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Knowledge sharing in project work: the dynamic interplay of knowledge domains and skills

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Abstract

Purpose: This study aims to illuminate the currently poorly understood inflow of knowledge originating from project managers across the value chain of construction projects. The primary purpose is to identify the domains of knowledge that project managers need to share in their management activities, the skills they need to develop in their sharing practices, and how these relate to each other across different phases of a construction project.

Methodology: Knowledge domains, skills and the relationships between them were identified following an inductive methodology, a combination of Grounded Theory and Case Study, and through the analysis of semi-structured interviews with twenty-one project managers and participants within a single construction project.

Findings: The outcome is a novel framework that theorises the dynamic interplay between knowledge domains and the skills that facilitate knowledge sharing for successful project work throughout the construction project.

Originality: The combined effects of task heterogeneity, knowledge interdependencies, and temporariness require paying increased attention to how knowledge domains and knowledge sharing skills impact project performance. In this paper, we address gaps in developing an integrative understanding of the nature of the domains of knowledge that need to be shared in a project context, the key skills contributing to knowledge sharing, and more importantly how they evolve and are interpreted and reinterpreted throughout the project and assist knowledge sharing practice in projects.

Key words: knowledge sharing; knowledge domains; knowledge sharing skills; project management

1. Introduction

Knowledge sharing (KS) plays a crucial role in enhancing collaboration and innovation in project management (Saenz et al., 2012). Current knowledge sharing theories and studies have made important contributions to understanding the practices, influential factors, and challenges of knowledge sharing in the project context. To date, however, the connections between knowledge sharing and project management have not been fully explored (Garwood and Poole, 2018). There is a call to advance research that combines both areas to overcome the challenges of knowledge management in temporary organizations, whilst effectively taking stock of working styles, project temporal orientation and intrinsic motivation of individual employees (Ren et al., 2018). Our study advances the state-of-the-art in all of these directions and approaches the phenomenon of knowledge sharing in construction projects as a form of temporary organising from a project manager skills perspective, considering different project stages and looking at the positionality of stakeholders in the temporary project work arrangement. Similarly, our proposed approach to conceptualising knowledge sharing skills and knowledge domains in construction projects as a form of temporary organising also extends the more recent work of Ren et al. (2018), through focusing on the identification of skills that are crucial in addressing the major bottlenecks affecting successful project-based knowledge sharing such as difficulties in establishing routines and organizational memory.

Furthermore, a limited number of studies focuses on skills facilitating knowledge sharing and the impact of these skills on the agency of project managers in shaping project work. Questions remain as to what are the key skills contributing to knowledge sharing in project management, and more importantly, how do they assist knowledge sharing practice in projects (Navimipour and Charband, 2016). Project managers, as key personnel in project management, often experience difficulties in sharing individual knowledge and in facilitating knowledge sharing within project teams. Kazadi *et al* (2016) also suggest that definitions of project management skills remain vague and abstract without offering an in-depth understanding of them. On the other hand, the identification of skills contributing to knowledge sharing in project management is also complicated by the absence of a consensus on the domains of knowledge that need to be shared in a project context (Navimipour and Charband, 2016). Despite substantial discussion on the essential generic skills of project managers, there is insufficient examination of skills pertaining specifically to knowledge sharing or the specific content and form of knowledge being shared within different project teams.

To unite these two research areas, we adopt an integrative approach to explore knowledge domains and skills, i.e., to first identify what knowledge needs to be shared within the context of a project, and then identify skills that contribute to and enable the sharing those knowledge domains. In

fact, recent theoretical advances regarding knowledge domains and skills contributing to knowledge sharing have indicated that they are still considered as separate dimensions (e.g. Haraldsdottir *et al*., 2018), with only few studies attempting to establish interrelationship between them (e.g. Costa and Santos, 2017). While these studies adopt quantitative approaches, they do not provide an in-depth understanding of how the skills can be applied to the sharing of knowledge in practice.

In this paper, we present an integrative framework that provides a categorisation of knowledge domains that are crucial for project managers in the construction industry, as well as a categorisation of skills that facilitate the knowledge sharing throughout the construction project. Specifically, we address the following three questions:

1. What are the domains of knowledge that project managers need to share in a typical construction project?
2. What are the skills that contribute to their knowledge sharing practices?
3. How do these domains and skills interrelate across different phases of a construction project?

This paper aims to make three significant contributions. First, we investigate the knowledge domains and skills deployed by project managers who are based in different organizations and hold different temporal orientations and project work interests, but work within the same construction project team, proposing a novel categorisation of knowledge domains that need to be shared within a construction project. Second, this paper contributes to the broader literature on knowledge sharing by demonstrating how the emphasis on these knowledge domains and skills changes across the different phases of a construction project. Third, the development of a framework which integrates i) knowledge domains, ii) skills facilitating the sharing of these knowledge domains and iii) their interrelationships throughout the different phases of a construction project will expand the understanding of how knowledge domains and skills dynamically inform project managers' work in construction projects as forms of temporary organizing. By investigating a project for the construction of a five-star hotel where three independent organizations - an investment company, an architectural design institute and a construction company - were involved, the paper provides insights regarding the multiple perspectives and different organizational positions towards knowledge sharing when working on a project collaboratively, while advancing a conceptual and empirical integration of knowledge sharing and project management literature that illuminates the complexity of temporary organizing in a construction project setting.

