seminars, forums, talks, expert panels and project lessons-learnt sharing sessions* had been one of the least regularly used and effective tool.

Recommendations

It is suggested that the firm place greater emphasis on *brainstorming sessions and information sessions, seminars, forums, talks, expert panel* since they had been one of the most regularly and effectively used of the *sessions/forums* tools in specifically enabling learning between projects and between phases, resolving problems and experiencing learning at various levels of the organisation (despite the much lower capability of the latter tool). Lower emphasis should be given to *project lessons-learnt sharing sessions and team building activities* since they had been the least effective of the tools (despite the much higher regularity and effectiveness of use of team building activities).

Also, the firm should encourage its staff to increase the use of all the *sessions/forums* tools since they had all been much less regularly used than they had been effective.

In particular, it is suggested that firm focus on *brainstorming sessions*- especially during each project and for the company meetings in order to draw new ideas (and help continually be innovative).

Again, due to the size of the firm, it also appears that there is less need for *project lessons-learnt sharing sessions and team building activities* since staff in the firm were collegial and could reach each other easily (as observed by the author and mentioned by staff). *Project lessons-learnt sharing sessions* would, however, be beneficial to project staff who were located on different project sites to come together and learn from each others' project experiences.

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<u>Meeting tools</u>

Analysis & Findings

Formal project-team meetings and management meetings appear to have been the most (equally) effective as well as regularly used and effective tools while *directors' only meetings* was the least effective of the meeting tools.

However, all three tools appear to have been highly effective in enabling learning to occur from one project for application in another.

Recommendations

It is suggested that the firm give greater emphasis all the meeting tools. This is because *formal project team meetings and management meeting*s had been the most effective and regularly used and effective of the tools while *directors' only meetings* (despite having received below average response rates for its existence) appear to have been the most regularly used and effective tool.

Furthermore, it is suggested that the firm encourages its staff to use (and provides the means for) *formal project team meetings and directors' only meetings* to be held more regularly since they were currently much less regularly used than they had been effective. Only *management meetings* had been as regularly used as it had been effective.

<u>Project Reviews tools</u>

Analysis & Findings

It appears that *informal reportback/feedback sessions by employees to superiors* had been the most regularly used and effective as well as the most effective of the project review tools while *meetings to discuss/evaluate completed project reviews* had been the least regularly used and effective as well as the least effective of the tools.

Recommendations

It is suggested that the firm give greater emphasis on *informal reportback/feedback sessions by employees to superiors* (even though it had already been much more

regularly used than it had been effective), and lower emphasis on *meetings to discuss/evaluate completed project reviews.*

The latter tool may currently not be as important since the firm is still small in size where staff still had the opportunity to informally communicate to each other direct and share their experiences, and did not require a formal medium of doing so.

Human Resource tools

Analysis & Findings

Mentoring and apprenticeship, and formal rotation of people around projects, functional departments, different job scopes appears to have been the most effective and most regularly used and effective of the tools while *work induction for new staff* and *informal rotation of people around projects, functional departments, different job scopes* had been the least effective and the least regularly used and effective of the tools.

Recommendations

Therefore, it is suggested that the firm gives greater emphasis on *mentoring and apprenticeship, and formal rotation of people around projects, functional departments, different job scopes* and lower emphasis on *work induction for new staff* and *informal rotation of people around projects, functional departments, different job scopes.*

This is because although the firm is small, the author believes that *mentoring and apprenticeship* should still be a necessity in the firm to enable the more experienced staff to share their knowledge and experiences directly with new staff or fresh graduates, while since the *formal rotation of people around projects, functional departments, different job scopes* appears to have been much more regularly used and effective as well as more effective than *informal rotation of people around projects, functional departments, different job scopes*, the firm should simply use the formal mode of rotation.

Also, due to the small, compact and collegial nature of the firm, *work induction for new staff* may not be pertinent to the firm at the moments since staff could easily get to know one another.

(A2) Connecting People-to-Organisation via non technological tools

Project Reviews

Analysis & Findings

The firm currently appears to be weakest in the use and effectiveness of both *project reviews at the end of each phase of a project and formal post-project reviews*. This may be because the firm is small and compact and their staff turnover is very low, hence the knowledge and experience would be usually retained amongst the staff in the firm and easily shared amongst them. However, the former was one of the less effective tool (but not the least) of the project review tools while the latter was one of the most effective.

Recommendations

It is suggested that the firm give greater emphasis on *formal post-project reviews* and less emphasis on *project reviews at the end of each phase of a project* since they appear to be weak in both tools and weaker in *formal post-project reviews* than *project reviews at the end of each phase of a project*. Once the former gets running and is stable, the firm could consider implemented the latter.

Furthermore, the firm has to encourage their staff to use *formal post-project reviews* more regularly since it is currently used less regularly than it is effective, and that both tools did not have significant responses to indicate that the tools existed.

The firm may do a 'trial' of project reviews (starting with post project reviews). This is to insure the firm for two reasons: 1) just in case someone leaves the firm, the knowledge and experiences would not be lost, 2) humans have limited memory capabilities- we cannot remember every single detail that occurred on a project, hence it would be useful for staff to record their knowledge and experiences for future reference (especially to learn from their past mistakes and not make them again).

Manuals/Guidelines/Standards tools

Analysis & Findings

Project management and quality assurance manuals appear to be the most effective of the review tools while *lessons-learnt manuals and best practices* guides appear to have been least effective tools.

However, *project management manuals* had been much more regularly used and effective than *quality assurance manuals, lessons-learnt manuals and best practices guides.*

Recommendations

Although findings appear to suggest that the firm should place greater emphasis on *project management and quality assurance manuals*, and lower emphasis on *best practices guides and lessons-learnt manuals*, the author suggests that the firm should instead place lower focus on *project management and quality assurance manuals* and more emphasis on *lessons-learnt manuals and best practices guides*. This is because since the firm is trying to maintain its focus on being an innovative rather than standardised firm, it needs to be able to learn from its past experiences and knowledge which *lessons-learnt manuals and best practices guide* are effective of doing while *project management and quality assurance manuals* are best used as references or guides.

5.6.1.3 Summary of Recommendations for Changes to be Made in the Firm

Should the firm wish to maintain its current business type and priorities, it should focus approximately three-quarters of its KM efforts on tools that connect people to what the organisation has, and one-quarter on tools that connect people to people. A table outlining the suggested/recommended focus of the tools is espoused below, and categorised in terms of those tools which are meant to be the primary focus, secondary focus and recommended to be removed.

Grid	Primary emphasis	Secondary Emphasis	To be removed
A1		**Computing tools**	
	Intranet	Electronic tender document	-
	Electronic document management system	management system	
		Extranet	
	Computer aided design programs	Electronic contract/procurement system	
B1		**Discussion tools**	
	-	Discussion/forum boards placed on intranet/extranet	-
		Computing tools	
	-	Electronic message exchange	Expertise locator (could be placed on the firm's website, however, to enable external customers to locate professionals in the firm)
B2		**Discussion tools**	
	Regular and irregular discussions between superior and subordinate	Regular discussions between peers	-
	Irregular discussions between peers		
		Sessions/forums tools	
	Brainstorming sessions	Project lessons-learnt sharing sessions	-
	Information sessions, seminars, forums, talks	Team building activities	
		Meetings tools	
	Formal project-team meetings	-	
	Management meetings		
	Directors' only meetings		
		Project review tools	
	Informal reportback/feedback sessions by employees to superiors	Meetings to discuss/evaluate completed project reviews	
		Human resource tools	
	Mentoring and apprenticeships	Work induction for new staff	-
	Formal rotation of people around projects, functional departments, different job scopes	Informal rotation of people around projects, functional departments, different job scopes	
A2		**Project review tools**	
	Formal post-project reviews	Project reviews at the end of each phase of a project	-
		Manuals/guidelines/standards tools	
	Lessons-learnt manuals	Project management manuals	-
	Best practice guides	Quality assurance manuals	

Table 21: Firm S- Summary of Recommendations for Changes to be made in the Firm

Limitations

It is important to note, however, that the President's view (under 2nd Tier Analysis) contrasted that of the majority of respondents. He believed that the organisation was currently a 'Type ß' business (he described the firm as 'decentralised', 'open', 'innovative', and 'creativity-focused'). (i.e. apart from 'nature of business' which both the majority of respondents and President felt the organisation was 'innovative', the President's contrasted with the majority of the respondents views on 'style of operation', 'organisational culture', 'business focus').

Should the President intend to take a full 'Approach ß', he should discuss his intentions with and make them clear to all staff regarding the purpose of his decisions, and seek their understanding and concurrence in order to align the organisation's business aims, objectives and strategies prior to proceeding with the initiatives. Also,

prior to taking 'Approach ß', any gaps arising from any differences in the priorities of the organisational objectives should be discussed and the final 'direction' agreed with all staff.

The prospects of the organisation taking 'Approach ß' is further supported by findings espoused in *Table 1* which showed that the majority of respondents would like to improve the following business objectives: 'cultivating staff creativity and innovation' (need to improve by a gap of 25%), staff satisfaction and support (24%), staff development (23%); indicating that the organisation has a wish to become more open, creative and innovative.

Should the firm decide to take the above approach, it is pertinent that the organisation does not ignore the enabling the connection between its people to the data and information it has. This is because a formalised 'infrastructure/system' assists the organisation in retaining data and information that exists in individuals' heads when they retire and/or resign from the organisation (with particular attention on the capturing and retention of individuals' 'exemplars' of past project experiences via storytelling, analogies).

5.6.2 Firm M – The American Firm (see *Appendix G*)

5.6.2.1 Context of the Firm: Analysis and Findings of and Recommendations for the Firm's Business Type and Priorities

Analysis of the organisation's prevailing business type and priorities (based on 1st tier analysis)

According to the 1st Tier Analysis for 'Business Type' (*Figure 14*), the majority of respondents felt that the organisation was (at time of study) partially taking a mixed 'Type α and ß', and Type ß approach.
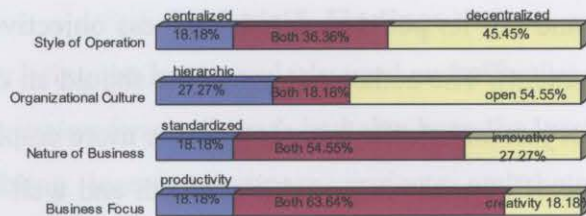
Figure 14: Firm M- Case Study Organisation's Prevailing Business Type (1st Tier Analysis)

Organisation's prevailing business type and approach to managing data, information and knowledge (based on 2nd tier analysis)

On closer examination, according to the 2nd Tier Analysis *(Figure 15)*, it appears that the majority of respondents felt they were (largely) a 'Type ß' business.
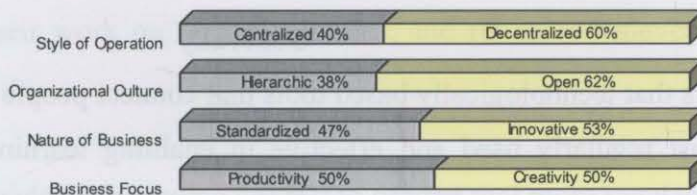
Figure 15: Firm M- Case Study Organisation's Prevailing Business Type (2nd Tier Analysis)

From the above, it is evident that the firm was largely of Type ß (being decentralised, open, innovative, and creativity focused); except for business focus which was equally distributed between productivity and creativity. Hence, assuming that the business strategy of the firm was decided based upon the four business types mentioned above,

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the firm could be considered to have an overall business type of three and a half-quarters Type ß and half-a-quarter Type α.

Recommendations

Hence, it appears that three and a half-quarter of the tools, methods and mechanisms should be those that support Type ß that enable the connection of people to people. The remaining half-a-quarter should be tools that enable the connection of people to organisation.

In addition, it appears that the firm's business priorities were relatively similar to the Taiwanese firm. They were largely focused on the operational aspects of the organisation and not its people; only 1 business objective was that of people aspects (staff development). The author reiterates that should an organisation wish to retain its good staff (not just any staff), it needs to place more emphasis on (at least not neglect) its people's (staff's) needs (e.g. welfare, health and well-being, security), and not just the external customers (i.e. the business clients). The customers of the firm should not just be the external customers (business clients) but also that of its internal customers (staff).

5.6.2.2 Analysis and Findings of and Recommendations for the Regularity of Use and Effectiveness of the Tools, Methods and Mechanisms Currently Used by the Firm to Manage Data, Information and Knowledge

Generally

It appears that technologically based tools that connect people to people (Grid B1) had been most regularly used and effective in enabling learning from one project for application in another. This was followed relatively equally by the use of technologically-based tools that connect its people to the organisation (Grid A1) and non-technologically based tools that connect people to people (Grid B2).

In contrast, non-technological tools that connect people to organisation (Grid A2) had been least regularly used and effective in enabling learning from one project for application in another.

Hence, the firm appears to be largely focused on connecting its people to the organisation and people to people via technologically-based means, and connecting people to people by non-technological means. They had not insufficiently focused on the non-technological means that connect people to the organisation.

In Detail

(Grid B1) Connecting People-to-People via technological tools

Discussions

Analysis & Findings

Apart from generally being the least regularly used and effective (6.00 and 6.40) of the discussion tools, *discussion forums/boards* had also been the least effective of the tools in specifically enabling learning between projects and between project phases, resolving problems and enabling respondents to experience learning at various levels of the organisation.

Recommendations

Despite apparently being least regularly used and effective, the author suggests that due to the size of the organisation and difficulty for project staff to meet together for discussions, the firm should continue encouraging its staff to utilise this more. Staff can simply place their comments, advice or queries on the forum/board and then proceed with their work on the project sites, and return (whenever they are free) to view or answer it.

The firm also needs to encourage its staff to use the tool more regularly as it had not been as regularly used as it had been effective.

Computing tools

Analysis & Findings

Generally, *electronic message exchange* had been much more regularly used and effective than expertise locator (former: 9.57 and 9.00 respectively; latter: 6.60 and

6.20 respectively). This was consistent with findings on the specific effectiveness of the tools in that the former tool had been one of the most effective in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation while the latter had been much less effective in doing so in the firm.

Expertise locator may have been much less regularly used and effective and effective because, internally, staff knew or had little difficulty in knowing where or who to look for when they needed some advice. Furthermore, all staff were located on the same level in the office building.

Recommendations

It is suggested that the continual primary use of *electronic message exchange* (this tool is easy to use and is usually a freeware- especially for project-based staff who have internet access) while *expertise locator* be maintained but placed on lower emphasis.

(A1) Connecting People-to-Organisation via technological tools

Computing tools

Analysis & Findings

Generally, only *intranets, computer aided design programs, and electronic contract/procurement system* appear to have been most regularly used and effective (9.50 and 8.13, 7.86 and 8.29, and 8.00 and 7.50 respectively). This was followed by *extranet and electronic document management system* which had been much less regularly used and effective (7.40 and 6.00, and 7.00 and 6.17 respectively) while *electronic tender document management system* had been the least regularly used and effective (5.33 and 5.33).

On detailed analysis, *intranets, computer aided design programs, extranet and electronic document management system* appear relatively consistent with the findings of the effectiveness of the tools in specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation. However, *electronic contract/procurement*

management system appears to be one of the least effective of the computing tools in doing so (which contradicted that of the general findings). In addition, the findings for the specific effectiveness of the *electronic tender document management* also appeared to have been consistent with the general findings.

Recommendations

Hence, it is suggested that *intranet and computer aided design programs* be given greater emphasis while the remaining tools be given lower emphasis. Also, the firm should encourage their staff to use *computer aided design programs* more regularly since it had been much less regularly used while the remaining tools had been much more regularly used than it had been effective. If there was a tool that should be eliminated based on its effectiveness, it would be *electronic tender document management system*, followed by *contract/procurement system*. However, the author suggests that they should not removed as they are (and will continue to be) important platforms on which past projects' tender and contract documentation and even lessons-learnt could be retained in the firm's 'knowledge' repository.

(B2) Connecting People-to-People via non technological tools

Discussion tools

Analysis & Findings

All the discussion tools appear to have been very effective as well as regularly used and effective. The most consistently regularly used and effective tools appear to be *irregular discussions (between employees of same or similar standing, and between superior and subordinate)* (7.57 and 7.43, and 7.29 and 7.29 respectively). *Regular discussions (between peers, and between superior and subordinate)* appear to have been much less regularly used than effective (6.00 and 8.29, and 6.57 and 7.43 respectively).

Interestingly, the irregular discussions did not appear to have been as effective in specifically enabling learning between projects, resolving generic and recurrent problems. They had however been the most effective in specifically enabling learning between project phases within a project and resolving specific and less-recurrent

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problems while a mix of regular and irregular discussions appears to have been more prevalent in enabling respondents to experience learning at various levels of the organisation.

Recommendations

It is suggested that all the discussion tools be given greater emphasis since the firm is taking approach B. However, due to the larger size of the firm and since most project staff are segregated on different project sites (i.e. often not in office), the author suggests that the firm institute formal requirements for project staff to meet up (either physically in office or virtually using information technology) to ensure regular discussions occur amongst staff. It also needs to encourage its staff to use both the regular discussion tools more regularly as they are currently much less regularly used despite having been most effective).

Sessions/forums tools

Analysis & Findings

Generally, all the tools appear to have been relatively regularly used and effective. *Information sessions, seminars, forums, talks, expert panels and brainstorming sessions* appear to have the consistent in having been most regularly used and effective of the tools (7.00 and 7.67, and 7.14 and 7.71 respectively) while *project lessons-learnt sharing sessions and team building activities* had been the much less (and least) regularly used than effective (6.00 and 8.14, and 4.67 and 7.17 respectively). Overall, *team building activities* appear to be the least competent.

Although *brainstorming sessions* appear to have been one of the most effective in specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, this was not evident for *information sessions, seminars, forums, talks, expert panels*. The detailed analysis also revealed that *project lessons-learnt sharing sessions* had been the most effective of the tools while *team building activities* was the least.

Recommendations

Therefore, it is suggested that *project lessons-learnt sharing sessions and brainstorming sessions, and information sessions, seminars, forums, talks, expert panels* be given greater emphasis, while team building activities be given lower emphasis.

In addition, the firm needs to encourage its staff to use all the tools in this category more regularly as they had been all been much less regularly used despite their much higher effectiveness. In particular, the largest variance lies with *project lesson-learnt sharing sessions and team building activities*; of which the firm needs to encourage its staff to use more of the former since it had been the most effective.

Meeting tools

Analysis & Findings

It appears that despite having been identified as generally the most effective tool in enabling learning from one project for application in another (5.50 and 8.67), *directors' only meetings* had been the least effective in specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

On the other hand, it was clear that *formal project team meetings* (8.88 and 8.38), followed by *management meetings* (7.14 and 6.57) appears had generally been the most regularly used and effective as well as specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

Recommendations

It is suggested that greater emphasis should be placed on *formal project-team meetings and management meetings* than *directors' only meetings*.

Also, it is necessary for all three tools to exist because each of three tools apparently enable staff to primarily experience learning at different levels of the organisation:

formal project team meeting- individual and project levels; management meeting-individual and division levels; and directors' only meetings- corporate level.

In addition, it is important for the organisation to note that these tools should not be utilised in segregation from one another. Instead, they need to ensure that outcomes of discussions as well as instructions are communicated between the different meetings (e.g. decisions (that affect other levels of staff) made by the directors at *directors' only meetings* should have taken other levels of staff into consideration, and communicated to other levels of the staff).

Project Review tools

Analysis & Findings

Generally, both *informal verbal reportback sessions and meetings to discussion/evaluate completed project reviews* appear to have relatively regularly used and effective.

Only *informal verbal reportback sessions* appear to have been effective in specifically enabling learning between projects and between project phases, and resolving specific and less-recurrent problems. It had been much less (and least) effective in resolving generic and recurrent problems, and enabling respondents to experience learning at the individual and division levels.

Furthermore, *meetings to discussion/evaluate completed project reviews* had only been effective in enabling respondents to experience learning at the corporate level, and ineffective in all other aspects.

Recommendations

Despite the above findings, it is suggested that both *informal verbal reportback and meetings to discuss completed project reviews* should be given greater emphasis and that staff should be encouraged to use them more regularly since it had been much less regularly used despite its much higher effectiveness. This is because the latter tool would aid project staff in understanding, sharing their views and ideas as well as reflecting upon the lessons-learnt recorded in the formal project reviews. Furthermore,

there would be no logical point in collecting and storing data, information and even lessons-learnt storied from past projects if no activities are instituted for staff to sharing their views of these past experiences to understand and reflect upon in order to derive new ideas.

Also, as observed in the firm and discussed with respondents, it was apparent that staff felt that it was often not the fact that they did not wish to have meetings to discuss past projects or even discussions to share their knowledge with others, but the time (commitment) involved in doing so. They were already extremely busy as such, and have difficulty 'squeezing' extra time for the meetings. Furthermore, such meetings if held often had to be held outside their office hours (which they had to spend on project sites, meetings clients, consultants and contractors), and such time were not company designated time and neither were they financially accounted for as part of a project and the organisation's costs.

Human Resource tools

Analysis & Findings

Generally, *mentoring and apprenticeship, informal procedures for rotating people around projects, and work induction for new staff* appear to have been the most regularly used and effective of the tools. *Formal procedures for rotating people around projects, functional departments, different jobs scopes* had been the least regularly used and effective. Furthermore, the *informal mode of rotation* had been (much more) regularly used and effective than the formal mode.

The above general findings were also consistent with the more specific effectiveness of the tools in enabling learning between projects and between project phases, and resolving specific and less-recurrent problems in having *mentoring and apprenticeship* as being most effective, followed by *work induction for new staff, informal and then formal rotation of people around projects, functional departments, different jobs scopes.*

Recommendations

Due to largeness of the firm and hence the difficult for new staff to get to know others in the firm, the author suggests that it is still necessary to have *work induction for new staff* (despite having been not as effective as it had been regularly used), *mentoring and apprenticeship* (to enable experienced staff to guide/train new staff), and *informal rotation of people around projects, functional departments, different job scopes etc* (as they had been much more effective in enabling learning in this firm than the formal mode).

However, *work induction for new staff* should not be placed as primary emphasis while *mentoring and apprenticeship and informal rotation* should be placed as primary emphasis. And since informal mode of rotating people had been much more regularly used and effective (generally and specifically) than the formal mode, the firm should simply do away with the formal mode.

(Grid A2) Connecting People-to-Organisation via non technological tools

Project Reviews

Analysis & Findings

Both project reviews tools appear to have been generally highly regularly used and effective as well as specifically highly effective in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

Recommendations

Being a project-based organisation and since the tools had been highly regularly used and effective, these tools should be placed on primary emphasis and staff should be encouraged to use them more regularly as they had been much less regularly used despite having been highly effective.

Also, the project review tools were clearly much more important in a larger firm (as compared to the smaller and more compact Taiwanese firm) because it was much more difficult for staff in larger firms to 'reach' (i.e. locate) one another as compared to the

small/compact one. Project review tools would not only potentially enable all firms to record and retain such valuable lessons-learnt by individual staff on different projects to learn from each other but also enable the prevention of loss of data, information, and lessons-learnt in the event of their departure (e.g. resignation or made redundant).

Manuals/Guidelines/Standards tools

Analysis & Findings

Generally, *project management and quality assurance manuals* appear to have been the most regularly used and effective tools while *best practices guides and lessons-learnt manuals* had been the least effective.

These appear to be consistent with the more specific findings of the effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

Recommendations

Although *project management and quality assurance manuals* had been the most regularly used and effective tools as well as the most specifically effective tools, and *best practices guides and lessons-learnt manuals* were the least in both aspects, it is suggested that the firm place greater emphasis on the latter tools and lower emphasis on the former tools. This is because *lessons-learnt manuals and best practices guides* are fundamental tools that should be implemented to provide staff with 'examples' of things that had happened in previous projects in order to enable learning from one project for application in another while *project management and quality assurance manuals* (although they appear to be very effective) should only be used as a source of reference and does not contain lessons-learnt experiences). Hence, the former tools should be placed as primary emphasis while the latter as secondary emphasis.

Furthermore, while the firm should encourage its staff to use *best practices guides* more regularly as it had been less regularly used than it had been effective, it should also regularly improve/update its contents while it also should implement/develop

lessons-learnt manuals that enable staff to explicitly record and allow others to learn from what their colleagues had learnt.

5.6.2.3 Summary of Recommendations for Changes to be Made in the Firm

It appears that the firm is currently well-placed in terms of 'organising' its KM initiatives in line with its business objectives and priorities, since its emphasis is largely on connecting what individuals know with each other (people to people) and individuals to what the organisation knows (people to organisation) via technologically, and people to people non-technologically. It also appears to be the most capable of the three case study firms in aligning its business objectives/priorities with the tools, methods and mechanisms employed to manage knowledge.

However, it still appears to be lacking in the proliferation and use of information technology tools that enable staff who are geographical segregated from each other to locate one other and tap on each others' expertise (e.g. discussion forums/boards, expertise locator) as well as tools that effect the personal (face-to-face) transference of knowledge and skills from a more experience person to a less experienced person (mentoring and apprenticeship, and management meetings).

In addition, the firm appears to be dreadfully lacking in the utilisation of lessons-learnt manuals and best practice guides to enable its staff to retrieve, understand, and learn from past projects for application in new or future projects.

Grid	Primary Emphasis	Secondary Emphasis	To be removed
B1		**Discussion tools**	
	Discussion/forum boards placed on intranet/extranet		-
		Computing tools	
	Electronic message exchange	Expertise locator (could be placed on the firm's website, however, to enable external customers to locate professionals in the firm)	-
A1		**Computing tools**	
	Intranet	Electronic document management system	-
	Computer aided design programs	Electronic tender document management system	
		Extranet	
		Electronic contract/procurement system	
B2		**Discussion tools**	
	Regular and irregular discussions between superior and subordinate		-
	Regular and irregular discussions between peers		
		Sessions/forums tools	
	Brainstorming sessions	Team building activities	-
	Information sessions, seminars, forums, talks		
	Project lessons-learnt sharing sessions		
		Meetings tools	
	Formal project-team meetings	Directors' only meetings	-
	Management meetings		
		Project review tools	
	Informal reportback/feedback sessions by employees to superiors	-	-
	Meetings to discuss/evaluate completed project reviews		
		Human resource tools	
	Mentoring and apprenticeships	Work induction for new staff	Formal rotation of people around projects, functional departments, different job scopes
	Informal rotation of people around projects, functional departments, different job scopes		
A2		**Project review tools**	
	Formal post-project reviews	-	-
	Project reviews at the end of each phase of a project		
		Manuals/guidelines/standards tools	
	Lessons-learnt manuals	Project management manuals	-
	Best practice guides	Quality assurance manuals	

Table 22: Firm M- Summary of Recommendations for Changes to be made in the Firm

5.6.3   Firm L - Singaporean (see *Appendix H*)

5.6.3.1 Context of the Firm: Analysis and Findings of and Recommendations for the Firm's Business Type and Priorities

Analysis of the Firm's prevailing business type and priorities
(based on 1st tier analysis)

According to the 1st Tier Analysis for 'Business Type' (*Figure 16*), the majority of respondents felt that the organisation was (at time of study) partially taking a mixed 'Type α and ß', and Type α approach.
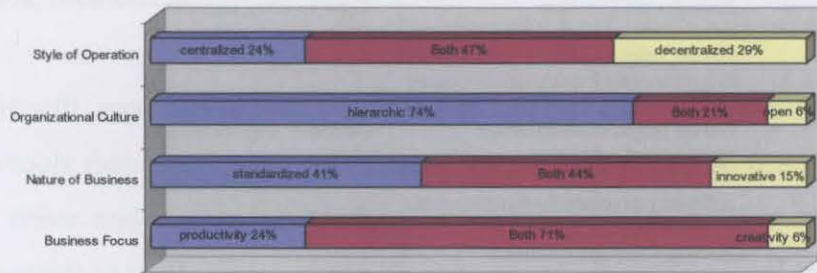
Figure 16: Firm L- Case Study Firm's Prevailing Business Type (1st Tier Analysis)

Firm's prevailing business type and approach to
managing data, information and knowledge (based on 2nd tier analysis)

On closer examination, according to the 2nd Tier Analysis (*Figure 17*), it appears that the majority of respondents felt they were (largely) a 'Type α' business.
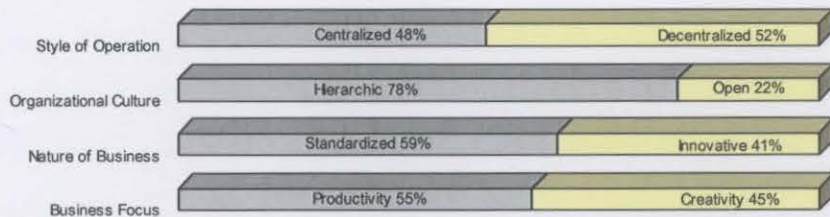
Figure 17: Firm L- Case Study Firm's Prevailing Business Type (2nd Tier Analysis)

From the above, it is evident that the firm was largely of Type α (being hierarchic, standardised, and productivity focused); except for style of operation which was slightly skewed towards decentralised.

Hence, assuming that the business strategy of the firm was decided based upon the four business types mentioned above, the firm could be considered to have an overall business type of approximately three-quarters Type α and one-quarter Type ß.

Recommendations

From the above, it appears that firm needs to utilise tools, methods and mechanisms that largely (three-quarters) support Type α which are tools that connect people to what the organisation has. The remaining one-quarter should be tools that enable the connection of people to people.

However, dissimilar to the Taiwanese and American firm, it appears that the firm's business priorities were entirely and primarily focused on the operational aspects of the organisation. All the people aspects were placed as secondary priorities. Interestingly, an operational aspect (business processes) was also included in secondary priorities.

Internally, senior management and professional staff appear mixed in their interpretation of the priorities of technological capability (which top management believing that it had been given primary emphasis while professional staff believed that it had only been given secondary emphasis) and cost of projects (which professional staff believed that it had been given primary emphasis while top management believed it had been given secondary emphasis).

The author believes that should an organisation wish to retain its good staff (not just any staff), it needs to focus more on its people (staff) and their needs (welfare, well-being, job security, good work environment), and not just focus on the external customers (i.e. the business clients). In other words, the customers of the firm should not just be the external customers (business clients) but also that of its internal customers (staff).

5.6.3.2 Analysis and Findings of and Recommendations for the Regularity of Use and Effectiveness of the Tools, Methods and Mechanisms Currently Used by the Firm to Manage Data, Information and Knowledge

Generally

It appears that the firm had most been regularly used and effective in enabling staff to learn from one project for application in another via the use of non technologically-based tools to connect people to people (Grid B2). This was followed by the use of technologically-based tools to connection people to people (Grid B1), and non technologically-based tools to connect people to what the organisation has (Grid A2). It had found non technologically-based tools to connect people to what the organisation (Grid A1) to have been the least regularly used and effective of the tools.

Hence, the firm appears to have placed greater emphasis on connecting its people to its people, and much lesser emphasis on connecting people to what the organisation has (both first via non technologically-based tools, and then technologically-based tools).

In Detail

(Grid B2) Connecting People-to-People via non Technological Tools

Discussion tools

Analysis & Findings

Generally, it appears that most of the verbal discussion tools had been highly regularly used and effective in enabling learning from one project for application in another: *irregular discussions between peers* (8.50 and 8.00 respectively); *regular discussions between peers* (7.20 and 8.00 respectively), *irregular discussions between superior and subordinates* (7.14 and 7.50 respectively). Only *regular discussions between superior and subordinates* appear to have a substantial variance between its regularity of used (6.89) and effectiveness (8.11).

On closer examination of the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to

experience learning at various levels of the organisation, it appears that *irregular discussions between peers* had been one of the most effective while regular discussions between peers appears to be one of the least effective. The specific effectiveness of *regular and irregular discussions between superior and subordinates* were however consistent with the general findings above.

Recommendations

It is suggested that the firm place primary emphasis on *irregular discussions between peers, irregular and regular discussions between superior and subordinates*, and secondary emphasis on *regular discussions between peers*.

Furthermore, the firm should encourage its staff to use *regular and irregular discussions between superior and subordinates* more regularly since they had been much less regularly used despite having been very effective (with particular focus on the former).

Sessions/forums tools

Analysis & Findings

Generally, *project lessons-learnt sharing sessions, brainstorming sessions, and information sessions, seminars, forums, talks, expert panels* appear to have been the most regularly used and effective of the *sessions/forums* tools while team building activities had been the least.

On closer examination of the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, it appears that the above findings were consistent in that *project lessons-learnt sharing sessions* was clearly the most effective of the tools, followed equally by *information sessions, seminars, forums, talks, expert panels, and brainstorming sessions*. It was also clear that the least effective was *team building activities*.

Recommendations

Since it appears that most of these tools (*project lessons-learnt sharing sessions, information sessions, seminars, forums, talks, expert panels, and brainstorming sessions*) were highly effective, they should be given primary emphasis (with particular focus on *project lessons-learnt sharing sessions*)

Between *brainstorming sessions and information sessions, seminars, forums, talks, expert panels*, however, the author suggests that greater emphasis needs to given to improving the existence and use of *brainstorming sessions* than *information sessions, seminars, forums, talks, expert panels* (due to the former being generally much effective than the latter).

Furthermore, as discovered from discussions with respondents, since most project staff 'rarely' get to meet one another to share their knowledge and experiences or to know one another (due to the large size of the firm, mostly being out on project sites, and the layout of the different divisions), it is not only necessary to utilised tools to enable staff to meet up to share what they know with each other but also tools that enable them to get to know (familiarise with) each other (especially important for newcomers to the firm)- i.e. a need for team building activities. However, they should be given secondary emphasis.

In addition, since all the tools in this category appear to have been much less regularly used than they had been effective, there is a need for the firm to encourage its staff to use them more regularly.

Meeting tools

Analysis & Findings

Generally, *formal project team meetings* appear to have the most regularly used and effective in enabling learning from one project for application in another, and followed by *management meetings*. The least regularly used and effective tool was *directors' only meetings*.

On closer examination of the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, it appears that *management meetings* were the most regularly used and effective of the tools, followed by *formal project team meetings* while the least effective was clearly *directors' only meetings*.

Recommendations

It is suggested since *directors' only meetings* appear to not only be insignificantly regularly used and effective and also the least effective, it should be placed on secondary emphasis while *formal project-team meetings and management meetings* be given primary emphasis since they had been both highly regularly used and effective.

Project Reviews tools

Analysis & Findings

Although both meetings to *discuss/evaluate completed project reviews and informal verbal reportback sessions* appear to have been relatively regularly used and effective (former: 6.29 and 7.43 respectively; latter: 6.40 and 7.20 respectively), the latter appears to have been the most effective, followed by *meetings to discuss/evaluate completed project reviews* when a more detailed examination was made of the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

Recommendations

The author suggests that even though it may be difficult for staff to get together for meetings or discussions since they are often moving around from project to project or based on sites, both tools should still be given primary emphasis and that staff should be encouraged to use them more regularly since they had been much more effective than they had been regularly used.

Human Resource tools

Analysis & Findings

Generally, it appears that *formal procedures for rotating people around projects, functional departments, different jobs scopes etc*, and *mentoring and apprenticeship* had been the most regularly used and effective of the human resource tools while *informal rotation of people around projects, functional departments, different jobs scopes etc, and work induction for new staff* had been the least regularly used and effective.

In contrast, the findings from the closer examination of the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation appears to show otherwise for *formal and informal procedures for rotating people around projects, functional departments, different jobs scopes etc*- the former had been one of the least effective of the tools while the latter had been the most effective.

However, the detailed findings were consistent with that of the earlier general findings in that *mentoring and apprenticeship* had been the second most effective while *work induction for new staff* was clearly the least effective.

Recommendations

The author suggests that, *mentoring and apprenticeship and informal rotation of people around projects, functional departments, different jobs scopes etc* be given primary emphasis.

On the other hand, although it would appear logical to remove both *formal procedures for rotating people around projects, functional departments, different jobs scopes etc* and work induction for new staff altogether, the author suggests that both tools should be placed on a secondary emphasis simply because they are 'necessities'. Formal procedures for rotating people are necessary because it would help 'formalise' any rotations within the firm according to the firm's and/or divisions' strategic objectives. Having said that, it is also important to 'balance' the use of both formal and informal

procedures of rotation appropriately. Work induction for new staff is also important because it would introduce new staff to existing staff in the firm, and to build collegiality in the firm.

(B1) Connecting People-to-People via technological tools

Discussions

Analysis & Findings

Discussion forums/boards had not only been generally the least regularly used and effective in enabling learning from one project for application in another, it had been the least effective in specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

Recommendations

However, due to the size of the organisation and difficulty for its project staff to come together for discussions (be it regular or irregular), the author would still suggest that the firm encourages its staff to utilise this more regularly to enable staff to simply place their comments, advice and/or queries on the forum/board and continue with their daily/usual work on project sites and return to the forum/board as and when they are free to view or answer it.

Hence, it is suggested that this tool still be used in the firm but placed on secondary emphasis. In addition, the author believes that such a tool has a shortcoming in that it would not be useful in an emergency as it does not allow staff to quickly obtain a quick solution or suggestions to an immediate problem. As one respondent expressed: "If I were to run into an emergency on a project site, do you think I would waste time going through the set of questions and answers and discussions on the forum/board or directly call a colleague of mine whom I know has done a similar project or had run into similar problems previously to seek advise. In an emergency, no one would have such 'spare time' to sit down in front of a computer and search for answers or past experiences recorded on the firm's intranet or KM system."

Computing tools

Analysis & Findings

Clearly, *electronic message exchange* had generally not only been one of the most regularly used and effective tools in enabling learning from one project for application in another but also one of the most effective in specifically enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation.