2. Theoretical Background

2.1. Knowledge sharing and the project context

Forms of temporary organizing have in recent years grown in importance due to a combination of societal and organizational pressures: they represent the syncretism of acceleration and time constraints, and they provide flexibly for the actors involved in implementing innovative activities (Bakker et al., 2016). The construction industry concentrates some of the archetypical examples of project-based organizations and some of the most challenging facets of temporary organizing, such as the requirements of working in a dynamic environment, characterised by short-term collaboration patterns. Typically, after construction projects are delivered, project teams are dissolved (Ekrot, Kock, and Gemünden, 2016), which impacts on the possibility to carry forward all the valuable experiences accumulated during the execution stages. These potential impacts are deeply related to the productivity challenge of preventing that, at every new construction project, things are continuously reinvented, and the cycles of experimentation are prolonged. Another usual configuration in the construction industry is that of an arranged set of inter-organizational relationships between individuals and organizations that interact within the scope of the project, possibly transitioning into subsequent new projects (Manning, 2005).

Indeed, inter-organizational relationships are a common structural complexity of the construction industry where, as characteristic of project organizations, heterogeneous participants come together to work temporarily in order to realise a new and unique project (Schreyögg and Sydow, 2010). As a consequence of this make-up, project organizations are afflicted by temporariness, fragmented organizing due to task heterogeneity, interdependencies, short-term orientation and limited organizational routines (Geraldi *et al.*, 2011). In addition, project work often involves actors from different organizations, with divergent temporal orientations (McGivern *et al.*, 2018). This configures a situation whereby past, present, and future are all dimensions of an "ongoing temporality" (Hernes, 2014), continuously interpreted and re-interpreted by organizational actors (Kaplan and Orlikowski, 2013). Notwithstanding, it is not uncommon that in the context of project work, knowledge combined to serve strategic goals may disperse and dissipate (Lampel et al., 2008). Addressing calls for an enhanced understanding of the dynamics of temporary organizing (Bakker et al., 2016) and acknowledging that temporary organizing requires a distinctive focus on transience and limited duration, our inquiry is motivated by the overall question of how knowledge domains and skills inform the agency of project managers' work in construction projects as a form of temporary organizing. Before that, however, further clarification is required around the relevance of knowledge sharing in construction industry projects, as a form of temporary organizing.

Knowledge sharing involves a two-way voluntary process to transfer or exchange knowledge from one person, group or organization to another in various forms (Schauer *et al.,* 2015). This reveals the two fundamental elements in sharing: knowledge and skills. Knowledge sharing is inherent to project practice, yet projects are often faced with knowledge sharing challenges and difficulties (Solli-Sæther *et al.*, 2015). In project-based organizations people tend to ignore the common knowledge extracted from different projects due to the fact that each project develops in a relatively isolated manner (Leseure and Brookes, 2004). However, knowledge in terms of solutions and ideas in one project might contribute to developing the routines and processes of the entire organization (Lampel *et al.*, 2008). This conflict raises the necessity of adequately managing and sharing project knowledge - an activity that intersects and overlaps with the construct of human capital.

Human capital comprises the set of an individual's knowledge, skills, abilities and other characteristics (KSAOs) that can be used to generate value (Ployhart & Moliterno, 2011). Organizational human capital is therefore dependent on access to knowledge that takes place through the available KSAOs of employees and KSAOs themselves can be context-generic (e.g. cognitive ability, personality, values and interests) or context-specific (i.e. specific to narrow domains). Nevertheless there has been an evolution in the conceptualisation of context-specificity where specificity refers less to the universe of task-related KSAOs and instead reflects more a relational orientation that stems from the interdependencies and interactions among co-workers (Ployhart et al., 2014).

Similarly, Mayer et al (2012) draw attention to the heterogeneity in organizations' resources and capabilities concerning the acquisition of human capital. Focusing specifically on the sourcing decisions of organizations, their occupational human capital framework posits that knowledge intensive projects are less likely to be outsourced when they require and develop high levels of firm-specific and industry specific human capital. This has consequences in terms of the particular conditions under which organizations develop knowledge outcomes, more specifically the strategies they employ and the relational roles key individuals play to stimulate local dynamics of knowledge circulation, and the dynamic interplay of connection and integration (Grigoriou and Rothaermel, 2012).

2.2 Domains of knowledge in project practice

Knowledge that is sought by employees or needs to be shared through face-to-face communication tends to be domain-specific and complex (Pee, 2018). A domain relates to a specific content area of knowledge or practice (Byosiere and Luethge, 2008). The sharing of domain-specific knowledge involves the communication of information about the context (Pee, 2018). Different

domains of knowledge and practice can be communicated and shared when there is a common understanding or a common language between organizational members (Swan *et al.,* 2007). However, it is challenging to share this domain-specific knowledge with those outside the same organization, as syntactic, semantic and pragmatic boundaries are involved in the sharing process (Carlile, 2004). In order to summarise the current literature in relation to essential knowledge domains within a project context, our review of the literature has identified four categories of knowledge domains as summarized in Table 1 below.

Table 1: Summary of prior studies on knowledge domains in projects

Knowledge Domains	Explanation and Example	References
Knowledge of Business Value	Knowledge of project short-term goal of the project (e.g. available time for completion, budget); Knowledge of project long-term goal.	Reich et al., 2012; Oluikpe, 2015; Schryen, 2013; Love et al., 2014
Procedural Knowledge	Knowledge of project solutions if there are changes (e.g. structure, processes, application of culture, etc.); Reduced waiting time; Problem solving.	Reich et al., 2012; Lech, 2014; Lampel et al., 2008;
Managerial Knowledge	Knowledge of strategic thinking; Knowledge of contract management.	Edum-Fotwe and McCaffer, 2000; Lampel et al., 2008; Lech, 2014
Experienced Expert Knowledge	Lessons learned; Techniques in using different tools; Knowledge of regulation and construction supervision.	Reich et al., 2012; Ghobadi and Mathiassen, 2016; Chan, 2016;

Knowledge of business value, concerning the understanding of objectives that the project is expected to deliver (Reich et al., 2012), is critical in shaping project directions and influencing project performance at both operational and strategic levels (Schryen, 2013). This knowledge domain is characterised as dynamic because the understanding of business value is an evolving process; it can be modified and even changed throughout the project lifecycle (Love *et al*., 2014). Project participants with a mutual interpretation and understanding of the value of business also tend to share other domains of knowledge more effectively (Oluikpe, 2015). Project managers are responsible for leading the project team and managing project activities, and therefore should share knowledge about business value and ensure this knowledge is understood effectively.

Procedural knowledge, embedded within the project processes, concerns the awareness and understanding of "how to do" and "how to act" throughout the project procedures, in order to meet project goals and business value. It helps project participants in problematic situations by providing knowledge of "how to act" (Reich *et al.,* 2012) and informs better business process redesign (Schryen, 2013). For example, in a construction project, it is important to communicate standardised procedures and templates; however, this type of knowledge usually needs to be combined together with tailored solutions or specific interpretations of the situation. This combines both knowledge about the particular situation and a reflection of previous work experience for similar situations. It contributes to deploying the knowledge of business value, and is particularly useful in avoiding resource waste (Li *et al.,* 2017).

Managerial knowledge refers to the ensemble of understandings surrounding the coordination of project elements including team members, materials, tools and policies for the purpose of better management (Lech, 2014). This type of knowledge is embedded and institutionalized in performing, managing, and directing project processes, such as thinking strategically and managing contracts efficiently (Edum-Fotwe and McCaffer, 2000). It has been widely recognised that the knowledge required within a project transcends the scope of technical knowledge and includes more generic managerial knowledge, especially for the role of project manager (Navimipour and Charband, 2016).

Experienced expert knowledge is obtained from project experience; it refers to the critical, cumulative experience which has a broader and more generic relevance and that can be used in future projects (Li *et al.,* 2017). As Chan (2016) suggests, expertise is a knowledge domain with a strong tacit dimension and is defined during interactions among people in a group context. Each project has its unique tasks and characteristics; however, there are common problems that take place across different projects (Navimipour and Charband, 2016). This means that the expert knowledge accumulated over time can be adjusted to different situations and address specific problems. The successful delivery of a project, especially involving participants from multiple organizations, relies on different specialists collectively putting their own expertise to work and sharing professional knowledge (Chan, 2016). In addition, sharing and reusing expert knowledge contributes to organizational innovation, as the previous experience can be a trigger for new ideas in new product and service delivery (Love et al., 2014).

2.3 Skills in project knowledge sharing

Skill is highly dependent on experience and requires further clarification according to its actual context (Von and Roos, 1995); it extends beyond merely task-focused issues and relates to the value and success of the business. Skill is also considered as being developed and achieved through practice,

rather than emerging as a given. In organizational studies, skill is often related to the capability of negotiating the new, more changeable and communication-rich world of work; it is developed from ongoing engagement in social practice (Orlikowski, 2002). As this study focuses on the skills exhibited by a group of people with a particular occupation (i.e. project managers) within a particular industry (i.e. the construction industry), we consider skill as inherent to a particular context and embedded in professional practice.

The discussion on skills has mainly focused on non-technical and transferable skills (Sevcenko and Ethiraj, 2018). As argued by Edum-Fotwe and McCaffer (2000), with an increasingly professional demand for project managers, project managers are expected to supplement their technical and engineering expertise with non-engineering, social oriented skills. Nellore and Balachandra (2001) discussed the fact that usually a project manager is appointed to the position based on their individual technical ability, while often lacking the necessary soft skills such as cross-functional management skill and leadership skill, which are usually learned and developed later while on the job. Table 2 presents a synthesis of the current literature addressing the non-technical skills that are considered useful in generic project knowledge sharing practice.

Table 2: Summary of prior studies on skills contributing to knowledge sharing

Skills	Explanation and Example	References
Leadership Skills	Recognise attitudes and sentiments that someone brings into a situation;	Napier et al., 2009; Donate and Pablo, 2015; El-Sabaa, 2001;
Performance Skills	Being able to promote the best knowledge sharing practice in project and organizations.	Lord and Hall, 2005; El-Sabaa, 2001;
Communication skills	Effectively communicating ideas to others.	Napier et al., 2009; El-Sabaa, 2001;
Managerial skills	Building and continusouly developing a good framework for knowledge sharing.	Reich et al., 2012; Meredith et al., 2017; Love et al., 2014; Melville et al., 2004
Social-oriented skills	Knowing how to negotiate.	Edum-Forwe et al., 2000; Love et al., 2014
Knowledge absorption skills	Applying and reimagining solutions from one project into similar situations encountered in other projects.	Napier et al., 2009; Lee et al., 2016; Love et al., 2014

Leadership skills are concerned with the capabilities of project managers in understanding, formulating, interpreting and communicating their knowledge regarding the vision and direction of the project (Napier et al., 2009). Leadership skills also involve emotional intelligence and the ability to share knowledge in a manner that encourages and garners enthusiasm from the project team (Donate and de Pablo, 2015). Furthermore, leadership skills involve fostering an organizational culture of knowledge sharing that tolerates mistakes and promotes cross-functional and inter-disciplinary engagements (El-Sabaa, 2001).

Performance skills refer to an understanding of the different processes of a project, not only as separate entities but also as a whole and the interconnections among them (Lord and Hall, 2005). This can assist project managers in understanding the issues and problems that arise in the project, and in externalizing individual knowledge in a more comprehensive manner. Performance skills relate also to project implementation issues and enable project managers to understand and share the 'know how' knowledge that is normally embedded within the project processes (Napier et al., 2009).