In contrast, *expertise locator* had generally been much less regularly used and effective as well as less specifically effective than electronic message exchange. Logically speaking, this finding does not make logical sense as the firm was very large and 'fragmented' (17 divisions) that they would have difficulty knowing where or who to look for when they needed some advice. Furthermore, since staff were not located on a single office level, we would have thought that this would have been the most useful and effective of the tools in enabling staff to locate an expert from within their firm.

Recommendations

It is suggested that the continual primary emphasis of *electronic message exchange* (especially important for project staff based on sites who should be provided with the technological capabilities to facilitate communication between staff located on different site locations and different levels in the office building)- furthermore, it is easy to use and free while *expertise locator* be maintained but placed on secondary emphasis since it was deemed much less effective (and also received a below average response rate for its existence) by the respondents. However, the author suggests that such an expertise locator should also be placed on the firm's website for external customers to locate an expert in the firm.

(A2) Connecting People-to-Organisation via non technological tools

Project Reviews

Analysis & Findings

Generally, both *formal project reviews at the end of each phase of a project and formal post-project reviews* had relatively (although not extremely) regularly used and effective in enabling learning from one project for application in another (6.30 and 6.60 respectively; and 5.71 and 6.71 respectively).

However, upon having examined the specific effectiveness of the tool enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, it appears that formal post-project reviews was much less effective than project reviews at the end of each phase of a project.

Recommendations

The above 'phenomenon' could be because of the larger and more complex projects handled by the firm where it was important for them to review each phase of a project instead of just a post project review. Hence, the author suggests that the firm should give primary emphasis to *formal project reviews at the end of each phase of a project* and remove *formal post-project reviews* altogether, and that the firm needs to encourage its staff to use *formal project reviews at the end of each phase of a project* more regularly since it had been much less regularly used than it had been effective.

Furthermore, it was incomprehensible was that the project review tools were overall much more regularly used and effective in the medium sized American firm than the large Singaporean firm and even much less in the small Taiwanese one. One would have believed that as a firm gets larger (with number and value of projects handled, its turnover gets larger), and hence there would have been a greater impending need for project review tools to record what had been learnt by the individuals for retention in the firm. This does not appear to be true when comparing these three case studies.

Manuals/Guidelines/Standards tools

Analysis & Findings

Generally, all the tools in this category did not appear to have been significantly regularly used and effective in enabling learning from one project for application in another. *Quality assurance manuals* appear to have been the most regularly used and effective (6.46 and 6.54 respectively), followed by *best practice guides* (5.60 and 6.60 respectively), *project management manuals* (5.46 and 6.15 respectively), and *lessons-learnt manuals* (5.50 and 6.00 respectively).

However, upon having examined the specific effectiveness of the tool enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, it appears that *quality assurance manuals and project management manuals* had been most effective while *best practices guides and lessons-learnt manuals* had been least effective.

Recommendations

Despite the below average response rates for the existence of *lessons-learnt manuals and best practices guides* in this firm, the author believes that these fundamental tools that should still be placed on primary emphasis and implemented given a pertinent need to provide staff with 'best examples' of 'things' that happened in projects so as to enable learning from one project for application in another as well as to insure firms which have high turnovers from not losing organisational knowledge that had been derived from their staff (since they had been one of the most effective of the tools) while *project management and quality assurance manuals* (although important) should be given secondary emphasis since they usually only include guidelines or procedures which does not contain lessons-learnt experiences.

In addition, the there is a need for the firm to encourage its staff to use the above tools more regularly as most of the tools had much less regularly used than they had been effective (except for *quality assurance manuals* which had been relatively regularly used as it had been effective).

(A1) Connecting People-to-Organisation via technological tools

Computing

Analysis & Findings

Intranet appears to have been the only tool (apart from *electronic message exchange*) that had been significantly regularly used and effective in enabling learning from one project for application in another (8.33 and 7.07 respectively). All the other computing tools had been much less significantly regularly used and effective in doing so: *extranet* (6.45 and 5.27 respectively); *electronic document management system* (7.00 and 5.00 respectively); *electronic tender document management system* (4.50 and 5.00 respectively), and *computer aided design programs* (5.27 and 3.36 respectively). *Electronic contract/procurement management system* appears to have been the least regularly used and effective (having received no responses from the respondents).

However, upon examining the specific effectiveness of the tools in enabling learning between projects and between phases, resolving problems, and enabling respondents to experience learning at various levels of the organisation, it appears that *intranet, extranet, and computer aided design programs* had been amongst the more effective of the tools while *electronic document management system, electronic tender document management system, and electronic contract/procurement system* had been the least effective.

Recommendations

It is suggested that if the firm wishes to stay status quo in terms of its business type, and hence taking approach alpha, the author suggests that the firm should gives primary emphasis to *intranets, extranet, and electronic document management system*, and secondary emphasis on *electronic tender document management system, electronic contract/procurement system, and computer aided design programs*.

This is because *intranet* was clearly the most regularly used and effective as well as specifically effective of the computing tools. On the other hand, although *extranet and electronic document management system* had generally been much less regularly used and effective when compared to *intranet, extranet* had been one of the most

specifically effective of the computing tools. Also, although *electronic document management system* had generally been one of the least effective tools, it appears to have been the relatively effective in enabling learning between project phases, and enabling staff to experience of learning at the individual and division levels of the firm.

And although the firm appears to use most of the computing tools more regularly than they had been effective (apart from *electronic tender document management system*), it should continue encouraging its staff to use them more regularly if they wish to continuously focus on connecting their people to what the organisation has in accordance to their business objectives. In addition, they also need to reassess the contents of their KM infrastructure- and ensure that what enters and is retained in the organisation's are experience and knowledge, and not just data and information.

5.6.3.3 Summary of Recommendations for Changes to be Made in the Firm

Being a project-based organisation and since the firm should be taking approach α, the firm should focus on tools that connect people to the organisation and staff should be encouraged to use them more regularly to enable them to learn across projects.

Grid	Primary Emphasis	Secondary Emphasis	To be removed
B2		**Discussion tools**	
	Regular and irregular discussions between superior and subordinate	Regular discussions between peers	-
	Irregular discussions between peers		
		Sessions/forums tools	
	Brainstorming sessions	Team building activities	-
	Information sessions, seminars, forums, talks		
	Project lessons-learnt sharing sessions		
		Meetings tools	
	Formal project-team meetings	Directors' only meetings	-
	Management meetings		
		Project review tools	
	Informal reportback/feedback sessions by employees to superiors	-	-
	Meetings to discuss/evaluate completed project reviews		
		Human resource tools	
	Mentoring and apprenticeships	Work induction for new staff	-
	Informal rotation of people around projects, functional departments, different job scopes	Formal rotation of people around projects, functional departments, different job scopes	
B1		**Discussion tools**	
	-	Discussion/forum boards placed on intranet/extranet	-
		Computing tools	
	Electronic message exchange	Expertise locator	-
A2		**Project review tools**	
	Project reviews at the end of each phase of a project	-	Formal post-project reviews
			-
		Manuals/guidelines/standards tools	
	Lessons-learnt manuals	Project management manuals	-
	Best practice guides	Quality assurance manuals	
A1		**Computing tools**	
	Intranet	Electronic tender document management system	-
	Extranet		
	Electronic document management system	Electronic contract/procurement system	
		Computer aided design programs	

Table 23: Firm L- Summary of Recommendations for Changes to be made in the Firm

5.7 Other Key Findings

5.7.1 Guidelines for the Development, Implementation, and Maintenance of a KM Infrastructure and Key Issues for Consideration

5.7.1.1 Guidelines for the Development, Implementation, and Maintenance of a KM Infrastructure

The purpose of these guidelines is to aid construction firms that currently do not have any KM initiatives in developing, implementing and maintaining a holistic KM infrastructure as well as those that may already have some KM initiatives or infrastructure in place to reassess and improve their ability to manage what they currently have and/or what they may potentially have to manage in the near future.

5.7.1.1.1 Development

At this stage, the firm needs to first assess its current and future 'organisational context' in terms of its size, culture, and business objectives and priorities, and mutually (at all levels of the organisation) confirm whether it would like to remain status quo (in its current status) or forecast and identify what it would like to achieve in the future (prepare a schedule).

Secondly, it should then attempt to understand the various tools, methods and mechanisms that are available for them to manage knowledge, what the firm would like the tools, methods and mechanisms employed to achieve, and each of their effectiveness (i.e. their effectiveness in enabling learning between projects within an organisation or between phases within a project; to resolve generic and less-recurrent problems and/or specific and less-recurrent problems; and at which level of the organisation they had enabled respondents to experience learning etc.). At this moment, it would be advisable to make a preliminary assessment of the resource and cost requirements.

The underlying premise of this stage is to ensure that the tools, methods and mechanisms employed to manage knowledge in the firm are aligned with their context and the intended strategies, objectives and priorities of the firm. Given that the intention of this stage is to preliminarily identify the need for and potential of such a

KM infrastructure, it would be wise to include senior management of each divisions to gather their views as well as to ensure that they are aware of any forthcoming development and implementation programs for KM.

Once a preliminary assessment of a potential KM infrastructure at the corporate level has been confirmed, corporate members must discuss their intentions and views with senior management staff and key members of the professional staff (those who would be playing key roles in driving, developing, implementing and maintaining the initiatives- for e.g. principal engineers, senior project managers) taking into account the context (culture, structure, objectives/priorities) of each division. A list of potential tools, methods and mechanisms to be employed in each division and the corporation as whole should be mutually selected and agreed upon. In addition, the technological and non-technological support required for the KM infrastructure is adequate.

During the entire process (and best prior to the identification of the appropriate tools, methods and mechanisms), it is important to ensure that all staff have been made aware of the intention of the firm to develop a KM infrastructure, and gather their opinions/views as well as 'buy-in' their support and participation in the development, implementation and maintenance stages. It is also important to ensure that all levels of staff have been convinced of the purpose of the initiatives, and that they will be freely willing to participate and support the initiatives. A decision will then have to be made as to whether to proceed with the implementation phase of the earlier identified KM tools, methods and mechanisms.

Having said the above, it is also important to note that the development of the KM infrastructure could either be done 'in-house' (that is if the firm has the resources to do so- which may include a KM team that consists of lead professionals from the various fields such as project management, architecture, civil and structural engineer etc. and supported by the information technology professionals) or 'out-sourced' to a KM consultancy that is capable of developing tools, methods and mechanisms that support both the social/humanistic aspects as well as the information technology or technological aspects of the KM infrastructure (and not just any information technology firms that are only skilled in setting up the latter). Prior to confirming whether to proceed with the next stage of implementation or not, the 'real' cost of

setting up the KM infrastructure 'in-house' (assess resources, costs, time and effort required) or 'out-sourced' (assess quotations from KM consultants) has to be assessed and decided upon.

In addition, in order to ensure the successful delivery of the above initiatives, it is necessary to ensure that the following three issues have been taken into consideration right from the start of the KM 'project' and throughout its development, implementation and maintenance.

Firstly, the organization must ensure the proper selection of persons (at the corporate, division and individual levels) who would potentially be most capable of leading, driving and effecting the initiatives.

Secondly, senior corporate and divisional staff must ensure that employees at all levels in the firm are aware of the forthcoming initiatives as well as their roles and responsibilities in relation to the development of the initiatives. In addition, they need to campaign for and obtain 'buy-in' and encourage the participation of all employees in each division and at the corporate level.

Thirdly, KM leaders and teams for each division, and the corporation must be appointed to ensure that there is a strong continual driving force behind the initiatives. This includes the careful selection of leaders and team members who are freely willing to participate and give their time to the development of the KM initiatives. In doing so, the corporation also needs to implement procedures to ensure that the efforts of these KM leaders and their team are recognised and rewarded, and how their time spent on the initiatives could be counted towards part of either their official job scope and working hours (say as an engineer or a project manager) or outside their job scopes and working hours.

5.7.1.1.2 Implementation

This stage involves taking into account and putting in place the technological and non-technological 'foundations' required to support the tools, methods and mechanisms that facilitate the storage and retrieval as well as the direct communication between individuals (be it face-to-face or virtual communication) of data and information

respectively. Tools, methods and mechanisms which facilitate storage and retrieval may include information technology softwares and hardwares such as software programs, electronic document management system, and electronic tender document management system, servers and central processing units while those which facilitate direct communication between staff may include regular and irregular discussions between peers and between superiors and employees, brainstorming sessions, lesson-learnt sharing sessions, meetings, electronic message exchange and discussion forums/boards placed on the intranet/extranet or another program as well as ensuring that staff (especially the KM Team/s) are willing to commit themselves and participate in implementing and maintaining the KM 'project'.

This KM infrastructure (usually at the set up at the division and corporate levels-because at the individual level data, information and knowledge lies within individuals' heads) would then have to be progressively populated with the appropriate data and information.

5.7.1.1.3   Maintenance

Once the KM infrastructure has been implemented, it is necessary to ensure that provisions are made for its maintenance. Apart from ensuring the adequate provision of the technological systems to support the KM infrastructure, it is also pertinent to not only maintain it regularly in terms of the regular upgrading of the technological systems but also in terms of the ensuring the 'value' and 'updated-ness' of the data and information that resides in the technological systems (removing 'gems from rocks' and eliminating obsolete data and information), and the timely introduction and elimination of tools, methods and mechanisms utilised to manage data, information and knowledge in the firm.

In regards to providing adequate technological systems to support the infrastructure, the firm needs to be willing to commit sufficient resources (be it time, money and/or effort) to ensure that the technological infrastructure is capable of supporting the KM initiatives. The author believes that this is largely dependent on the level of support from senior staff in the firm and their appropriate assessment and allocation of budget to the initiatives.

In regards to ensuring the 'value' and 'updated-ness' of the data and information that resides in the technological systems, it is important to select the appropriate staff to maintain the data and information that resides in the technological system (sort 'gems from rocks', and removing obsolete data and information) as well as those who are able and willing to drive the facilitation of sharing of what each person knows (e.g. selecting people with good PR skills to facilitate the tools employed to facilitate sharing). In addition, there is a need for the organisation to develop a protocol as to how to ensure that staff involved in the KM initiatives (as well as maintenance) are recognised, acknowledged and rewarded (either monetarily or non-monetarily) for their contributions.

5.7.1.1.4   Scheduled Calibration of KM Infrastructure

It is important to note that the development, implementation and maintenance of the KM infrastructure do not end at the maintenance stage. It is necessary for the organisation to setup a scheduled refurbishment of its KM infrastructure. This is because a firm is not static in nature. It is organic and dynamic and therefore changes with time (be it culturally and/or structurally).

At scheduled intervals, the firm needs to review (i.e. reassess) its 'current state of the firm', where it would like to go, and what it would like to achieve in the future. It should then identify its future organisational strategies, objectives and priorities, and recalibrate its current tools, methods and mechanisms that are used to support its current needs to its future needs. The underlying premise is to realign an organisation's context with its KM strategies (which includes the reassessment of the tools, methods and mechanisms used to manage data, information and knowledge in the firm).

For instance, as the firm foresees that it may upsize over the next 3years due to an economic and construction boom (say they estimate that the firm will increase from 30 to 100 staff), it will needs to review its current versus future objectives as well as the current tools, methods and mechanisms in place (realignment) and gradually implement an electronic messaging system/program to enable staff to communicate with each other distantly between project sites which may not have been originally required when it was smaller.

Figure 18: Guide to Developing, Implementing and Maintaining a KM Infrastructure

STAGES	PRIMARY AIM/S	LEVEL OF STAFF INVOLVEMENT
DEVELOPMENT — Assess present and future Context of Firm (e.g. size, structure, and business strategies, objectives and priorities) & Determine whether to proceed with present or future context	Preliminary assessment of the need for, and requirements and potential of a KM infrastructure. Alignment of organisational business strategies and objectives with that of the KM initiatives. Conduct preliminary resource and cost requirements	Board or Corporate level staff. Divisional/Departmental Senior Management
Assess & Identify the various KM tools, methods and mechanisms available in relation to their effectiveness and performance outcomes arising from the research & preliminarily determine the appropriateness and potential benefits of utilising the selected tools, methods and mechanisms (individually and as a whole)		
Board and/or Corporate level staff to discuss intentions to develop KM infrastructure with key divisional/ departmental senior management and professional level staff participating in the development, implementation and maintenance of the KM infrastructure.	Assess whether firm has the resources to develop the KM infrastructure 'in-house' or to 'out-source' the 'KM project'. Determine 'real' cost of doing the project 'in-house' or 'outsourced'. ('In-house': set-up KM team; 'Outsourced' KM consultant: obtain quotations and select consultant) & Select appropriate internal KM team members or external KM consultant. Select and Affirm the tools, methods and mechanisms that are most appropriate for the firm. Ensure that staff at all levels of the firm are aware of the firm's intentions and time frame of setting up a KM infrastructure. Ensure there is strong support for the development, implementation and maintenance of the KM initiatives.	Board or Corporate level staff. Divisional/Departmental Senior Management & Key Professional Staff who will be participating in the KM initiatives (be it driving, developing, implementing or maintaining). *[Necessary for Divisional/Departmental Senior Management & Key Professional Staff to keep the rest of the staff informed of the intent and progress of the KM 'project']*
Discuss, identify and select potential tools, methods and mechanisms within each division, between divisions (as a corporation), the technological and non-technological requirements as well as to obtain staff 'buy-in' in support of the KM initiatives.		
IMPLEMENTATION — Set up the 'foundational' support (technological and non-technological) required to ensure the successful implementation of the tools, methods and mechanisms selected. — Technological support include that of the hardwares and softwares (usually information technology) to enable the firm to store and retrieve what they have. — Non-technological support include tools that facilitate direct communication between individuals & ensuring that key staff in the firm are determined (i.e. committed) participants of the KM 'project' for the 'long-haul' as well as ensuring that all staff are aware of and are required to support the firm's and the KM team in carrying out the 'KM project'. Plan for and Set-up the KM infrastructure — Pilot KM project (with one or a few division/department) — Set-up remaining parts of the KM project in the rest of the divisions/departments progressively	Ensure that staff at all levels of the firm are aware of the time frame of setting up a KM infrastructure and the need for key staff to participate regularly during the entire process of implementation as well as its future maintenance. Ensure there is strong support for the development, implementation and maintenance of the KM initiatives. Setting up KM infrastructure ('in-house' or 'outsourced' KM team in regular discussions and collaboration with divisional/departmental staff in each division and between the divisions/ departmental)	Divisional/Departmental Senior Management & Key Professional Staff who have been and/or will be participating in the KM initiatives and/or be part of the KM Team (be it driving, developing or maintaining the infrastructure) or 'Outsourced' KM Consultant In Consultation with other Divisional/Departmental staff
MAINTENANCE — Scheduled Maintenance (i.e. upgrading) of KM infrastructure (both its technological and non-technological tools, methods and mechanisms as well as the information technology infrastructure and the humanistic aspects required to support them). Appropriate staff appointed to maintain the KM infrastructure to ensure the value of, updated-ness & the identification of the 'gems from the rocks' of/from the content (data and information) provided or 'inserted' by staff into the infrastructure. Senior management to constant promote and ensure staff awareness of the need and importance of the KM initiatives to succeed, and for their fervent participation in its maintenance (and not just its development and implementation).	Ensure continued commitment and willingness of the corporate or board members to dedicate their time, effort and organisational resources (be it monetary or non-monetary in terms of time and effort) as well as the time and effort dedicated by individual staff on the maintenance of the KM infrastructure.	Divisional/Departmental Senior Management & Key Professional Staff who have been and/or will be participating in the KM initiatives and/or be part of the KM Team (be it driving, developing or maintaining the infrastructure) or 'Outsourced' KM Consultant In Consultation with other Divisional/ Departmental staff + Internal maintenance of the KM infrastructure by Corporate KM Team and Divisional/ Departmental KM Teams (includes collaboration between Divisional/Departmental KM Teams)

Scheduled Calibration of KM infrastructure

Right margin (vertical text):
- Progressively develop/inculcate a corporate and divisional culture of openness and willingness to share (if one does not exist in the firm).
- Appropriate selection of persons (& KM Team/s) to lead and drive the development, implementation and maintenance of the KM infrastructure.
- Ensure that the corporate or board members and other key staff (senior management and professional staff of divisions/departments) involved in the development, implementation and maintenance of the KM infrastructure are aware of and willing to commit themselves to the KM 'project' (provided that a recognition 'system' is concurrently in place).
- Ensure that the effort and time dedicated by staff to the development, implementation and maintenance of the KM infrastructure is recognised and/or rewarded (be it monetarily or non-monetarily).