Communication skills refer to the ability to express knowledge in a clear manner, and to comprehend reactions and recognise the attitudes of project participants to the knowledge being shared. The sharing and spill-over of knowledge is not automatic and develops through effective communications (Lee et al., 2016). Furthermore, when a project involves stakeholders from different organizations, communication skills contribute to the accommodation of the expectations of various stakeholders and the coordination of their efforts through knowledge sharing (Mazzucato, 2018). Additionally, weak communication capabilities can negatively impact, and even hinder, project knowledge sharing (Napier et al., 2009).

Management skills include the development and application of strategic methods such as assessing the scope of the project, coordinating participants, considering political ramifications, and developing projects based on specifications and within a given time frame (Melville et al., 2004) in order to facilitate knowledge sharing both directly and indirectly. Managerial skills can be generally considered as being part of two main types: specialist managerial skills with strong technical foundations which can only be applied in particular projects; and generic managerial skills that can be applied in different projects (Meredith et al., 2017). Both are crucial for knowledge sharing activities because the role of the project manager entails the sharing of technical solutions and the coordination of project work.

Social-oriented skills refer to the capability of obtaining and sustaining cooperation from the individuals with whom they interact. This includes individuals from within the same company as the

project manager as well as outside organizations (Li et al., 2017). By increasing the number and intensity of both internal and external links and networks, the possibility of obtaining useful knowledge outside of a single organization and applying it to project innovation can be increased (Love et al., 2014).

The purpose of knowledge absorption skills is to obtain useful knowledge from the project manager's previous experience and to apply it to solve problems that appear during project work (Napier et al., 2009). Knowledge is obtained and improved via the learning and absorptive process in repeated use (Lee et al., 2016). This requires the project manager to be able to first identify pertinent knowledge, secondly to assimilate and integrate it, and finally to apply it in problem solving. It is important to develop knowledge absorption skills in order to enrich the 'knowledge stock' of project managers and to produce complementarities between internal and external knowledge (Love et al., 2014).

The synthesis above relates different project management skills within the context of knowledge sharing practice. Many studies have been conducted to identify the skills for project managers and relate these skills to project success (Blomquist et al., 2016). These concerns have prompted the development of standards for project managers in terms of managing knowledge and project practices, and the development is based primarily on research that collects the opinions of experienced practitioners. There has always been an assumption in these studies that the standards describe the requirements of achieving effective project performance, therefore implying that the managers following the project skill standards for knowledge sharing perform more effectively than those whose performance does not satisfy the standards (Crawford, 2005). There is empirical evidence that supports the assumption that project management practices and knowledge sharing practices are related (Leseure and Brookes, 2004). There is therefore a need to understand the nature and role of skills that directly contribute to knowledge sharing practice.

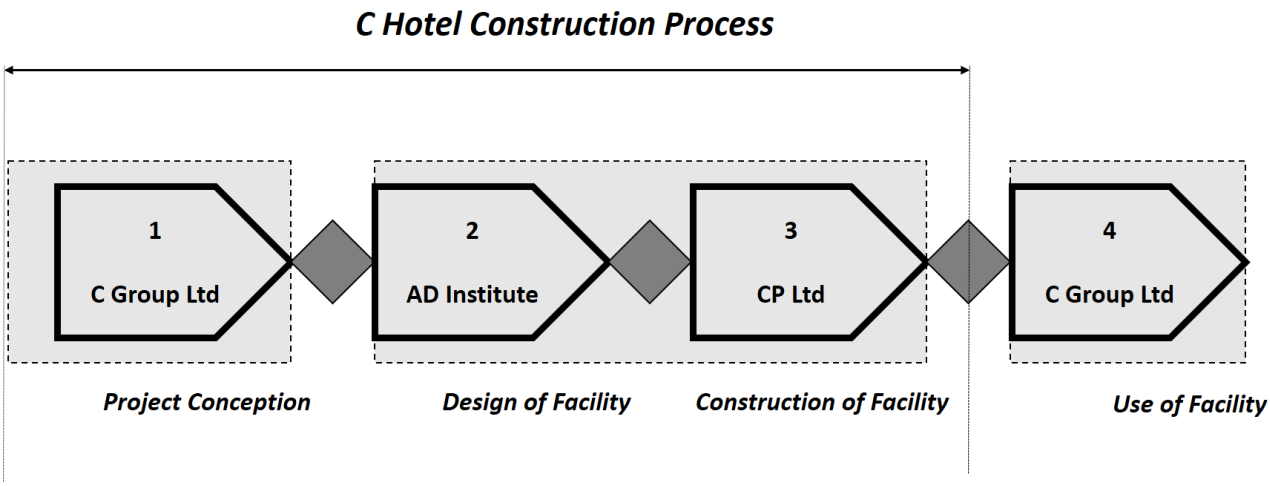
From the literature review, it is also evident that studies contributing to the categorisation of knowledge domains or skills related to knowledge sharing usually investigate each subject separately without integrating them or exploring the specific relationships between them and of how they influence the agency of project managers in temporary settings. Therefore, we propose to address this gap by exploring knowledge domains and the skills associated with effective sharing of these knowledge domains in the context of construction industry projects in an integrative manner, which takes into account the complex interrelationships between domains and skills throughout the construction process.

3. Method

Given the qualitative nature of the research questions, this study adopts an inductive approach and follows Grounded Theory methodology for data collection and analysis (Glaser and Strauss, 1967). The construction project of C Hotel is the empirical context for this study. It was proposed, designed and constructed according to the standards of five-star hotels, and in fact it is the first five-star hotel in the located city, Xingtai, a medium-sized city in China. The development of C Hotel started in June 2011 and was completed in May 2015.

Within this project, three key companies were involved, namely, C Group Ltd as the investor and time-scale controller, AD Institute as the architecture designer, and CP Ltd as the construction firm. Amongst all stakeholders in a construction project, the investor, architecture designer and construction firm are the main participants and they need to constantly share their expert knowledge regarding the whole project development. Based on Kamara et al.'s (2002) construction process model, the investor establishes construction requirements and passes a set of client demands to the architecture design; the construction management starts from this stage when the working team converts the user requirements into an appropriate facility design which is later passed on to the facility construction phase. In this study, we have demonstrated the knowledge flow and sharing practices between the three organizations. Figure 1 links the case conceptualization of the sequence of construction processes, which illustrates the inter-organizational nature of the three organizations, links it to the typical stages of construction projects, and matches construction companies' typical workflow in Kamara et al.'s model.

Figure 1: Key actors in the construction processes of the C Hotel (adapted from Kamara et al., 2002)



Theoretical sampling (Glaser and Strauss, 1967) was employed to inform the data collection strategy and was used to provide constant direction for the research team to obtain data for the further development of the study and the generation of theory. Data collection and analysis developed iteratively (Fernández, 2004), with the theoretical sampling strategy guiding data collection and analysis in the case-project and resulting in a total number of twenty-one semi-structured interviews. The summary of participants is indicated in Table 3, including their organizations, professional positions, years of experience and gender. A unique indicator for each interviewee and quotation was generated. For example, "PMD – I1 – 182-184" means the interview is taken with the project manager from the design institute; it is the first interview transcript being analysed, and the quotation is from lines 182 to 184 in the transcript.

Table 3: Interview participants in the research

Name of Organization	**Professional Position (Identifier Code)**	**Years of Experience**	**Gender of Participant**	**Time length**
AD Institute (The Design Institute)	Project Manager (PMD - I1)	20	Female	96 mins
	Vice Project Manager (VPMD - I2)	18	Male	68 mins
	Chief Engineer (CED - I3)	28	Male	48 mins
	Team Member (TMD - I4)	5	Male	32 mins
	Team Member (TMD - I5)	4	Female	85 mins
	Team Member (TMD - I6)	6	Male	104 mins
	Team Member (TMD - I7)	5	Male	64 mins
C Group Ltd (The Investing Company)	Project Manager (PMI - I8)	26	Male	15 mins
	Project Manager (PMI - I9)	20	Female	45 mins
	Project Manager (PMI - I10)	23	Male	66 mins
	Project Manager (PMI - I11)	25	Male	53 mins

	Vice Project Manager (VPMI - I12)	9	Male	25 mins
	Vice Project Manager (VPMI - I13)	12	Male	42 mins
	Vice Project Manager (VPMI - I14)	10	Male	45 mins
	Vice Project Manager (VPMI - I15)	12	Male	28 mins
	Senior Manager (SMI - I16)	29	Male	70 mins
	Team Member (TMI - I17)	4	Male	18 mins
CP Construction Ltd (The Construction Company)	Project Manager (PMC - I18)	12	Male	32 mins
	Leader of Construction Team (LCTC - I19)	15	Male	30 mins
	Technical Member (TMC - I20)	6	Male	15 mins
	Supplying Member (SMC - I21)	3	Male	40 mins

Part of the structure of interview questions was developed on the basis of Table 1 and Table 2 from the previous literature. The interview questions were designed in three sections: general research context; knowledge domains; and skills contributing to knowledge sharing. The section of knowledge domains serves as an important path to the investigation of skills, as the questions within this section provide the scenarios for participants to recall and deliberate the skills they utilised in order to share these knowledge domains. Each section consisted of a series of open-ended questions. Furthermore, under each semi-structured question, several trigger and follow-up questions were developed for the purpose of prompting more in-depth answers according to the previous response, as well as in informing the interviewees about the level of response that is expected. It is important to re-emphasise that the two tables are a result of the process of enhancing theoretical and contextual sensitivity, but have not pre-determined the data analysis and theory development. After the first round of data collection, the interview questions in the transcript were revised and evolved due to the adoption of theoretical sampling and constant comparison strategies.

Data analysis followed the constant comparison method. Initially data analysis was performed concomitantly with data collection and continued with an explicit coding stage and an analytical coding

procedure stage (Glaser and Strauss, 1967). During the explicit coding stage, the analysis started by comparing and coding each incident from the data into categories. The researchers began to search for codes and identify the emerging properties and dimensions, starting from the first interview transcript. Relevant data were labelled and either created as a new code and given a definition, or assigned to the existing codes with memos indicating their relevance and potential properties or dimensions. Through this, the data are broken down into different units of meanings, i.e. different concepts. Figure 2 demonstrates an example of codes and associated definitions given by the research team. This procedure allowed categories to emerge, or data to emerge to fit in an existing category (Glaser and Strauss, 1967). After the explicit coding stage, the data were conceptualized, defined and categorized in terms of their properties and dimensions, which initiates the analytical coding stage.