5.7.2 Knowledge Management System: A Misnomer?

5.7.2.1 The Confusion: A Discussion

Most often, organisations and researchers term a 'suite' of initiatives which they claim to be used in their organisations to manage knowledge as KM systems. As discussed in this research, respondents in the case studies indicated that the majority of what was managed in the organisation by the initiatives was simply data and information. Hence, in a way, the term KM system is not a misnomer because the word 'system' clearly reflects an information technology connotation that KM was associated with an information technology infrastructure which imbues a notion that the such a 'system' primarily manages data and information.

On the other hand, the term is a misnomer in the sense that it is the people who develop, implement and use a KM system who quite often regard such a system to be an all encompassing tool that enables knowledge to be managed. Hence, the author believes the problems lies with people's understanding of a KM infrastructure. A KM infrastructure should ideally enable data, information and knowledge to be managed utilising an appropriate balance and mix of technological and non-technological tools, methods and mechanisms as opposed to a KM system that enables only data and information to be managed utilising only technological tools, methods and mechanisms. Also, in fact, the author asserts that such a technologically-based 'system' should not be termed KM system but at best information management system.

5.7.2.2 Knowledge is Personal and Needs to be Interpreted

Another issue which makes the management of knowledge even more difficult is the fact that knowledge is personal- it only resides in individuals' heads. Hence, for knowledge to become useful to another individual, it must be communicated in a manner that is it interpretable and accessible to other individuals. However, knowledge that is interpreted only becomes data and information (at best in the form of a lessons-learnt storyline). Furthermore, these hoards of data and information are of little value unless they have been actively processed (analysed, reflected, understood, and learnt) using the individuals' personal wisdom (including discernment and intuition) to produce knowledge.

5.7.2.3 Knowledge Often Not Distinguished from Data and Information

A most evident finding from the case studies was that the term knowledge was usually not distinguished from the terms data and information. Instead, they were used interchangeably. However, a respondent expressed in a discussion that "my knowledge is often only another person's data and information" which is consistent with the author's suggested view that knowledge only resides in individuals and not in information technology/systems- therein lies the importance of providing initiatives that enable the interpreting of (thereby converting) an individual's personal knowledge into data and information for other individuals to 'access' and acquire, and the process of analysing, reflecting, understanding, and learning from the data and information in the individuals' minds to produce knowledge.

5.7.3   Importance of Culture and Structure based Perspectives of KM

5.7.3.1 Importance of Culture-based Perspective of KM

It was also evident from the studies that the culture of a firm also plays a critical role in the successful development, implementation and utilisation of a KM infrastructure. From discussions with respondents, the majority of respondents felt that the cultural component should (on the average) make up 70% of a firm's KM infrastructure while the technological and non-technological tools, methods and mechanisms should account for the remaining 30%. In other words, this highlights the need for organisation to place primary and careful consideration on the culture of the organisation and not just focus on the tools, methods and mechanisms.

Three key issues which organisations need to consider when doing so came to light in the study: willingness of individuals to share what they know with and learn from each other, level of communication and collaboration between individuals, and issue of protecting the individuals' intellectual property. In particular, there also appears to be an impending need to employ the right person/s to drive the initiatives as well as those who are capable of convincing people to volunteer their knowledge with each other as well as to convince business units (e.g. divisions/departments) to share their knowledge with other units (these issues are ever more so important in situations where each business unit is responsible for showing a profit- creating a competitive nature/culture amongst business units to prove to the board of directors of their

profitability in comparison with the other divisions, which often cause divisions to restrict the sharing of what they know from other divisions for fear that other divisions may become more capable, enabled and profitable than them).

In relation to rewards and incentives, organisations have traditionally rewarded their professionals and employees based on their individual performance and know-how. Hence, a major cultural shift would be required to change employees' attitudes and behaviours, so that they willingly and consistently share their knowledge and insights. For instance, to encourage staff to initially contribute to a new KM infrastructure, they may need to provide incentives to 'attract' them to contribute their knowledge and at the same time explaining to employees of the importance of sharing knowledge openly. Once a 'culture of sharing knowledge' has become the norm (where employees have understood and recognised the need to share freely) in the firm, the firm may decide to 'tone' down the incentives given and subsequently do away with it.

5.7.3.2 Importance of Structure-based Perspective of KM

5.7.3.2.1 Additional Workload versus Accuracy of Content

It is also necessary to ensure that staff currently working on projects are not simply 'dumped' with the duties of administering the KM infrastructure. As their main duties are towards construction projects, any duties and time which they spend on administering KM should ideally be counted as part of their official working hours and not affect their primary roles and responsibilities for which they were employed in the firm. Should such duties be allocated outside their official working hours, they should be given due recognition or remunerations for 'over-time' work. Often, project staff do not have the extra time to spend on administering KM.

Furthermore, should they simply be 'dumped' with such duties apart from their official duties on projects, it would inevitable that the accuracy as well as quality of the content would be compromised.

There is therefore a need for organisations (in particular the superiors) to recognise and acknowledge the time and effort spent by such staff who dedicate their time to administering KM initiatives- be it by appropriately recognising or rewarding their

efforts or by simply ensuring that the time spent on KM initiatives have been 'clocked' into their timesheets (either as part of their official working hours or as an OT pay to them).

5.7.3.2.2 Information Overload versus Usefulness of Content

It is often simpler to upload all forms of data and information into an organisation's KM infrastructure- for instance, via the technological tools, methods and mechanisms that facilitate the transference and storage of data and information. Organisations need to ensure that staff do not get 'too carried away' with simply uploading data and information into the tools, methods and mechanisms without vetting the usefulness of their content.

Therefore, organisations need to clarify what data and information is relevant to or useful to which department, division or group of persons (e.g. professionals) because not everything that is retained within the organisation's 'knowledge-base' is useful for everyone. Appropriate and relevant persons need to be designated the responsibilities to vett the relevance and usefulness of the data and information that is 'given' for retention by staff or individuals in the organisation need to be made aware of and taught how to assess what data and information is more relevant than others before they are retained.

There is a need to avoid a "rubbish in, rubbish out" situation where there is an abundance of data and information retained within the organisation but little of it is of value.

As commented by some respondents in discussions with them: "KM should not just be about the fervent accumulation or hoarding of data and information. It is also important to avoid data and information overload by appointing appropriate persons to filter the gems from the rocks. These persons cannot be just anyone (for example, an administrative personnel), but someone who is trained or familiar with the primary field/profession for which the data and information relates as well as willing (and not 'forced') to take on such a role. If the person is not familiar with the field/profession for which the data and information relates, how would the person who able to sort out what is valuable and useful against what is not. However, because such a role is often

not counted as part of a person's primary role (e.g. a project manager or engineer), any work done by that person is often a non-thankful role- i.e. managing KM infrastructure is extra work for any person/s taking on such a role. Also, it is necessary to not just sort out the gems from the rocks but also to eliminate 'old/obsolete' (and regularly update) data, information or knowledge. In addition, the drivers of any KM initiatives must include sufficiently 'high-ranking' persons in the organisation to get the initiatives going. Often, lower ranked staff such as clerical and administrative staff are 'designated' to drive and manage the KM infrastructure."

5.7.4   Performing the Delicate Balancing Act

5.7.4.1   Balancing Exploitation and Exploration of Data, Information and Knowledge

In managing data, information and knowledge within organisations, organisations also need to balance what they have versus what they do not have carefully.

For instance, there is a danger that when a firm believes that it already has so much (i.e. a lot of) data, information and knowledge within itself, it may become complacent and regularly decide to only use whatever they have, and becomes slack and decide not to search for and/or develop new solutions or ideas that may be more effective.

Hence, firms need to inculcate a culture of awareness within staff that although it may be useful and easy to sometimes search for and use the abundant existing solutions to resolve problems, it is also necessary to create new solutions to better solve a same or even different problem. In other words, the firm needs to understand and learn how to continuously improve itself and not become 'stagnant' in its learning process.

This means that the use of KM infrastructure may lead to both positive and negative outcomes. On one hand, it may gain efficiency by streamlining problem solving processes through reusing data, information and knowledge. On the other, it may slowly become rigid, stagnant and lose its capability to learn, and innovate (create new solutions or ideas).

5.7.4.2 Balancing the Selection and Use of Tools, Methods and Mechanisms Available to Manage Data, Information and Knowledge

Despite the apparent fervent use of technological tools such as intranet, electronic message exchange systems, and extranet by respondents in the case study firms, no tools, method or mechanism was capable of solely dominating the management of data, information and knowledge in the firms.

Instead, the real solution lies in an integrated KM infrastructure that combines an appropriate balance of people-to-people and people-to-organisation tools, methods and mechanisms (technological and non-technological) developed in consideration of and aligned with each firm's unique characteristics (e.g. size, structure and culture), and its current and future business strategies, objectives and priorities.

5.7.5 Addressing the Contemporary Perspectives/Views of Project Management

The author believes that it is pertinent for project management researchers and practitioners to change their traditional mindsets and address the shortcomings of the mindsets with regards to managing projects (as discussed in *section 1.1.2*) and approach the management of projects in a more holistic manner: not just managing projects collectively (for example, applying program and portfolio management) but also by embracing more robust lessons-learnt practices within the organization. This can be achieved by enabling organizations with the capability to learn across their projects and its phases as well as allowing the input of facilities professionals at earlier stages of the project (discussed further in subsequent paragraphs). Such learning capabilities would not only enable project members to apply their experiences across different projects thereby improving their project and organizational performances but also optimizing value generation for the owner/sponsor and their constructed facility.
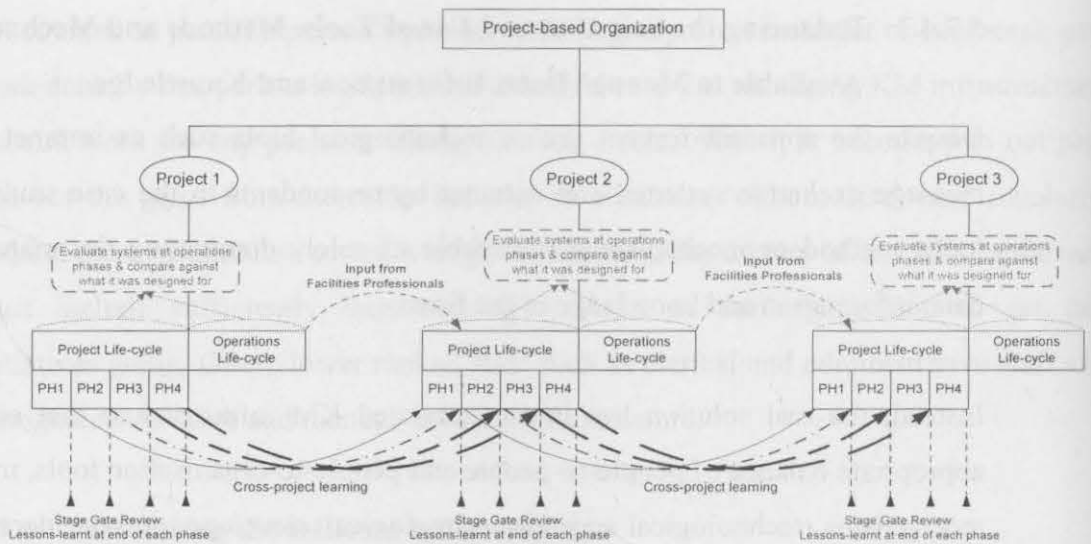
Figure 19: Enabling Cross-project & Cross-phase Learning

Project Life-Cycle Phases
PH1: *Conceptualization & Initiation*
PH2: *Planning/Definition/Design Development*
PH3: *Execution/Implementation & Controlling*

5.7.5.1 Addressing the Individualistic Nature of Projects and Organisations through Enabling Cross-project and Cross-phase Learning (see *Figure 19*)

This section proposes how cross-project learning may be used to tackle these shortcomings.

It is suggested that a project should first be broken down into the different phases (*see definitions of project life-cycle phases at end of Figure 1 and 19*). At the end of each phase, compulsory lessons-learnt session(s) are held using a combination of formal and less-formal learning practices. Lessons learnt at the end of each phase of a project (called 'stage-gate' reviews) can then be applied to prior to the start of the same phase of other projects. Some examples of more formal methods may include internal reviews (e.g. project team review meetings), third party auditing of projects, report-back sessions using a predetermined set of criteria, directors' meetings, project managers' meetings, and the use of database management systems; while less formal methods may include departmental and project team seminars, discussion forums and focus groups. These procedures would be beneficial in the two ways.

Firstly, lessons learnt through a combination of formal and less formal methods would allow the flow and transfer of both tacit and explicit knowledge. The importance of

combining tacit and explicit knowledge is also noted by Cooke-Davis (2002a): "an effective means of 'learning from experience' on projects, that combines explicit knowledge with tacit knowledge in a way that encourages people to learn and to embed that learning into continuous project management processes and practices" is one of the twelve key success factors in project-oriented organizations. Less formal methods may enable tacit knowledge to be transferred between project members as they would be able to share their personal 'real-life' project experiences with others.

For example, more experienced members would be able to share their experiences much more easily with their younger counterparts explaining how and why something went right or wrong using analogies or metaphors. More explicit knowledge acquired through more formal methods could be retained in a central repository; for example, database or document management systems, tender evaluation systems, contracts administration systems, where organizational members can search for past projects with comparable or similar characteristic to manage their future projects.

Secondly, applying lessons learnt between projects enables a more proactive and preventative approach (i.e. improves the 'foreseeability' of problems) to managing projects as compared to contemporary modes of managing projects which are primarily reactive in approach; For example, project members would traditionally address a problem only when they encounter it - a reactive mode to problem resolution. Resolving recurrent problems may not be difficult for an experienced project member because the member's past experiences and learning curves will allow him/her to begin to anticipate likely problem areas and points of potential difficulty. However, such tacit knowledge gained during a project resides only in the heads of team members. Once a project is completed and members reassigned almost immediately to a new project or when a member leaves the organization, that knowledge disappears with them. It is therefore critical to find ways to retain and improve working knowledge, routines and processes (Carillo et al. 2004; Love and Huang 2004).

Despite the importance of having mechanisms in place in organizations to facilitate cross-project learning, top management intervention is also necessary to support and promote a culture that provides its staff with adequate time to reflect on their past actions and encourages them to share their experiences with each other. If such a

culture is not forthcoming, project members would not have the opportunity to identify what lessons learnt could be carried over to the next phase or project (i.e. to ensure that cross-project learning occurs); resulting in cross-project learning mechanisms that are in place in organizations becoming largely redundant.

These paragraphs have highlighted the shortcomings that arise when projects are perceived as unique and temporal in nature, and have provided suggestions on how organizations may be able to resolve these problems through 'cross-project learning'. This 'picture' is still incomplete because another issue in the contemporary view of project management has been overlooked: the view that 'project life-cycle' (essentially concept, design, construct and handover) and 'operations life-cycle' (essentially maintenance and/or refurbishment) are separated from each other. This more inclusive view is discussed in the following section.

5.7.5.2 Addressing the Segregated Project and Operations Life-cycles through the Enabling of Input from Facilities Professionals into Early Stages of Projects (see *Figure 19*)

This section proposes how input from facilities professionals at early stages of a project could maximise value generation.

In contrast to the current perspective of project management, facilities management professionals should be brought into the early phases (for example, concept or design development phases) of a project life-cycle as early as possible. This would allow them to provide valuable 'lessons-learnt' input (for example, their past knowledge and experience on how to select the appropriate operational assets that can optimise energy efficiency and ensure longer operational life for the assets) together with the rest of the design and construction team. In doing so, the owner/sponsor of the facility could be better assured that the facility has been optimally designed and value-engineered with the maintenance phases in mind. Furthermore, having been involved in the management of existing facilities as well as the design development and construction phases of new facilities, they would have had developed closer relationships with the owners of the facilities as compared to the other consultants who are usually only employed during the design and construction phases. Hence, a facilities professional would not only have had a much more robust understanding of the initial requirements

and expected capabilities of the facility (for example, operational assets such as plants equipment, thereby enabling them to manage and rectify problems more efficiently and effectively), but also be much more aware and capable of aligning project and facilities management strategies and objectives with facility owner's strategic and business objectives.

Such a view is also supported by Morris (1998), Frame (1998), and Kolltveit and Gronhaug (2004) who highlighted the need for greater focus on more thorough front-end work (i.e. the early phases) as they were often neglected, and by Youker (1988) who highlighted that 'a related problem is the failure to manage the early stages of the project', and that 'delays are often not visible in the early stages since it is often less expensive to buy time in early stages compared to later ones.' Kolltvei (2004) also added that since the early phase is the phase when the 'technical concept' is developed and as it is the abstraction of the technical solution that satisfies the functional, quality and capacity requirements, decisions regarding the technical concept must be taken in the early phase in order to exploit the potential for value generation (especially the performance of the operational assets).

In addition to the above, lessons learnt practices should also be in place to enable facilities managers to evaluate the systems during the operations stage and compare it against what the system was designed for (provided that information and documents with regards to the system requirements have been adequately and appropriately transferred from the design and construction professionals to the facilities professional (Kenafake 2004). Any variations (whether good or bad) can be recorded and brought across to other projects.