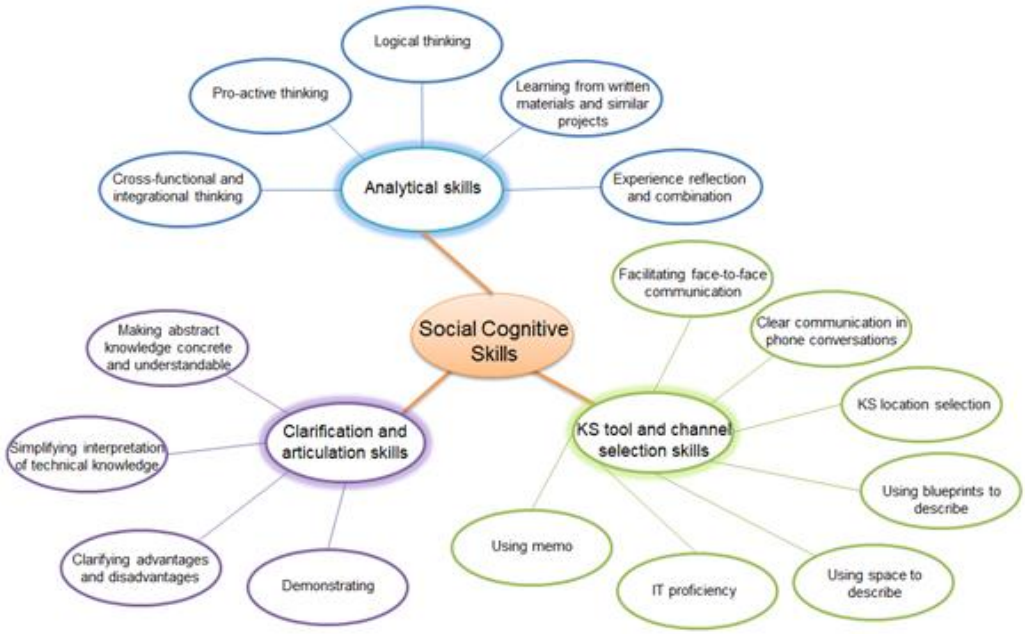
Figure 2. An example of coding list in this study

No.	Code	Definition
20	Personal understandings towards construction regulation items	Project managers need to know about construction rules, how to implement them in the project, and share their knowledge towards the rules with relevant members, so that their work can meet the official standards while maximizing the facility functions.
21	Feasibility of construction plans before actual construction	Personal opinions of whether the construction plans and ideas are feasible based on their understanding of the industry and investigation of other construction examples. *(They may go to other cities or sites to investigate.)*
22	Identification and investigation on similar projects	The skill to identify current completed construction projects that are similar the one they work on, and the skill to practically investigate and learn from these examples (in terms of when there are some problems or innovation issues, how these examples dealt with relevant issues).
23	Skill of responding quickly	Being able to respond to other's questions quickly by offering an appropriate answer. Even if the question is not very relevant to the project manager's own knowledge area, the project manager can still offer some guidance in terms of who is the appropriate person to consult.

During the analytical coding stage, the research team compared the properties and dimensions of the emergent categories. In order to constantly analyze and compare the categories, concept maps (of which an example is shown in Figure 3) were adopted as a diagrammatic tool to support the analysis and to visualize the findings. Using diagrams assisted especially in analyzing the relationships in the data in terms of 'why and how' between categories (Strauss and Corbin, 1967). During the analytical

procedure, the researchers' attention was quickly drawn to the fact that the categories were pointing in two major directions – knowledge domains that need to be shared and skills contributing to the sharing. Eight main categories emerged from the data analysis, five categories regarding to knowledge domains, three categories regarding to skills that contribute to share the knowledge domains, and the interrelationships between them. This is further presented in detail in Section 4. Additional exemplar quotations, responsive interviewees, together with the participating companies and relevant phases of the project are presented in Appendix 1.

Figure 3. An example of concept map generated in this study



Grounded Theory methodology has its own approach for assessing the quality and for judging the credibility of a study. Glaser and Strauss (1967) stated that the assessment should be based on the detailed elements embedded in the actual strategies in generating theory, including collecting, coding, analysing and presenting data. The analysis of the data, development of the theory are grounded inductively in the data. This ensures the findings accurately represent data. In this study, this is largely embedded and reflected in the constant comparison process. The data collection and analysis procedures were interrelated and coexisted, by following the theoretical sampling and constant comparison strategies, contributing to the systematic understanding and verification of data until the saturation of codes and categories. Furthermore, regular meetings among the research team during data collection and analysis processes, in terms of discussing interview techniques, reviewing emergent

codes and categories, and presenting interpretations, backed and further enhanced the validity, reliability and credibility of the findings. In addition, with the purpose of theory-building, Grounded Theory methodology focuses on explanatory power, i.e. explaining what is happening in given situations, rather than generalisability (Strauss & Corbin, 1998). This study is conducted with project participants within a construction project, and the findings are based on the exploration and explanation of what they perceived as important knowledge domains and skills in this particular setting. The linkages between codes and categories developed during the data analysis provide the explanation of the subject and of the research context that is being investigated.

The interview was conducted in Chinese language, with the questions written in both English and Chinese. The English terminologies assisted the researcher in being aware of theoretical sensitivity, and the Chinese questions were directly used to interact with informants. To minimise the language barriers, during the analysis, codes together with their attributes and properties were generated and labelled in English, supported by quotations in Chinese and translated into English. The research team constantly discussed the appropriateness of labelling for each code.

4. Findings

4.1 Domains of knowledge shared

Domains of knowledge are cumulative and dynamic in the temporary organizing of a construction project, and they also spread within and are experienced differently within three phases of the project. Sharing of these domains of knowledge contributes to efficiency and productivity of this temporary form of work. This section presents a categorisation of five knowledge domains that emerged from the study.

Knowledge of risk refers to the prevention, awareness and concern a project manager has about the potential threat that is connected to a decision or linked to a certain situation. Risk can be a potential difficulty, challenge or sequential consequence of an action. Knowledge of risk includes three different dimensions of potential risk in design, awareness of sequential disturbance and knowledge of hidden threats to the long-term sustainability of the building. Particularly, interviews conducted with the design institute and the investing company revealed that sharing hidden threats to long-term building sustainability can improve the overall quality of the project and also reflect different perspectives and focuses from the participating companies towards this knowledge. Due to the fact that the project is composed of three main organizations, each participant has its own concerns, interests and different time orientations within the project, as indicated by the project manager from the investing company.

"Construction workers are more concerned with finishing the job rather than what might happen afterwards e.g. maintenance problems. I need to notify them of potential problems that may occur after they have completed the work; these types of issues must be detected. Construction workers may not be aware of potential problems." (PMI – I15 – 127-130)

Revealed by the above quotation, the investor carries out the role of conceptualising the project and operating the project after completion; they are more concerned with long-term usage and sustainability, whereas the construction company focuses on completing current work and thus pays less attention to long-term sustainability. This leaves the possibility of generating tensions and conflicts among participating companies within the project. The communication of these concerns and the sharing of potential threats that the building sustainability is confronted with can help generate solutions in reducing relevant risks (PMD-I12-40:35), and therefore helps to reduce potential conflicts between the investing company and the construction company. It also reveals different institutional logics within temporary organizing forms that the skills can potentially correspond and harmonise.

Knowledge of planning refers to the consideration and suggestion of different ideas and solutions before conducting specific work, and the understanding of how to better plan the delivery of the project. Particularly, this knowledge domain emphasises the importance and suggestion of time frame, early concept and requirement of investing, and balance between appearance and utilisation. Regarding time frame, sharing is focused on the negotiations of different working groups in terms of their working speed and processes, in order to better coordinate and align them with appropriate tasks and working time. For instance, as exemplified by an interview with the project manager from the construction group, the time frame within a construction project is usually fixed and explicit, involving concrete engineering and operational information such as which group should complete which construction task: *"Time needs to be coordinated, so that after work A is completed, B enters the field; B does not interfere with other construction works, etc... There are sometimes changes to the blueprint which require coordination between companies... If there are more changes, more work will be needed and thus more days would be added* (PMC – I18 – 77-86)*"*. However, the process of time frame negotiation exceeds beyond this period and involves "*sharing tacit knowledge including the reasoning as to why the time frame is set in such a way and arranging how to control and coordinate the time for each group (PMD-I11-133-14)*".

Beyond the commonly-adopted definition in project management where planning highlights the explicit elements of task, time and team, the planning knowledge domain in this study has a strong tacit dimension by focusing on the project manager's personal reflection on previous work experience

and applicable suggestion on how to conduct the current work. For instance, as demonstrated by the investing company, the successful plan should incorporate cultural aspects in the hotel design at an early stage: "*Our company culture needs to be discussed versus the culture of the local region or city. In many ways, the regional culture needs to be reflected; this is quite a big idea. I must share my decision with team members and the construction teams. Then we can decide how to apply it exactly* (PMI-I6-78-16)". Sharing knowledge pertaining to this domain contributes to effectively scope the project for the suitable market and make efficient use of the investment.

Knowledge of implementation focuses on the 'how-to-do' knowledge based on a time-effective manner, in order to solve problems that occur during the architectural design and construction, usually associated with the project manager's work experience and lessons learned in the past. Despite the fact that construction work requires explicit and technical engineering knowledge as its foundation, many important tacit dimensions of implementation knowledge such as inter-connectedness of functional areas, emergent investing requirement, unplanned design changes and different interpretations of regulations need to be shared by the project manager. For example, as demonstrated by a project manager from the design institute, the rules and regulations place restrictions on the design but the requirements of the investing company still need to be met.

> *"In my perspective, it's often about the understanding of regulations when it comes to structure. There are times when myself and our chief engineer disagree about items in the regulations. Sometimes we even argue, but ultimately one person always persuades another. Our understanding of some project cases and regulations may differ." (PMD – I1 – 191-193)*

Different designers will have different views, ideas and solutions as to how to achieve these requirements whilst meeting the rules and regulations. Thus, project managers need to share their understanding of relevant regulations, achieve collective interpretation of the regulations and apply these to the current work.

Knowledge of human relations has two dimensions: knowing how to work efficiently with the project members and knowing when to refer to consulting experts externally. Specifically, it refers to the project manager's understanding of the strengths and weaknesses of the employees and bidding construction groups when appointing them to appropriate positions for the project. It also concerns addressing issues with "*coordinating project members and resolving conflicts inside the project* (SMI - I13 - 111-112)", i.e. the project manager's understanding and proposed solutions to minimise the

conflicts that occur during the project, usually involving coordination among project members and between project groups.

> *"There are some issues in the project that I haven't dealt with before. The project manager may tell me there was a similar project in the past and refer me to relevant people who were involved with that work. The PM would provide a way and a method, and I would solve the problem accordingly. This saves my time and works effectively." (TMD – I3 – 335-337)*

Furthermore, as indicated by the above quote from the design institute's team member, knowledge of people involves knowing experts in the field through social relations and knowing who can be consulted if any problems occur during the project. It is important to share, particularly for temporary form of organizing, as this knowledge can affect the outcome of the project from perspectives of teamwork and coordination.