5.7.6 Identifying the Forms/Levels of Learning at which the Three Case study Firms were at Time of Study (refer also to *Section 2.1.2*)

Firm S

As previously identified, firm S's current business approach fits that of managing knowledge via Model α. However, the firm currently takes a mixed approach to managing its knowledge. It employs a mixed range of tools- with a emphasis on utilising both technical and non-technical tools that manage people to people, and tools which connect people to the firm. It was least focused on the non-technological tools, methods and mechanisms that connect people to the firm.

Basically, the firm is not aligning its approach to managing knowledge appropriately with its business approach. If it wishes to continue with its current business approach, it needs to place greater emphasis on the tools, methods and mechanisms that connect its people to what it (the firm) has- i.e. employ and utilise the tools that support the connection of people to the firm.

In terms of the firm's level of learning, from discussions with their respondents, the author concludes that the firm was currently somewhere between the 1st and 2nd form of learning (but tilted toward the 2nd form). It was obvious that there was collegiality and cohesiveness (and hence non-defensive and open dialogue) amongst most staff in the firm (close knit and family), and that because the firm was young and small compared to the other industry players, it had the attitude of doing things differently.

Conversely most of the knowledge and experiences accumulated from their past projects were partially still tacit (i.e. still residing in the individuals heads). Despite the firm having focused primarily on the technological tools, little past project experiences had been recorded explicitly. However, knowledge would have somehow been converted to explicit form through verbal sharing between individuals using the non-tech tools that connect people to the people.

Firm M

As previously identified, firm M's current business approach fits that of managing knowledge via Model ß. The firm currently takes a mixed approach to managing its

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knowledge. It currently employs a mixed range of tools- with a larger swing towards utilising both technologically and non-technologically based tools, methods and mechanisms that manage people to what the firm has, and those which connect people to what other people in the firm have. It was least focused on the non-technological, methods and mechanisms that connect people to the people.

This firm was not aligning its approach to managing knowledge appropriately with its business approach. If it wishes to continue with its current business approach, it needs to primarily emphasize instead on the tools that connect its people to what the organisation has- i.e. employ and utilise the tools that support the connection of its people to people.

In terms of the firm's level of learning, from the embedded in the case study firm and the discussions with their respondents, the conclusion was that they were currently between the 1st and 2nd form of learning (but tilted to the 2nd form). It was obvious that the organisation was non-defensive and open dialogue amongst most staff in the firm. The size of the organisation had made verbal sharing of lessons-learnt experiences between staff difficult (although it appears that lessons-learnt sharing sessions had been very effective but not as regularly used). Moreover, the impression given was that the technological systems provided in the firm to support knowledge management had no lessons-learnt manuals.

Firm L

As previously identified, company L's current business approach fits that of managing knowledge via Model α. The firm currently takes approach ß to managing its knowledge. It primarily employs technological and non-technological tools which connect people to people. Its least focused on both the technological and non-technological tools that connect people to the organisation.

Clearly, the firm was not aligning its approach to managing knowledge appropriately with its business approach. If it wishes to continue with its current business approach, it needs to place a larger emphasize instead on the tools that connect its people to what the organisation has- i.e. employ and utilise the tools that support the connection of its people to organisation.

In terms of the form or level of learning at which the firm was at, from the embedded in the case study firm and the discussions with their respondents, the impression was that the firm was currently in the 1st form of learning. It was obvious that the organisation was largely only doing what it already knows best to do and that the work environment was largely non-collegial and hence no open dialogue between staff from different divisions (at most open dialogue between those in each division). Moreover, the size of the organisation had made verbal sharing of lessons-learnt experiences between staff difficult (especially between staff from different divisions). It appears that lessons-learnt sharing sessions had not been regularly used and were not effective. Moreover, the impression given was that the technological systems provided in the firm to support knowledge management had no or little lessons-learnt manuals, best practices guides and brainstorming sessions. Hence, the knowledge existing in this organisation was largely tacit.

5.8   Summary and Conclusions

In developing a KM infrastructure, individual firms need to first assess each of their own business strategies and objectives, and then employ the appropriate tools that suit/align with them.

Aligning the KM tools with the business strategies is not sufficient nor does it guarantee success in enabling the sharing of knowledge. This is because, often, tacit knowledge only resides within the heads of the individuals (people) and does not reside in the tools that enable people to obtain the institutional knowledge. The firm needs to not only employ tools that facilitate the conversion of tacit knowledge into explicit knowledge (either verbally or technologically), so that individuals may be able to share what they have in their heads with each other. Once tacit knowledge has been converted to explicit knowledge, it either gets stored/retained in the individuals' heads (individual memory) or into the technological systems (organisational memory media).

Hence, it is important to note that knowledge management infrastructures have to be tailored to suit the context of the firm. Ideally, firms should first assess (and restructure if required) their business strategies, objectives, priorities and approach, and then identify the tools, methods and mechanisms that are most suited to their business strategies. Otherwise, the firm could run the risk of failure after adopting the tools,

methods and mechanisms if their business strategies had not been well-defined at the
first instance.

6.0 SUMMARY CONCLUSIONS AND CONTRIBUTIONS/IMPLICATIONS TO BODY OF KNOWLEDGE

6.1 Introduction

This section aims to restate the research questions identified in section one and discuss whether they have been answered or not, and to what extent. This will be done by summarising key research findings, how and whether the findings were relevant to the research problem and questions.

It will then be followed by discussions on the findings and contributions of the research- in particular, the theoretical and practical (industry-wise) contributions of the research to the body of knowledge.

6.2 Significance of the Research

This research has addressed the gap in Knowledge Management research in Construction Project Management Organisations. In reviewing various definitions that appear in research literature, the writer has rationalised and proposed 'uniform' definitions that may be used in KM discourse.

A comprehensive literature review has been undertaken, and critiques summarised and presented in matrix form. Gaps ("shortcomings") in the research reported in the literature have been identified.

Data and information gathered by 'embedding' the researcher in industry has generated sophisticated insights into KM operation in three firms of different scales from different countries. Apart from a cross-cultural comparison, the information arising from the detailed analysis and findings of each firm is too extensive to be situated in the body of the thesis, but may be found in *Appendices I*.

Comparative analysis of the data and information collected from the study has suggested to the author two models of KM relating the vertical and horizontal transmission of knowledge through a Project Management organisation.

These models enable PM organisations to analyse the KM need in their organisation, and what strategies and tools might be best suited to improve their KM performance. These models have been applied to the case study organisations to accentuate the gaps in the firms' KM initiatives that need addressing. The research has also developed a measure that allows firms to compare their intentions (how important they think KM is to their core business and the ability of the KM initiatives implemented in their organisations to deliver projects) with the reality of what really is occurring.

The research, whilst limited to a select few case studies, has established the start of a benchmarking system against which other organisations can compare themselves.

6.3   Conclusions about the Research Questions

Questions relating to the strategies, objectives and priorities of the firms' business and their KM initiatives:

Q1   What is the purpose of the KM initiatives in the case study organisations?

A1   *The majority of respondents in the three case study firms believed that the KM initiatives implemented in the firms were not only used to facilitate the sharing of past project knowledge between individuals and divisions, they were a vital part of their business strategy as the basis for their competitiveness.*

However, it was astonishing to find that the majority of respondents in firms S and L felt that the KM initiatives in their firms were only aimed at centralising the pool of knowledge while only those from firm M indicated that it was doing both centralising and sharing knowledge. This research showed that it is often easier for a firm to want to manage knowledge than to actually do it.

In this regard, the author believes the firms need to first reassess their business and KM strategies and objectives and realign them if necessary, and secondly, ensure that if a key strategy or purpose of the KM initiatives is to share and centralise knowledge, then the firms have to ensure that the initiatives would be capable of or currently capable of doing so.

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Q2 & Q3 Does Board-level representation for KM exist in the case study organisations? And is there substantial top/senior management encouragement of the KM initiatives?

A2 & Q3 *The majority of respondents in firms S and M believed that although board level representation does not exist in the firms, there was substantial senior management encouragement of KM initiatives. On the other hand, the majority of senior management respondents in firm L believed there was board-level representation and substantial senior management encouragement while professional staff believed otherwise.*

In this regard, the author believes that: firstly, the presence of board-level representation in support of and drive KM initiatives is required to assure employees that their superiors are serious and supportive of such initiatives and in turn drive the employees to participate in the initiatives; and secondly, it is necessary for all levels of staff (board, senior management and professional staff) to work hand-in-hand to develop, implement and maintain the KM initiatives, and not for the board and senior management to introduce the initiatives and leave the development, implementation and maintenance to their employees thereafter; thirdly, it is not only necessary for the board and senior management to communicate with and explain their intentions and plans to their employees but also for them to be convinced of the need for and future benefits of initiatives the as well as 'buy-in' their employees in support of, drive and maintain the initiatives.

Q4 Who are the initiators of the KM initiatives in the case study organisations?

A4 *Most respondents in all three firms indicated that senior management had been the prime initiators of the KM initiatives in their firms. This makes logical sense as such initiatives usually require a certain degree of change or adjustment to current organisational policies and procedures as well as funding to develop, implement and maintain the initiatives which have to approved by senior management. Having said the above, it does not mean that senior management should just take a 'dictatorship' approach to developing, implementing and maintaining the initiatives but*

to include appropriately selected key staff at all levels of the organisation in the process.

Q5 How receptive are the organisation's staff to the KM initiatives, and is the level of staff's receptiveness to initiatives a key success factor?

A5 *Astonishingly, the initiatives at the three firms were most receptive at the senior management level, followed by middle and professional staff. The author recommends that for any KM initiatives to be successful, staff at all levels of the organisation have to not only be receptive to the initiatives but also be active participants, supporters and drivers throughout the development, implementation and maintenance of the initiatives.*

Q6 What are the critical factors of success for the KM initiatives?

A6 *The most important critical success factors of the KM initiatives were: 'alignment of organisational vision/mission and objectives with those of KM initiatives', 'explaining the purpose of the KM initiatives clearly to all levels of staff' to ensure staff awareness of the need for and the intended development, implementation, and maintenance of the KM initiatives, 'buying-in' of all levels of staff to ensure 'consistent and continuing full support, commitment and participation of the initiatives' to ensure its successful development, implementation and maintenance.*

Astonishingly, respondents indicated that 'selecting the right person/s to manage the content of the KM system', 'selecting person/s who are freely willing to manage the content', 'involving staff in the implementation process of the KM initiatives', and 'constantly promoting the awareness of the KM initiatives' were not as important.

The author, however, believes that it is very important that firms select persons who have been trained in the 'fields' of the professional knowledge (e.g. architecture, project management, civil engineering etc.) to manage the initiatives because someone from a non construction related field would not have the capability to understand the contents (professional knowledge) as well as to sort out the 'gems from the rocks' (e.g. what is more or less important and valuable than others). In

addition, it is also important to have a planned and structured approach to developing, managing and maintaining the initiatives to ensure the effective delivery of the initiatives.

Of least importance were: 'designing work processes in the KM system/initiatives that encourage knowledge sharing', 'involving staff in the development process of the KM initiative/s', 'implementing good recognition/incentive/reward mechanisms to encourage contributions', and 'implementing a KM initiative/s in stages (e.g. starting with a pilot project and implementing the rest of the project steadily)'.

Of these, the author wishes to refute that for the last two findings, it may be necessary for firms to initially use incentives (i.e. 'place a carrot in front of a horse') to attract and encourage their employees to participate in the development, implementation and maintenance of as well as contribution to the contents of the initiatives, and gradually remove the initiatives when the initiatives have been stabilised (e.g. when a sufficient number of people have been participating and contributing to the initiatives) while it would also be wise for a large firm to implement KM initiatives in stages (e.g. start in one division, 'test' and 'calibrate' it, and then implement them according to individual divisions' specific requirements and context).

Q7 Whether KM measures exist within the organisation. If yes, what are they?

A7 *In reality, no formal or official KM measures exist in the three case study organisations. The author believes that it would not be surprising to find similar situations in other construction firms that have KM systems or infrastructures. Hence, there is a need for firms to implement measures to manage their ability to manage knowledge. The lack of KM measures, the author believes, is often due to the intangible nature of knowledge management which makes measuring difficult.*

Having said the above, this research not only provides construction firms with real life exemplars of the tools, methods and mechanisms available

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to manage what they know, and each of their effectiveness and performance outcomes from which they could identify, develop, implement and maintain a set of initiatives that constitute a KM infrastructure, but also how the capability of construction firms to manage knowledge could be measured in relation to each of the tools, methods and mechanisms employed. (This is also a potential area for future research).

Questions relating to the existence, effectiveness and performance outcomes of the tools, methods and mechanisms employed:

Q8 What are the tools, methods and mechanisms currently used in the case study organisations to manage what they know?

A8 *All three firms employed different combinations of tools, methods and mechanisms to manage what they have and know. This was consistent with the author's earlier conjecture that there cannot be a single set of tools, methods and mechanisms that could be applicable to all types of construction firms, and that the context of the organisation is an important factor in determining the appropriate tools, methods and mechanisms that should be employed.*

However, it was clear that the tools, methods and mechanisms most commonly employed by the firms to manage what they have and know include: intranets, extranets, electronic message exchange programs (virtual discussions via information technology platforms), face-to-face group discussions/meetings, informal verbal reportback/feedback sessions to superiors, computer aided design programs (e.g. project management, architectural, engineering design programs), electronic document management system, team building activities, brainstorming sessions, and information technology hardware (e.g. servers and computers) that support the software programs.

The least employed appears to be electronic contract/procurement system, electronic tender document system, discussion forums/boards placed on the intranet or another program, formal project reviews at the end of

each phase of a project and formal post-project reviews, meetings to discuss/evaluate completed project reviews, lessons-learnt manuals, best practices guides, project lessons-learnt sharing sessions, mentoring and apprenticeship, and expertise locator/people finder.

Q9 How is knowledge 'transferred' or 'passed-on' from one project to another (in particular, from past projects to future projects)?

A9 *Although the case study firms employed a variety of tools, methods and mechanisms to manage what they know, their primarily function appears to be that of centralising knowledge and not the transference of knowledge from one project to another.*

The author surmises that this could be because the case study firms largely emphasized the use of information technology (apart from firm S-small firm) to support their KM initiatives which more often or not led to the primary focus on the emphasis of retention and retrieval of what the organisation and its staff had and knew instead of an emphasis on the 'direct' sharing of what each staff had and knew with each other either via face-to-face conversations (e.g. meetings and discussions) or virtual conversations (via software programs such as msn messenger or phone calls).

Q10 How regularly used and effective are these tools, methods and mechanisms in enabling individuals to learn from one project for application in another?

A10 *It was clear that each tool, method and mechanism had differing levels of regularity of use and effectiveness in enabling individuals to learn from one project for application in another in each of the case study organisations (of which have been discussed in detail in Section 4).*

However, it was evident that, overall, the most consistently regularly used and effective tools, methods and mechanisms appear to be intranets, extranet, electronic message exchange, project management and quality assurance manuals, regular and irregular discussions, brainstorming sessions, management meetings, formal project team meetings, informal verbal feedback sessions by employees to superiors, and mentoring and

apprenticeship.

Q11   Which of the tools, methods and mechanisms are effective in enabling learning between project phases in a project rather than between projects within an organisation?

A11   *Overall, it appears that regular discussions between superior and subordinate and irregular discussions between peers had been more effective in enabling learning between projects in an organisation while irregular discussions between superior and subordinate and between peers had been more effective in enabling learning between project phases within a project; management meetings had been more effective than formal project team meetings in enabling learning between projects in an organisation while formal project team meetings had been more effective than management meetings in enabling learning between project phases in a project; brainstorming sessions and project lessons-learnt sharing sessions had been more effective than information sessions, seminars, forums, talks, expert panels etc. and team building activities in enabling learning both between projects in an organisation and between project phases in a project; informal verbal reportback/feedback sessions by employees to superiors combined with formal post-project reviews had been more effective than meetings to discuss/evaluate completed project reviews and formal project-reviews at the end of each phase of a project in enabling learning between projects within an organisation while informal verbal reportback/feedback sessions by employees to superiors combined with formal project reviews at end of each phases of a project had been more effective than formal post-project reviews and meetings to discuss/evaluate completed project reviews in enabling learning between project phases in a project; project management manuals and quality assurance manuals had been more effective than best practices guides and lessons-learnt manuals in enabling both learning between projects in an organisation and between project phases in a project; mentoring and apprenticeship and formal procedures for rotating people around projects, functional departments, different job scopes etc had been more effective than informal rotation of people around projects, functional departments, different job scopes etc and work induction for new staff in*

enabling learning between projects in an organisation and between project phases in an organisation; and intranets, electronic message exchange, expertise locator, and electronic document management system, and computer aided design programs respectively had been more effective than extranet, electronic tender document management system, and electronic contract/procurement system in enabling learning between projects in an organisation while electronic message exchange, electronic document management system, intranets and computer aided design programs had been more effective than extranet, expertise locator, electronic tender document management system and electronic contract/procurement system in enabling learning between project phases in a project.

Q12   What types of problems (generic and recurrent, or specific and less recurrent) have the tools, methods and mechanisms employed enabled the organization to resolve?

A12   *Overall, it appears that irregular (ad-hoc) discussions had been most effective in resolving both types of problems with the differentiation lying with irregular discussions between peers being most effective for resolving generic and recurrent problems and irregular discussions between superior and subordinate being most effective for resolving specific and less-recurrent problems (followed by regular discussions between superior and subordinate) while the least effective in resolving both types of problems had been regular discussions between peers and discussion forums/boards placed on the intranet/extranet or another program; formal project team meetings had been more effective than management meetings and directors' meetings in resolving directors' only meetings respectively while management meetings had been more effective than formal project team meetings and directors' only meetings respectively in resolving specific and less-recurrent problems; brainstorming sessions followed by information sessions, seminars, forums, talks, expert panels had been more effective than project lessons-learnt sharing sessions and team building activities in resolving generic and recurrent problems while brainstorming sessions followed by project lessons-learnt sharing sessions had been more effective than information*

sessions, seminars, forums, talks, expert panels and team building activities in resolving specific and less-recurrent problems; informal verbal feedback sessions by employees to superiors followed by formal project reviews at the end of each phase of a project had been more effective than formal post project reviews and meetings to discuss/evaluate completed project reviews in resolving both types of problems; quality assurance manuals followed by project management manuals had been more effective than lessons-learnt manuals and best practices guides in resolving both types of problems; informal rotation of people around projects, functional departments, different job scopes and mentoring and apprenticeship had been more effective than formal procedures of rotation and work induction for new staff in resolving both types of problems; and electronic message exchange, intranets, extranet, computer aided design programs, and expertise locator had generally been more effective than electronic tender document management system, electronic document management system, electronic procurement system in resolving both types of problems.

Q13 Which of the tools, methods and mechanisms are effective in enabling staff to experience learning at the individual, division/department, and/or corporate level?

A13 *Overall, it appears that the less 'formal' tools (such as irregular face-to-face discussions, brainstorming sessions, informal verbal reportback sessions) had been most effective in enabling staff to experience learning at the individual level while more 'formal' tools (such as intranets, discussion forums/boards and formal post-project reviews) placed on intranet or another program, had been most effective at the corporate levels, and a combination of both tools were required at the division level.*

For instance, irregular discussions had been more effective than regular discussions in enabling staff to experience learning at the individual level while a combination of both regular discussion between superior and subordinate and irregular discussions between peers and between superior and subordinate had been most effective at the division level, and discussion forums/boards placed in the intranet or another program

and regular discussions had been more effective than irregular discussions at the corporate level; formal project team meeting followed by management meetings had been more effective than directors' only meetings in enabling staff to experience learning at the individual level while management meetings followed by formal project team meetings had been more effective than directors' only meetings at the division level and management meetings followed by directors' meetings had been more effective than formal project team meetings at the corporate level; information sessions, seminars, forums, talks, expert panels and brainstorming sessions had been more effective than project lessons-learnt sharing sessions and team building activities in enabling staff to experience learning at the individual level while brainstorming sessions and project lessons-learnt sharing sessions had been more effective than information sessions, seminars, forums, talks, expert panels and team building activities in enabling staff to do so at the division level, and information sessions, seminars, forums, talks, expert panels and project lessons-learnt sharing sessions were most effective in enabling staff to do so at the corporate level; informal verbal feedback by employees to superiors and formal post-project reviews followed by formal post-project reviews had been more effective than formal project reviews at the end of each phase of a project and meetings to discuss/evaluate completed reviews at the individual level while formal post-project reviews followed by formal project reviews at the end of each phase of a project had been more effective than informal verbal reportback/feedback sessions by employees to superiors at the division level, and formal post-project reviews and meetings to discuss/evaluate project reviews had been more effective than formal project reviews at the end of each phase of a project and informal verbal reportback/feedback sessions by employees to superiors at the corporate level; quality assurance and project management manuals had been more effective than best practices guides and lessons-learnt manuals in doing so at all three levels of the organisation; mentoring and apprenticeship followed by work induction for new staff had been more effective than formal procedures for rotating people around projects, functional departments, different job scopes and

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informal rotation of people around projects, functional departments, different job scopes in doing so at both the individual and division levels while formal procedures for rotating people around projects, functional departments, different job scopes followed by mentoring and apprenticeships and work induction for new staff had been more effective than informal rotation of people around projects, functional departments, different job scopes at the corporate level; intranets, followed by electronic message exchange, electronic document management system and computer aided design programs respectively had been more effective than extranet, expertise locator, electronic tender document management system and electronic contract/procurement system respectively at the individual level while electronic document management system followed by electronic message exchange, intranets, and electronic tender document management system respectively had been more effective than expertise locator, electronic contract/procurement system, computer aided design programs and extranet respectively at the division level, and intranets followed by computer aided design programs, electronic message exchange, and extranet respectively had been more effective than expertise locator, electronic document management system, electronic document management system, and electronic contract/procurement system respectively at the corporate level.

Q14   Are these tools, methods and mechanisms really capable of enabling learning to occur in the organisation; in particular between its members?

A14   *It was evident that not all tools, methods and mechanisms had been capable of enabling learning across organisational members, and that each had varying degrees of capability in doing so. In addition, the effectiveness and performance outcomes of each tool, method and mechanism were different in different types of organisations and their organisational context.*

Other questions:

Q15   Is what is currently managed in the case study firms really knowledge or simply data and information?

A15   *There was clearly a dichotomy in regards to how all three case study*

firms regard their set of KM initiatives which they had employed. On one hand, all three case studies believed that the KM initiatives employed in their firms were intended to assist them in managing the knowledge they had. On the other, they termed their set of initiatives as a 'KM system'- which obviously had an information technology connotation attached.

However, in reality, knowledge resides in the heads/minds of individuals and cannot be managed utilising an information technology. This is because when tacit knowledge is converted from the head/mind into verbal and written forms, it can only at best be explicit data and information (and/or a storyline of what had happened). Likewise, when data and information is obtained by an individual, it has to be process (organised, analysed, reflected, understood and learnt) to produce knowledge).

Q16   Do staff in the case study organisations consider loss of knowledge and know-how to be a problem that needs to be minimised?

A16   *From discussions with respondents, most respondents believed that loss of knowledge and know-how is a critical issue/problem that needs to be minimised in firms that manage projects on a daily basis (especially construction firms and projects) as they require past project knowledge to better improve the process of managing as well as the performance of future projects.*

Q17   What do staff in the case study organisations think are the most likely causes of loss of knowledge and know-how from past projects?

A17   *It was clear from discussions with respondents that the key causes of loss of knowledge and know-how from past projects were the inability of firms to provide a proper infrastructure to enable staff to retain and retrieve as well as share what the know with each other (via both technological and non-technological means), and high rates of staff turnover causing individuals to take away valuable knowledge that resided in their heads/minds.*

Additionally, the author believes that any KM infrastructure set-up needs to be aided by tools, methods and mechanisms that enable the process of

converting tacit knowledge into explicit information and vice-versa; in particular, the need to ensure that staff are aware and understand the need to utilise the process of organisation, analysis, reflection, understanding and learning aided by their individual wisdom to convert information to knowledge, and encouraging staff as well as providing staff with the necessary tools to convert the tacit knowledge in their heads into explicit information (a suggestion is for individuals to use story-telling to record what had happened in their projects).

Q18 Do staff in the case study organisations think that loss of knowledge and know-how (from lack of internal sharing of knowledge and experiences) affect project performance?

A18 *Although there was no direct indication from respondents that loss of knowledge and know-how will affect project performance, it could be inferred from discussions with them that loss of knowledge and know-how would logically reduce their ability to learn from the successes and failures of past projects to improve the process of managing as well as the performance of future projects and the organisations (i.e. project and organisational performances may not be improved or may worsen if staff were not provided with the infrastructure to enable them to learn from the lessons of their past projects)*

6.4 Conclusions about the Research Problem

This research on the knowledge management infrastructures of construction organisations have provided an in-depth understanding of not only the tools, methods and mechanisms available for managing knowledge within construction organisations, but also the effectiveness and performance outcomes the tools, methods and mechanisms in enabling learning between projects in an organisation versus between project phases in a project, resolving generic and recurrent problems versus specific and less-recurrent problems, and in enabling staff to experience learning at the individual, division and corporate levels of the organisation.

It was also clear from the research findings that there is no single set of tools, methods and mechanisms that is a panacea to best managing knowledge- i.e. it is not appropriate to simply identify and replicate a single set of tools, methods and

mechanisms for managing knowledge in all construction organisations. Each organisation has to first analyse or identify its business objectives and align them with their objectives of KM initiatives, and identify the available tools, methods and mechanisms that are most suited to their organisational context (size, business objectives and priorities).

It was also apparent that often what was managed in the case study firms did not appear to be knowledge but instead just data and information. The author believes that this may be due to two reasons: the 'take-for-granted' and misguided terminology of *knowledge management systems* to be able to manage knowledge instead of the more appropriate term *knowledge management infrastructures*, and the poor understanding or misconception of the terms knowledge and knowledge management. The former misguide concept is often a result of a 'norm' for organisations to simply regard the management of knowledge utilising primarily information technology tools; thereby terming knowledge management system. The latter may largely be due to the misguided definition of knowledge which is often intertwined with data and information.

The author also suggests that organisations need to understand that the management of knowledge does not just include the use of information technology tools to manage what the organisations know but also the use of non information technology tools (especially those that enable direct verbal communication between staff), and not just the storage and retrieval of what the organisation knows but also the facilitation of knowledge sharing via direct verbal means between individuals. Hence, the set of tools used to manage knowledge should not be limited to a technological connotation of knowledge management system but knowledge management infrastructure.

Therefore, knowledge essentially cannot be retained via information technology - only data and information can. This is because knowledge only resides in the heads/minds of individuals. Therefore, tools, methods and mechanisms enabling communication are required to convert the tacit knowledge that resides in the heads of individuals into explicit information (and vice versa) with each other. Apart from that, a level of personal intellect is required to organise, analyse, reflect upon and learn from the information obtained to convert it into knowledge. Likewise, the same process is

required to convert tacit knowledge into explicit information for use by another individual.

6.5 Contributions to the Body of Knowledge and to the Industry

Only recently has literature on knowledge management within the context of the construction industry been published (Chong, Uden and Naaranoja 2007; Carrillo & Chinowsky 2006; Amran 2006; Anumba, Egbu and Carrillo 2005; Egbu 2004; Hari, Egbu & Kumar 2005; Lee *et al.* 2005; Milton 2005; Palmer and Platt 2005; Kululanga and McCaffer 2001; Robinson *et al.* 2001; Sheehan and Payne 2004; Kazi 2005; Egbu *et al.* 2003a; Christiansson 2003; BSI 2003; Hamzah and Berawi 2001; McConalogue 1999).

However, few published studies involved detailed case studies of the knowledge management systems or infrastructures (e.g. examining the tools, methods and mechanisms used to manage knowledge, and their effectiveness and performance outcomes) in 'real-life' project based organisations (in particular, construction organisations), let alone document and discuss the tools, methods and mechanisms that had been implemented in such organisations, which tools, methods and mechanisms had been more effective than others in enabling learning to occur between projects in an organisation or between project phases in a project, which tools, methods and mechanisms had been more effective than others in resolving generic and recurrent problems versus specific and less-recurrent problems, and which tools, methods and mechanisms had been more effective in enabling staff to experience learning at the individual, division and corporate levels respectively.

Therefore, this research is unique and important in the following ways:

1) Analysis and findings are based on case studies conducted in 'real-life' construction firms which had developed, implemented and are currently maintaining a KM 'system'.

2) Provides construction firms that may already have a KM 'system' or infrastructure in placed as well as those that currently do not have one to reassess/assess their current position on KM (current status of KM in the firms

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and their strengths and weaknesses) by utilising the detailed analysis and findings of the three exemplars of knowledge management 'systems' (including the effectiveness and performance outcomes of the various tools, methods and mechanisms available for managing knowledge) to realign/align their KM initiatives (if they already exist) with their current or future business strategies and objectives by taking the context of the firms into consideration with the aim of improving their capability to manage what the firms and their staff have and know.

3) Provides evidence that KM infrastructures cannot simply be 'copied and applied' directly from one firm for application in another. In addition, the functions of an intranet set up to manage what a firm has and knows cannot (and should not) be simply transplanted from one firm for application in another, and that the general misconception that intranet equates a KM system or infrastructure should be eliminated. Also, the research shows that simply having a KM system does not necessarily meant that it is capable of managing knowledge. Often, what is managed is only data and information.

4) KM involves the tools, methods and mechanisms that enabled individuals to share what they know with each other by connecting people to what the firm has and people to what other people have (via both technological and non-technological means) as well as the inculcation of a corporate culture of sharing for the tacit knowledge to be effectively converted to explicit knowledge for the knowledge management infrastructure to be effective.

The benefits of the research (and in particular, the detailed analysis and findings from the three case studies) include:

1) Construction firms would now have the ability to assess, understand, learn, and adopt and/or adapt the appropriate tools, methods and mechanisms to suit their unique organisational context (such as size and business strategies, priorities, objectives and cultures).

2) Learning from the successes and failures of other organisations' attempts to

develop, implement and maintain and/or improve their KM infrastructures would enable other firms to "get it right the first time' by preventing the recurrence of mistakes or errors previously made by these organisations and effecting their successes. This would also clearly enable organisations to potentially reduce their own initial costs attributed to mistakes made in developing, implementing and maintaining own their KM infrastructure.

6.6   Limitations

Although these case studies were conducted in construction organisations in several countries namely Taiwan, Australia and Singapore, it did not examine in detail the cultural, social, economic and political aspects of each country in relation to the organisations, their business strategies and objectives, and the KM initiatives in place in the organisations- in particular whether cultural, social, economic and political differences in each country has an effect on the way the KM initiatives were developed, implemented, and maintained as well as the performance outcomes of the initiatives. For instance, the author felt that despite the supposed 'open' culture of organisations and their staff situated in western countries versus the presumably 'more shy or conservative' culture of their asian neighbours, the author had greater difficulty in obtaining firms in Australia to participate in the research as compared to those in the other two countries as well as encouraging respondents in the Australian firm to discuss the questions asked. It was also found through the research that, regardless of the geographic location or the origin of the firm, all the firms faced similar difficulties and challenges when developing, implementing and maintaining their KM initiatives.

In addition, it is necessary to note that we should be careful not to too quickly generalise the findings of these three case studies to all other construction organisations. Instead, the findings and recommendations of this research should be applied after an in-depth study of the context (e.g. size, culture, structure, objectives, geographic location etc.) of the organisation. The 'modus operandi' of studying the context of the firms could be learnt from the studies conducted as part of this research, adapted and applied to the study of other organisations.

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6.7   Further Research

The author proposes the following topics for future research- some of which data and information have already collected and preliminarily analysed but not reported in this thesis because the findings either did not allude directly to the research problem/s per say (i.e. these were 'extra'/additional findings) and the lack of substantial data and information to ensure their credibility and validity at this moment.

1) Conduct more case studies in construction firms of different sizes with the purpose of obtaining substantial data in order to statistically test and understand the relationship between the each process of managing knowledge (e.g. between capture and share, between retain and share, between share and apply, and between apply and capture etc.). Currently, the three case studies only provide an in-depth understanding of the components and effectiveness and performance outcomes of the tools, methods and mechanisms that make up the knowledge management infrastructures within the firms. More case studies are required to statistically test the relationships between each of the knowledge processes.

2) Examine whether there are any relationships between the spatial layout of the various departments/divisions within a construction firm, and the effectiveness and performance outcomes of the tools, methods and mechanisms currently employed to manage knowledge. For instance, research could be done on some firms that have spatially distinct divisions/departments (e.g. on different levels of a same building) versus those that have all divisions/departments on a same office level.

3) Examine and understand the reasons for the respondents' 'low regard for lessons-learnt manuals, best practice guides, and project lessons-learnt sharing sessions, and even formal project reviews (i.e. what is it that makes them so 'shunned'?), identify whether there is a need for construction firms to utilise such tools in the first place, and if required, develop ways in which the firms could eliminate the barriers to implementing and utilising them.

4) Identifying the specific types of data, information and knowledge required for each of the different professions employed on a construction project (project management, architecture, quantity surveying, civil and structural engineering,

mechanical and electrical engineering etc.), and verify if what is required by all the professions are the same, similar or different.

5) To explore whether the culture-based perspective of KM (e.g. people, their relationships and communication) or the structural-based perspective of KM (tools, methods and mechanisms used to support the initiatives- may be technology-based: e.g. softwares and hardwares, and/or non-technology-based: e.g. hardcopy documents, and verbal conversations) has a greater impact on the success of KM initiatives.

6) Conduct research on understanding why most employees of construction firms setting up a KM infrastructure are fearful of or do not wish to participate in KM initiatives, and develop methods of making the employees active and willing contributors to the development, implementation and maintenance of the KM infrastructure.

7) Develop ways (be it procedures, protocols or methodologies) to ensure that construction firms and their staff would be able to constantly ensure the relevancy and value (e.g. usefulness and 'updated-ness') of the data, information and knowledge managed by the tools, methods and mechanisms employed by the KM infrastructure.

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APPENDIX A

CONTEXTUAL COMPARISON OF THE THREE CASE STUDY ORGANISATIONS

		Firm S	Firm M	Firm L		
		(Taiwanese Contractor based in Taiwan)	(American MNC Consultancy based in Australia & Singapore)	(Singaporean MNC Consultancy based in Singapore)		
Size		Small	Medium	Large		
		(approximately 50 staff)	(approximately 230-280 staff)	(approximately 2300 staff)		
General Characteristic		Hierarchical but Collegial and Compact (free-flowing direct communication between staff and superiors- including the President of the firm)	Open (flat) structure (but appears to have some difficulties in communication between staff)	Hierarchical (with difficulty in communication between staff from different divisions).		
				Senior Management	Professional Staff	Overall (Senior Management + Professional Staff)
Business Type	Business Focus	**Productivity**	Equally **Productivity** & Creative	**Productivity**	**Productivity**	Productivity
	Nature of Business	Innovative	Innovative	Standardised	Standardised	Standardised
	Organisational Culture	Hierarchic	Open	Hierarchic	Hierarchic	Hierarchic
	Style of Operation	Centralised	Decentralised	Decentralised	Centralised	Decentralised
Business Priorities	Primary Emphasis (areas which the firm had placed a lot of emphasis on)	Cost of projects, cost to run the firm, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, technological capability, job security, business process	Cost of projects, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, technological capability, staff development	Cost to run the firm, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, market share, technological capability	Cost to run the firm, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, market share, cost of projects	Cost to run the firm, quality of product and services, client satisfaction and support, staff's work productivity, sales/turnover, market share
	Secondary Priorities (areas that require substantial improvement)	Staff creativity and innovation, staff satisfaction and support, comfortable work environment, market share, staff development	Staff creativity and innovation, staff satisfaction and support, comfortable work environment, market share, business processes, job security, cost to run the firm	Staff creativity and innovation, staff satisfaction and support, comfortable work environment, business processes, staff development, cost of projects, job security	Staff creativity and innovation, staff satisfaction and support, comfortable work environment, business processes, staff development, technological capability, job security	Staff creativity and innovation, staff satisfaction and support, comfortable work environment, business processes, job security, staff development, technological capability

Views on KM in the Organisation	Majority of the respondents believe that KM is regarded as a vital part of business strategy and knowledge is widely recognised as the basis for the company's competitive position, and that it also acts as a platform to enable	All the respondents believe that KM is regarded as a vital part of business strategy and knowledge is widely recognised as the basis for the company's competitive position, and that it also acts as a platform to enable organisational	Majority of the respondents believe that KM is regarded as a vital part of business strategy and knowledge is widely recognised as the basis for the company's competitive position, and that it also acts as a platform to enable organisational staff to share knowledge gained from projects done by different staff. However, a much larger percentage of professional staff held such a belief as compared to senior management staff.

organisational staff to share knowledge gained from projects done by different staff.

staff to share knowledge gained from projects done by different staff.

Views on the Existence of Methods or Systems to Manage Knowledge	Majority believe that methods or system to manage knowledge exists within the firm.	Majority believe that methods or system to manage knowledge exists within the firm.	Majority believe that methods or system to manage knowledge exists within the firm.		
Views on the Overall Purposes of KM Initiatives Implemented	Centralisation of the pool of knowledge and experiences acquired and/or developed by staff in order to increase staff productivity and innovation, and better decision making.	Equally split between the facilitation of a sharing culture amongst staff, and the centralisation of the pool of knowledge and experiences acquired.	Centralisation of the pool of knowledge and experiences acquired and/or developed by staff in order to increase staff productivity and innovation, and better decision making. However, a much larger percentage of senior management staff held such a belief as compared to professional staff.		
Views on the Existence of a Board-level Representation for KM & Substantial/demonstrable Top/Senior Management Encouragement	No existence of a Board-level Representation for KM but senior management encouragement was substantial	No existence of a Board-level Representation for KM but senior management encouragement was substantial	A Board-level Representation for KM exists, and senior management encouragement was substantial	No existence of a Board-level Representation for KM but senior management encouragement was substantial	A Board-level Representation for KM exists, and senior management encouragement was substantial
Vews on the Initiator of the KM initiatives	KM was largely (and at best equally) initiated by senior management and middle management	KM was largely initiated by senior management, followed by middle management	KM was largely initiated by senior management, followed by middle management	KM was largely initiated by senior management, followed by middle management	KM was largely initiated by senior management, followed by middle management
Views on the Receptiveness of KM Initiatives	All three levels of the organisation had been relatively receptive (although the level of receptiveness was highest at the senior management level, and subsequently followed by the middle management and professional staff levels)	All three levels of the organisation had been relatively receptive (although the level of receptiveness was highest at the senior management level, and subsequently followed by the middle management and professional staff levels.) However, they were higher in Company S than in M.	All three levels of the organisation had been relatively receptive (although the level of receptiveness was highest at the senior management level, and subsequently followed by the middle management and professional staff levels)	All three levels of the organisation had been relatively receptive (although the level of receptiveness was highest at the senior management level, and followed an equally receptive middle management and professional staff levels)	All three levels of the organisation had been relatively receptive (although the level of receptiveness was highest at the senior management level, and subsequently followed by the middle management and professional staff levels)

APPENDIX B

COMPARISON OF THE THREE CASE STUDY ORGANISATIONS

Regularity of Use and Effectiveness of the Tools, Methods & Mechanisms within the Firm in Enabling Learning from One Project for Application in Another
(Ranked from most (1) to least (largest number) regularly used and effective)

Ranked from smallest to largest number: least and most regularly used and effective tool respectively		Company S (Taiwanese Contractor based in Taiwan)	Company M (American MNC Consultancy based on Australia and Singapore)	Company L (Singaporean MNC Consultancy based in Singapore)	Overall
DISCUSSIONS	1	Regular discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organisation	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organisation	Regular discussions between superior and subordinate
	2	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate
	3	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organisation	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organisation
	4	Discussion forums/boards placed on the intranet/extranet or another program	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organisation	Regular discussions between employees of same or similar level of position/standing in the organisation	Regular discussions between employees of same or similar level of position/standing in the organisation
	5	Regular discussions between employees of same or similar level of position/standing in the organisation	Discussion forums/boards placed on the intranet/extranet or another program	Discussion forums/boards placed on the intranet/extranet or another program	Discussion forums/boards placed on the intranet/extranet or another program
MEETINGS	1	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)
	2	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only)	Management meetings (managers only)
	3	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings
SESSIONS/FORUM S	1	Brainstorming Sessions	Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Brainstorming Sessions
	2	Team Building Activities	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels
	3	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Project Lessons-learnt Sharing Sessions
	4	Project Lessons-learnt Sharing Sessions	Team Building Activities	Team Building Activities	Team Building Activities

	#				
PROJECT REVIEWS	1	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors
	2	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project
	3	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Meetings to discuss/evaluate completed project reviews	Formal Post-project reviews
	4	Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews	Formal Post-project reviews	Meetings to discuss/evaluate completed project reviews
MANUALS/GUIDELINES/CHECKLISTS/STAND	1	project management manual	project management manual	quality assurance manual	project management manual
	2	quality assurance manual	quality assurance manual	project management manual	quality assurance manual
	3	best practices guides	best practices guides	best practices guides	best practices guides
	4	lessons-learnt manual	lessons-learnt manual	lessons-learnt manual	lessons-learnt manual
HUMAN RESOURCE	1	Mentoring & apprenticeship	Mentoring & apprenticeship	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship
	2	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Mentoring & apprenticeship	Formal procedures for rotating people around projects, functional departments, different job scopes etc.
	3	Work Induction for New Staff	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc
	4	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Work Induction for New Staff
COMPUTING	1	Electronic message exchange	Electronic message exchange	Electronic message exchange	
	2	Intranets	Intranets	Intranets	
	3	Computer Aided Design Programs	Computer Aided Design Programs	Extranet	
	4	Electronic Document Management System	Extranet	Electronic Contract/Procurement System (e.g. contract management, purchasing)	
	5	Electronic Tender Document Management System	Electronic Document Management System	Expertise Locator/People Finder	
	6	Extranet	Expertise Locator/People Finder	Electronic Document Management System	
	7	Electronic Contract/Procurement System	Electronic Contract/Procurement System	Electronic Tender Document Management System	
	8	Expertise Locator/People Finder	Electronic Tender Document Management System	Computer Aided Design Programs	

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APPENDIX C

COMPARISON OF THE THREE CASE STUDY ORGANISATIONS

Effectiveness of the Tools, Methods and Mechanisms in Enabling Learning to Occur Between Projects within an organisation and/or Between Project Phases within a Project.
(Ranked from most (1) to least (largest number) effective- where no learning had been enabled either between projects or between project phases, the sentence 'NIL' will be denoted in the cell)

	Company S (Taiwanese Contractor based in Taiwan)		Company M (American MNC Consultancy based on Australia and Singapore)		Company L (Singaporean MNC Consultancy based in Singapore)		Overall	
	Between Projects within the Organisation	Between Project Phases within a Project	Between Projects within the Organisation	Between Project Phases within a Project	Between Projects within the Organisation	Between Project Phases within a Project	Between Projects within the Organisation	Between Project Phases within a Project
1	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization Irregular (ad-hoc) discussions between superior and subordinate
2	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate
3	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organization
4	Discussion forums/boards placed on the intranet/extranet or another program	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program	Discussion forums/boards placed on the intranet/extranet or another program.
5	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program.	Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between employees of same or similar level of position/standing in the organization	

(Left margin label: DISCUSSIONS)

MEETINGS 1	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)
2	Management meetings (managers only)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Directors' only meetings	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)
3	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Directors' only meetings	Directors' only meetings	Directors' only meetings
SESSIONS/FORUMS 1	Brainstorming Sessions	Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Brainstorming Sessions; Project Lessons-learnt Sharing Sessions	Brainstorming Sessions
2	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions
3	Team Building Activities	Team Building Activities	Team Building Activities	Team Building Activities	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Team Building Activities	Information sessions, seminars, forums, talks, expert panels
4	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Team Building Activities	Team Building Activities		Team Building Activities
PROJECT REVIEWS 1	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors
2	Formal Post-project reviews	No responses for: - formal project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project
3	Formal Project-reviews at the end of each phase of a project; Meetings to discuss/evaluate completed project reviews	- formal post-project reviews; - meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Formal Post-project reviews	Formal Post-project reviews	Meetings to discuss/evaluate completed project reviews	Formal Post-project reviews
4			Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Meetings to discuss/evaluate completed project reviews

MANUALS/GUIDELINES/CHECK LISTS/STANDARDS

	C1	C2	C3	C4	C5	C6	C7	C8
1	project management manual	project management manual	project management manual / quality assurance manual	project management manual / quality assurance manual	quality assurance manual	quality assurance manual	project management manual	project management manual
2	quality assurance manual	quality assurance manual	best practices guides	best practices guides	project management manual	project management manual	quality assurance manual	quality assurance manual
3	best practices guides	best practices guides	lessons-learnt manual	lessons-learnt manual	lessons-learnt manual	lessons-learnt manual	best practices guides	best practices guides
4	lessons-learnt manual	No responses for: - lessons-learnt manual			best practices guides	best practices guides	lessons-learnt manual	lessons-learnt manual

HUMAN RESOURCE

	C1	C2	C3	C4	C5	C6	C7	C8
1	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship	Mentoring & apprenticeship	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship	Mentoring & apprenticeship
2	Mentoring & apprenticeship	Mentoring & apprenticeship	Work Induction for New Staff	Work Induction for New Staff	Mentoring & apprenticeship	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Formal procedures for rotating people around projects, functional departments, different job scopes etc. / Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc. / Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc
3	Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Mentoring & apprenticeship	Work Induction for New Staff	Work Induction for New Staff
4	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Work Induction for New Staff	Work Induction for New Staff		

#								
1	Intranets	Electronic Document Management System	Intranets	Electronic message exchange	Intranets	Electronic message exchange	Intranets	Electronic message exchange
2	Computer Aided Design Programs	Electronic message exchange	Electronic message exchange	Electronic Document Management System	Electronic message exchange	Intranets	Electronic message exchange	Electronic Document Management System
3	Electronic Document Management System	Computer Aided Design Programs	Expertise Locator/People Finder	Intranets	Extranet	Computer Aided Design Programs	Expertise Locator/People Finder / Electronic Document Management System	Intranets
4	Electronic message exchange	Intranets	Electronic Document Management System	Expertise Locator/People Finder	Computer Aided Design Programs	Electronic Document Management System	Computer Aided Design Programs	Computer Aided Design Programs
5	Electronic Tender Document Management System	Electronic Tender Document Management System	Computer Aided Design Programs	Computer Aided Design Programs	Expertise Locator/People Finder	Expertise Locator/People Finder	Extranet	Extranet
6	Expertise Locator/People Finder	Electronic Contract/Procurement System	Extranet	Extranet	Electronic Document Management System	Extranet	Electronic Tender Document Management System	Expertise Locator/People Finder
7	Extranet	Extranet	Electronic Contract/Procurement System	Electronic Contract/Procurement System	Electronic Tender Document Management System	Electronic Tender Document Management System	Electronic Contract/Procurement System	Electronic Tender Document Management System
8	Electronic Contract/Procurement System	No responses for: Expertise Locator	Electronic Tender Document Management System	Electronic Tender Document Management System	Electronic Contract/Procurement System (e.g. contract management, purchasing)	No responses for: Electronic Contract/Procurement System		Electronic Contract/Procurement System

APPENDIX D

COMPARISON OF THE THREE CASE STUDY ORGANISATIONS

Effectiveness of the Tools, Methods and Mechanisms in Resolving Generic and Recurrent Problems Versus Specific and Less-recurrent Problems
(Ranked from most (1) to least (largest number) effective- where a tool, method or mechanism had not effective in doing either at all, the word 'NIL' will be denoted in the cell.)

DISCUSSIONS

	Company S (Taiwanese Contractor based in Taiwan)		Company M (American MNC Consultancy based on Australia and Singapore)		Company L (Singaporean MNC Consultancy based in Singapore)		Overall	
	Generic and Recurrent Problems	Specific and Less-recurrent Problem	Generic and Recurrent Problems	Specific and Less-recurrent Problem	Generic and Recurrent Problems	Specific and Less-recurrent Problem	Generic and Recurrent Problems	Specific and Less-recurrent Problem
1	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate; Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization; Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization; Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate
2	Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate; Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Regular discussions between superior and subordinate
3	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program	Discussion forums/boards placed on the intranet/extranet or another program	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization
4	Irregular (ad-hoc) discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program.			Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization; Discussion forums/boards placed on the intranet/extranet or another program.	Regular discussions between employees of same or similar level of position/standing in the organization
5	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization			Discussion forums/boards placed on the intranet/extranet or another program.	Discussion forums/boards placed on the intranet/extranet or another program.		Discussion forums/boards placed on the intranet/extranet or another program.

MEETINGS

	1	2	3	4	5	6	7	8
1	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)
2	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)
3	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings

SESSIONS/FORUMS

	1	2	3	4	5	6	7	8
1	Brainstorming Sessions	Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Brainstorming Sessions	Brainstorming Sessions
2	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions
3	Team Building Activities	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels
4	Project Lessons-learnt Sharing Sessions	Team Building Activities	Team Building Activities	Team Building Activities	Team Building Activities	Team Building Activities	Team Building Activities	Team Building Activities

PROJECT REVIEWS

	1	2	3	4	5	6	7	8
1	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors
2	Formal Post-project reviews	No responses for: Formal project-reviews at the end of each phase of a project	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors	Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project
3	Formal Project-reviews at the end of each phase of a project	Formal post-project reviews / Meetings to discuss/evaluate completed project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Formal Post-project reviews	Formal Post-project reviews	Formal Post-project reviews	Formal Post-project reviews
	Meetings to discuss/evaluate completed project reviews				Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews		
4			Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews			Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews

MANUALS/GUIDELINES/CHECKLISTS/STANDARDS

1	quality assurance manual	project management manual	quality assurance manual / project management manual	project management manual	quality assurance manual	lessons-learnt manual	quality assurance manual	quality assurance manual
2	project management manual	quality assurance manual	best practices guides	quality assurance manual	project management manual	best practices guides	project management manual	project management manual
3	best practices guides	best practices guides / lessons-learnt manual	No responses for: Lessons-learnt manual	best practices guides	best practices guides	quality assurance manual	best practices guides	lessons-learnt manual
4	lessons-learnt manual			No responses for: Lessons-learnt manual	lessons-learnt manual	No responses for: Project management manual	lessons-learnt manual	best practices guides

HUMAN RESOURCE

1	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Mentoring & apprenticeship	Mentoring & apprenticeship	Mentoring & apprenticeship	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship	Mentoring & apprenticeship
2	Mentoring & apprenticeship	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Work Induction for New Staff	Mentoring & apprenticeship	Mentoring & apprenticeship	Formal procedures for rotating & informal rotation of people around projects, functional departments, different job scopes etc.	Work Induction for New Staff
3	Work Induction for New Staff	Work Induction for New Staff	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Work Induction for New Staff	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc
4	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.		Formal procedures for rotating people around projects, functional departments, different job scopes etc.

COMPUTING

#								
1	Electronic Tender Document Management System	Electronic message exchange	Intranets	Electronic message exchange	Electronic message exchange	Electronic message exchange	Intranets	Electronic message exchange
2	Computer Aided Design Programs	Computer Aided Design Programs	Extranet	Expertise Locator/People Finder	Intranets	Intranets	Computer Aided Design Programs	Intranets
3	Intranets	Electronic Document Management System / Intranets	Computer Aided Design Programs	Electronic Document Management System	Computer Aided Design Programs / Extranet	Extranet	Electronic message exchange	Expertise Locator/People Finder
4	Electronic Document Management System	Expertise Locator/People Finder	Electronic message exchange	Intranets	Expertise Locator/People Finder	Expertise Locator/People Finder	Extranet	Electronic Document Management System
5	Electronic message exchange	Electronic Contract/Procurement System	Electronic Document Management System	Extranet	Electronic Tender Document Management System	Computer Aided Design Programs / Extranet	Electronic Document Management System	Extranet
6	Electronic Contract/Procurement System	Electronic Tender Document Management System	Expertise Locator/People Finder	Computer Aided Design Programs	Electronic Document Management System	Electronic Document Management System	Electronic Contract/Procurement System	Computer Aided Design Programs
7	Extranet	Extranet	Electronic Contract/Procurement System	Electronic Contract/Procurement System	Electronic Contract/Procurement System	No responses for: Electronic Tender Document Management System / Electronic Contract/Procurement System	Expertise Locator/People Finder	Electronic Contract/Procurement System
8	Expertise Locator/People Finder		No responses for: Electronic Tender Document Management System	Electronic Tender Document Management System			Electronic Tender Document Management System	Electronic Tender Document Management System

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APPENDIX E

COMPARISON OF THE THREE CASE STUDY ORGANISATIONS

Effectiveness of the Tools, Methods and Mechanisms in Enabling Staff to Learn at Various Levels of the Organisations
(Ranked from most (1) to least Effective- where a tool, method, and mechanism had not enabled respondents to experience learning at any of the levels in the organisation, the word 'NIL' will be denoted in the cell)

DISCUSSIONS

	Company S (Taiwanese Contractor based in Taiwan)			Company M (American MNC Consultancy based on Australia and Singapore)			Company L (Singaporean MNC Consultancy based in Singapore)			Overall		
	Individual-level	Division/Department-level	Corporate-level	Individual-level	Division/Department-level	Corporate-level	Individual-level	Division/Department-level	Corporate-level	Individual-level	Division/Department-level	Corporate-level
1	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program.	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program.	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program
					Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization							
					Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization					
2	Discussion forums/boards placed on the intranet/extranet or another program.	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate
				Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization							Regular discussions between employees of same or similar level of position/standing in the organization	
				Regular discussions between employees of same or similar level of position/standing in the organization							Irregular (ad-hoc) discussions between superior and subordinate	
3	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Discussion forums/boards placed on the intranet/extranet or another program	Regular discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program	Discussion forums/boards placed on the intranet/extranet or another program	No responses for: Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization
		Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization				Regular discussions between superior and subordinate				Regular discussions between employees of same or similar level of position/standing in the organization		Irregular (ad-hoc) discussions between superior and subordinate
4	Regular discussions between superior and subordinate	Irregular (ad-hoc) discussions between superior and subordinate	Regular discussions between employees of same or similar level of position/standing in the organization				Regular discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	Irregular (ad-hoc) discussions between superior and subordinate	Discussion forums/boards placed on the intranet/extranet or another program.	Discussion forums/boards placed on the intranet/extranet or another program	
5	Regular discussions between employees of same or similar level of position/standing in the organization	Regular discussions between employees of same or similar level of position/standing in the organization					Discussion forums/boards placed on the intranet/extranet or another program.	Discussion forums/boards placed on the intranet/extranet or another program.	No responses for: Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization			

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MEETINGS

#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
1	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Directors' only meetings	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only) / Directors' only meetings	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only)
2	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	No responses for: Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Management meetings (managers only)	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Directors' only meetings
3	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Directors' only meetings	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)	Directors' only meetings	Directors' only meetings		Directors' only meetings	Directors' only meetings	Formal project-team (includes only staff within the organization) meetings (managers & non-managers)

SESSIONS/FORUMS

#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
1	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions / Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions / Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels / Project Lessons-learnt Sharing Sessions
2	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Team Building Activities	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions
3	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Brainstorming Sessions	Team Building Activities	Team Building Activities	Project Lessons-learnt Sharing Sessions	Team Building Activities	Team Building Activities
4	Team Building Activities	Team Building Activities	Team Building Activities		Team Building Activities	Team Building Activities	Team Building Activities	Information sessions, seminars, forums, talks, expert panels	No responses for: Brainstorming Sessions	Team Building Activities		

SESSIONS/FORUMS

#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
1	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions / Brainstorming Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions / Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels / Project Lessons-learnt Sharing Sessions
2	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Team Building Activities	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Project Lessons-learnt Sharing Sessions	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions
3	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Project Lessons-learnt Sharing Sessions	Information sessions, seminars, forums, talks, expert panels	Information sessions, seminars, forums, talks, expert panels	Brainstorming Sessions	Brainstorming Sessions	Team Building Activities	Team Building Activities	Project Lessons-learnt Sharing Sessions	Team Building Activities	Team Building Activities
4	Team Building Activities	Team Building Activities	Team Building Activities		Team Building Activities	Team Building Activities	Team Building Activities	Information sessions, seminars, forums, talks, expert panels	No responses for: Brainstorming Sessions	Team Building Activities		

PROJECT REVIEWS

	1	2	3	4	5	6	7	8	9	10	11	12
1	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews; Formal Post-project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Formal Post-project reviews	Formal Post-project reviews
2	Formal Post-project reviews	Formal Post-project reviews	No responses for: - Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project	Meetings to discuss/evaluate completed project reviews
3	No responses for: - Formal Project-reviews at the end of each phase of a project	Formal Project-reviews at the end of each phase of a project	No responses for: - Formal Post-project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project	Formal Post-project reviews	Formal Project-reviews at the end of each phase of a project; Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Formal Project-reviews at the end of each phase of a project	Informal verbal reportback/feedback sessions by employees to superiors; Meetings to discuss/evaluate completed project reviews	Formal Project-reviews at the end of each phase of a project
4	No responses for - Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews	No responses for: - Meetings to discuss/evaluate completed project reviews	Meetings to discuss/evaluate completed project reviews	Informal verbal reportback/feedback sessions by employees to superiors	Informal verbal reportback/feedback sessions by employees to superiors	Meetings to discuss/evaluate completed project reviews			Meetings to discuss/evaluate completed project reviews		Informal verbal reportback/feedback sessions by employees to superiors

MANUALS/GUIDELINES/CHECKLISTS/STANDAR

	1	2	3	4	5	6	7	8	9	10	11	12
1	quality assurance manual	project management manual	project management manual	project management manual; quality assurance manual	project management manual; quality assurance manual	project management manual; quality assurance manual	quality assurance manual	quality assurance manual	best practices guides	quality assurance manual	project management manual	project management manual
2	project management manual	quality assurance manual	quality assurance manual	No responses for: lessons-learnt manual	best practices guides	No responses for: lessons-learnt manual	project management manual	project management manual	quality assurance manual	project management manual	quality assurance manual	quality assurance manual
3	lessons-learnt manual	best practices guides	best practices guides	No responses for: best practices guides	No responses for: lessons-learnt manual	No responses for: best practices guides	best practices guides	best practices guides	No responses for: project management manual	unclear	best practices guides	best practices guides
4	best practices guides	No responses for: lessons-learnt manual	No responses for: lessons-learnt manual				lessons-learnt manual	lessons-learnt manual	No responses for: lessons-learnt manual	unclear	lessons-learnt manual	lessons-learnt manual

HUMAN RESOURCE

	1	2	3	4	5	6	7	8	9	10	11	12
1	Mentoring & apprenticeship (i.e. coaching)	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Mentoring & apprenticeship (i.e. coaching)	Mentoring & apprenticeship (i.e. coaching)	Work Induction for New Staff	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship (i.e. coaching) Formal procedures for rotating people around projects, functional departments, different job scopes etc	Work Induction for New Staff	Mentoring & apprenticeship (i.e. coaching)	Mentoring & apprenticeship (i.e. coaching) Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.
2	Work Induction for New Staff	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Mentoring & apprenticeship Formal procedures for rotating people around projects, functional departments, different job scopes etc. Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Work Induction for New Staff	Work Induction for New Staff	No responses for: Mentoring & apprenticeship	Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Mentoring & apprenticeship (i.e. coaching) Work Induction for New Staff
3	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Work Induction for New Staff	Work Induction for New Staff	Work Induction for New Staff	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	No responses for: Work Induction for New Staff	Mentoring & apprenticeship	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	No responses for: Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Formal procedures for rotating people around projects, functional departments, different job scopes etc.	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc
4	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Mentoring & apprenticeship (i.e. coaching)	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc		Formal procedures for rotating people around projects, functional departments, different job scopes etc.	No responses for: Formal procedures for rotating people around projects, functional departments, different job scopes etc.	No responses for: Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc		

#												
1	Intranets	Electronic Tender Document Management System	Intranets	Intranets	Electronic Document Management System	Extranet	Electronic message exchange	Electronic message exchange	Electronic Tender Document Management System / Expertise Locator/People Finder	Intranets	Electronic Document Management System	Intranets
2	Electronic Document Management System	Electronic Document Management System	Electronic Document Management System	Electronic message exchange	Expertise Locator/People Finder	Electronic Document Management System	Intranets	Intranets	Intranets	Electronic message exchange	Electronic message exchange	Computer Aided Design Programs
3	Computer Aided Design Programs	Computer Aided Design Programs	Computer Aided Design Programs	Electronic Document Management System	Intranets	Electronic message exchange	Extranet / Computer Aided Design Programs	Extranet	Computer Aided Design Programs	Electronic Document Management System	Intranets	Electronic message exchange
4	Electronic message exchange	Electronic message exchange	Electronic message exchange	Extranet	Electronic message exchange	Computer Aided Design Programs	Expertise Locator/People Finder	Electronic Tender Document Management System	Electronic message exchange	Computer Aided Design Programs	Electronic Tender Document Management System	Extranet
5	Electronic Tender Document Management System	Intranets	Electronic Tender Document Management System	Expertise Locator/People Finder	Computer Aided Design Programs	Intranets	Electronic Document Management System	Electronic Document Management System	Extranet	Extranet	Expertise Locator/People Finder	Expertise Locator/People Finder
6	Extranet	Electronic Contract/Procurement System	Electronic Contract/Procurement System	Computer Aided Design Programs	Electronic Contract/Procurement System	Electronic Contract/Procurement System	Electronic Tender Document Management System	Electronic Contract/Procurement System	No responses for: Electronic Document Management System	Expertise Locator/People Finder	Electronic Contract/Procurement System	Electronic Document Management System
7	Electronic Contract/Procurement System	Expertise Locator/People Finder	Extranet	Electronic Contract/Procurement System	Electronic Tender Document Management System	No responses for: Expertise Locator/People Finder	No responses for: Electronic Contract/Procurement System	Expertise Locator/People Finder	No responses for: Electronic Contract/Procurement System	Electronic Tender Document Management System	Computer Aided Design Programs	Electronic Tender Document Management System
8	Expertise Locator/People Finder	No responses for: Extranet	Expertise Locator/People Finder	Electronic Tender Document Management System	No responses for: Extranet	No responses for: Electronic Tender Document Management System		Computer Aided Design Programs		Electronic Contract/Procurement System	Extranet	Electronic Contract/Procurement System

APPENDIX F:
Analysis of Current KM Infrastructure & Recommendations for Changes for Firm S (Taiwanese Firm)

(A) CONNECTING PEOPLE-TO-ORGANISATION

TECHNOLOGICALLY BASED TOOLS

(A1) Computing

Item	Regularity of Use	Effectiveness in enabling learning from one project for application in another
Computer Aided Design Programs	8.86	7.14
Intranets	8.62	7.62
Extranet	7.50	8.25
Electronic Document Management System	7.00	7.15
Electronic Tender Document Management System	6.56	6.89
Electronic Contract/Procurement System	6.71	7.00
Average:	**7.54**	**7.34**
Sub-Total Average:	**7.54**	**7.34**

NON-TECHNOLOGICALLY BASED TOOLS

(A2) Project Reviews

Item	Regularity of Use	Effectiveness
Formal Project-reviews at the end of each phase of a project	3.00	4.00
Formal Post-project reviews	4.00	4.50
Average:	**3.50**	**4.25**

Manuals/Guides/Checklists/Standards

Item	Regularity of Use	Effectiveness
Project management manual	5.75	8.25
Quality assurance manual	5.25	6.50
Lessons-learnt manual	7.00	7.00
Best practices guides	8.00	7.00
Average:	**6.50**	**7.19**
Sub-Total Average:	**5.50**	**6.21**
TOTAL AVERAGE:	**6.52**	**6.78**

(B) CONNECTING PEOPLE-TO-PEOPLE

TECHNOLOGICALLY BASED TOOLS

(B1) Discussions

Item	Regularity of Use	Effectiveness in enabling learning from one project for application in another
Discussion forums/boards placed on the intranet/extranet or another program.	6.50	6.00
Average:	**6.50**	**6.00**

Computing

Item	Regularity of Use	Effectiveness
Electronic message exchange	9.20	8.10
Expertise Locator/People Finder	5.00	6.67
Average:	**7.10**	**7.38**
Sub-Total Average:	6.90	6.92

TOTAL AVERAGE (this section): 7.33 | 7.20

NON-TECHNOLOGICALLY BASED TOOLS

(B2) Discussions

Item	Regularity of Use	Effectiveness
Irregular (ad-hoc) discussions between superior and subordinate	6.38	7.38
Regular discussions between superior and subordinate	6.78	7.44
Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	6.00	7.22
Regular discussions between employees of same or similar level of position/standing in the organization	6.25	6.50
Average:	**6.35**	**7.14**

Sessions/Forums

Item	Regularity of Use	Effectiveness
Information sessions, seminars, forums, talks, expert panels	4.00	5.29
Project Lessons-learnt Sharing Sessions	3.33	4.67
Brainstorming Sessions	6.13	8.00
Team Building Activities	4.75	6.00
Average:	**4.55**	**5.99**

Meetings

Item	Regularity of Use	Effectiveness
Directors' only meetings	8.00	9.00
Management meetings	7.31	7.31
Formal project-team meetings	6.92	ˋ7.33
Average:	**7.41**	**7.88**

Project Reviews

Item	Regularity of Use	Effectiveness
Meetings to discuss/evaluate completed project reviews	3.00	4.00
Informal verbal reportback/feedback sessions by employees to superiors	7.33	6.22
Average:	**5.17**	**5.11**

Human Resource

Item	Regularity of Use	Effectiveness
Work Induction for New Staff	6.70	5.70
Mentoring & apprenticeship (i.e. coaching)	6.67	7.33
Formal procedures for rotating people around projects, functional departments, different job scopes etc.	7.43	6.86
Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	6.75	6.00
Average:	**6.89**	**6.47**
Sub-Total Average:	6.10	6.60

TOTAL AVERAGE (this section): 5.94 | 6.50

TOTAL AVERAGE: 6.22 | 6.65

APPENDIX G:
Analysis of Current KM Infrastructure & Recommendations for Changes for Firm M (American Firm)

		(A) CONNECTING PEOPLE-TO-ORGANISATION				(B) CONNECTING PEOPLE-TO-PEOPLE					
			Regularity of Use	Effectiveness in enabling learning from one project for application in another				Regularity of Use	Effectiveness in enabling learning from one project for application in another		
TECHNOLOGICALLY BASED TOOLS	**Computing**	**(A1)**				**Discussions**	**(B1)**				
		Computer Aided Design Programs	7.86	8.29			Discussion forums/boards placed on the intranet/extranet or another program	6.00	6.40		
		Intranets	9.50	8.13			Average:	6.00	6.40		
		Extranet	7.40	6.00							
		Electronic Document Management System	7.00	6.17		**Computing**	Electronic message exchange	9.57	9.00		
		Electronic Tender Document Management System	5.33	5.33			Expertise Locator/People Finder	6.60	6.20		
		Electronic Contract/Procurement System	8.00	7.50			Average:	8.09	7.60	**TOTAL AVERAGE**	**TOTAL AVERAGE**
		Average:	7.52	6.90							
		Sub-Total Average:	7.52	6.90			Sub-Total Average:	7.39	7.20	7.47	7.00
NON-TECHNOLOGICALLY BASED TOOLS	**Project Reviews**	**(A2)**				**Discussions**	**(B2)**				
		Formal Project-reviews at the end of each phase of a project	7.00	8.14			Irregular (ad-hoc) discussions between superior and subordinate	7.29	7.29		
		Formal Post-project reviews	7.33	8.17			Regular discussions between superior and subordinate	6.57	7.43		
		Average:	7.17	8.15			Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	7.57	7.43		
	Manuals/Guides/Checklists/Standards						Regular discussions between employees of same or similar level of position/standing in the organization	6.00	8.29		
		Project management manual	8.25	7.50			Average:	6.86	7.61		
		Quality assurance manual	8.13	7.50		**Sessions/forums**	Information sessions, seminars, forums, talks, expert panels	7.00	7.67		
		Lessons-learnt manual	0.00	0.00			Project Lessons-learnt Sharing Sessions	6.00	8.14		
		Best practices guides	6.50	7.00			Brainstorming Sessions	7.14	7.71		
		Average:	5.72	5.50			Team Building Activities	4.67	7.17		
		Sub-Total Average:	6.20	6.38			Average:	6.20	7.67		
						Meetings	Directors' only meetings	5.50	8.67		
							Management meetings	7.14	6.57		
							Formal project-team meetings	8.88	8.38		
							Average:	7.17	7.87		
						Project Reviews	Meetings to discuss/evaluate completed project reviews	7.50	7.75		
							Informal verbal reportback/feedback sessions by employees to superiors	6.83	7.50		
							Average:	7.17	7.63		
						Human Resource	Work Induction for New Staff	8.14	6.43		
							Mentoring & apprenticeship (i.e. coaching)	6.60	7.60		
							Formal procedures for rotating people around projects, functional departments, different job scopes etc.	5.67	5.33		
							Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	6.50	7.50	**TOTAL AVERAGE:**	**TOTAL AVERAGE:**
							Average:	6.73	6.72		
							Sub-Total Average:	6.76	7.46	6.62	7.18
		TOTAL AVERAGE:	6.86	6.64			**TOTAL AVERAGE:**	6.86	7.46		

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Analysis of Current KM Infrastructure & Recommendations for Changes for Firm L (Singaporean Firm)

			(A) CONNECTING PEOPLE-TO-ORGANISATION				(B) CONNECTING PEOPLE-TO-PEOPLE				
				Regularity of Use	Effectiveness in enabling learning from one project for application in another			Regularity of Use	Effectiveness in enabling learning from one project for application in another		
TECHNOLOGICALLY BASED TOOLS	Computing	**(A1)**				**(B1)**	Discussions				
			Computer Aided Design Programs	5.27	3.36			Discussion forums/boards placed on the intranet/extranet or another program.	4.80	5.20	
			Intranets	8.33	7.07			**Average:**	4.80	5.20	
			Extranet	6.45	5.27						
			Electronic Document Management System	7.00	5.00		Computing	Electronic message exchange (emails, instant messaging	9.60	7.47	
			Electronic Tender Document Management System	4.50	5.00			Expertise Locator/People Finder	6.40	5.60	
			Electronic	0.00	0.00			**Average:**	8.00	6.53	
			Average:	**6.31**	**5.14**						TOTAL AVERAGE:
			Sub-Total Average:	6.31	5.14			**Sub-Total Average:**	6.93	6.09	6.50 5.55
TECHNOLOGICALLY BASED TOOLS		**(A2)**				**(B2)**					
			Formal Project-reviews at the end of each phase of a project	6.30	6.60			Irregular (ad-hoc) discussions between superior and subordinate	7.14	7.50	
			Formal Post-project reviews	5.71	6.71			Regular discussions between superior and subordinate	6.89	8.11	
			Average:	**6.01**	**6.66**			Irregular (ad-hoc) discussions between employees of same or similar level of position/standing in the organization	8.50	8.00	
								Regular discussions between employees of same or similar level of position/standing in the organization	7.20	8.00	
			Project management manual	5.46	6.15			**Average:**	**7.43**	**7.90**	
			Quality assurance manual	6.46	6.54						
			Lessons-learnt manual	5.50	6.00			Information sessions, seminars, forums, talks, expert panels	6.13	6.93	
			Best practices guides	5.60	6.60			Project Lessons-learnt Sharing Sessions	6.21	7.36	
			Average:	**5.76**	**6.32**			Brainstorming Sessions	6.10	7.40	
								Team Building Activities	3.40	4.00	
			Sub-Total Average:	5.84	6.43			**Average:**	**5.46**	**6.42**	
								Directors' only meetings	4.83	4.33	
								Management meetings	7.00	6.75	
								Formal project-team meetings	8.54	7.85	
								Average:	**6.79**	**6.31**	
								Meetings to discuss/evaluate completed project reviews	6.29	7.43	
								Informal verbal reportback/feedback sessions by employees to superiors	6.40	7.20	
								Average:	**6.34**	**7.31**	
								Work Induction for New Staff	5.31	3.85	
								Mentoring & apprenticeship (i.e. coaching)	7.25	7.25	
								Formal procedures for rotating people around projects, functional departments, different job scopes etc.	7.33	7.33	
								Informal (ad-hoc) rotation of people around projects, functional departments, different job scopes etc	5.13	6.00	TOTAL AVERAGE:
								Average:	**6.25**	**6.11**	
								Sub-Total Average	6.45	6.78	6.29 6.69
			TOTAL AVERAGE:	5.55	5.36			**TOTAL AVERAGE:**	6.52	6.68	

APPENDIX I:
## Brief Outline of Questions Used in Interviews and Discussions

1) What is your perception of knowledge management, and definitions of data, information and knowledge?

2) What is the current state of knowledge management in your organisation?

3) How was the decision to develop and implement a Knowledge Management System made?
   - who was/were the initiator/s of the KMS?
   - who was the KM Champion?
   - were any studies done to examine the business needs of the KMS?
   - who is the KMS project leader?

4) What was the primary purpose of establishing the KMS

5) What were the challenges faced during the development, implementation and maintenance of the KM System?

6) What were the most critical success factors for KM System development and implementation, maintenance?

7) Was there sufficient top/senior management support to the KMS development, implementation, and maintenance in the organisation? If yes, how was it reflected? Who was the main supporter of the initiatives? If no, do you think it is necessary to have top/senior management support and how do think it could be improved?

8) Were (and how) are the KM initiatives aligned with organizational objectives/strategies?

9) Were there attempts to cultivate and promote/encourage a cultural environment in which information and knowledge is shared, managed and used- i.e. to promote a knowledge-sharing and tolerant culture?

10) What do you feel could/should be improved to enable a 'knowledge-sharing culture'?

11) What 'incentive' system(s) or method(s) is/are currently used to promote, motivate and effect a knowledge-sharing environment (e.g. to change the 'secrecy', 'protective', 'confidential' mindset of staff which often protects their own knowledge and keep what they know to themselves individually only- i.e. how to get them to share their knowledge)?

12) How do you ensure good content management, and prevent 'rubbish in, rubbish out'? (i.e. how do you ensure that the 'stuff' which is captured and retained by the KMS are relevant and useful?/how do you go about deciding what knowledge to include in the KMS?)- I.e. how do you recognise that the knowledge captured is valuable knowledge.

13) Who (corporate and/or divison and/or individual) identifies the domain experts and allocate them with the responsibilities to manage the KM system and particular domains; and how are they identified/chosen?
   - Are they willing parties?
   - What are their tasks?
   - How and what incentives are provided to staff to encourage them to become and remain as a domain expert?

14) Are there any measures currently used to assess the benefits and performance of the KM initiatives?
   - If Yes, What are they? What are their opinions on the measures (useful or not)?
   - If No, How does the organization know whether the KMS is 'successful' or not?

15) In advising other firms who may be intending to set up their own KM systems, how much of each of the following would you suggest they emphasise on to ensure the successful delivery of such a KM system- 'information technology' versus 'people and culture' (e.g. culture of openness and willingness to share)? How many percent would you allocate to 'information technology' and how many percent would you allocate to 'people and culture' (Total of both should make up 100%)?
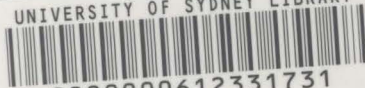
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APPENDICES I - III.

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