Strategic and operational knowledge refers to the understanding of business value and objectives and how to achieve them within the project scope. It includes the project manager's personal strategies and ways to operate and manage the project more effectively, such as how to act in the industrial market and political environment. Compared to other knowledge domains, the domain of strategic and operational knowledge for project business is framed at a more strategic level to guide the direction and development of the project, by focusing on its goals and values. Specifically, in the first conceptualisation phase of the project, knowledge about organizational self-interests is shared between the investing company and the architectural design institute, with the focus and aim of reaching agreements on the project plan (indicated by *PMI – I10 – 132-134 and SMI – I13–248-251* in Appendix 1). During the sharing process, disagreements and conflicts between the two organizations can occur due to their different interests and positions within the project; the investing company places an emphasis on the appearance and uniqueness of the building, while the design institute is more concerned about safety issues and thus tends to adopt conventional methods of design in accordance with regulations. The quotations below from interviewing a project manager in the design institute and a project manager in the investing company illustrate these differences.

> *"Our main goal is to explain our own reasons to the investing company's project managers and try our best to convince them. The building appearance is almost as important as safety in a five-star hotel. But the design institute emphasizes safety way above appearance. It also adopts a traditional approach that gives away the innovation and nice appearance." (CED – I4 – 139-142)*

The five domains emerged in this study are dynamic and have different emphases on different construction project stages. Knowledge of planning tends to focus on the first phase of the project because this domain is concerned with conceptualising and planning issues before the actual design and construction work begin. Knowledge of implementation tends to be emphasised during the second and third phases of the project, as this knowledge domain accentuates the issues that need to be considered and the problems that can occur during the design and construction stages. Knowledge of risk, human relations, and strategic and operational knowledge are cross-cutting domains and need to be shared throughout the project. Furthermore, the various knowledge domains also demonstrate the mobilization of knowledge from past projects to the current project, and also can be applied for future work. For instance, knowledge of risk and implementation involves a large amount of reflection on the experience of previous projects which is applied to the conduction of current work.

4.2 Skills contributing to sharing different domains of knowledge

Three sets of skills that contribute to sharing the above knowledge domains emerged from the study: social cognitive skills, interpersonal skills, and strategic orientation skills. ***Social cognitive skills*****,** revealed by the participating project managers and members, refer to the capabilities of project managers to perceive knowledge differences between themselves and others, analyse different situations, and generate means to balance the differences and to reach mutual understandings. As the construction project is composed of different organizations and its members might not know each other before the project starts, it is common for interpretative differences to occur among participants (PMD – I2 – 103-104). Social cognitive skills involve project managers perceiving knowledge differences among participants, in order to ensure adequate knowledge is shared in a timely manner.

Firstly, the project manager needs to be analytical with regard to different situations, other project participants and the knowledge that he or she wants to share. For instance, as indicated by the quotation below from the senior manager of the investing company, it is crucial to be able to identify construction projects that are similar to the one the project manager is working on, especially similar projects in the same geographical region. This assists the project manager in enhancing individual knowledge, avoiding failures that occurred in other projects and using these cases as vivid examples when sharing knowledge with others.

> *"As an example, we studied fixture styles in other cities and sites initially. Many people make mistakes during the hotel's preparation. For example, WF Hotel (another five-star hotel in the same city) had many difficulties due to inexperience… They teach us many things; it can be viewed as work experience, or failure lessons. (SMI – I13 – 172-178)"*

In sharing analytical thinking and considerations, especially when confronted with interpretative differences of other project participants, clarification and articulation skills enable the project manager to share knowledge more effectively in terms of being understood and reaching shared meanings with the team. As exemplified by the interviewee from the design institute, the project manager should be able to explain their working plan and concerns in details when arguing about project time length with the investor: *"We would draw the regulations on paper and explain the technical aspects if the investor doesn't understand. Be detailed and concrete. The investor may not understand if you just say it doesn't work according to regulations. Sometimes rules are drawn to explain." (TMD – I2 – 222-227)*. Making abstract knowledge concrete and understandable can be with aids of drawing or referring to other construction cases.

The third component of social cognitive skills, knowledge sharing channel and tools selection skills, are focused on selecting the appropriate sharing methods and tools, in order to share the knowledge efficiently. As demonstrated by the interview from the design institute below, this type of selection is particularly useful for the design phase as there are more tasks and participants involved, and task-dependency makes generating and reaching shared meanings more challenging. Appropriate selection of the channel and tool to use for knowledge sharing is an important factor influencing its effectiveness.

> *"Since last year, we use a collaborative design software. Architecture is the basis for all other functional areas of the design process. Whenever an architecture design changes, the designer should inform others of the change and make changes accordingly, so we can avoid inconsistencies, especially if time is short. (TMD – I2 – 307-312)"*

Interpersonal skills are used by project managers to establish and build relations with project participants, especially those from other organizations, while working on a time-constrained project. This skills-set enables the project manager to socially interact, understand and communicate with project teams, with the aim of resolving conflicts and achieving the project goals. Building and sustaining positive relations is an important component of interpersonal skills, aiming to create and maintain constructive interpersonal relations with people involved in the project and those useful for the project such as external consultants and relevant departments (PMI – I10 – 232-236). Through forming good relationships with project participants, the project manager can make them more willing to listen and understand the knowledge being shared. Another dimension of building positive relations requires sharing criticised or negative information with consideration, as demonstrated by the senior manager from the investing company below. By doing this, the knowledge is shared in a way that

makes the receiver feel that his position and interests are being considered and therefore more willing to cooperate.

> *"There are ways to criticise when negative information needs to be expressed. If there's something you did wrong, I would point it out privately or personally if there are many people present. (SMI – I13 – 240-242)"*

Timing and communicating corrective feedback also involves the project manager clearly explaining his/her position and that of the company he/she works for when sharing corrective knowledge relevant to other companies involved in the project. For example, demonstrated by the interviewee from the design institute below, there are occasional situations where the construction groups require changes in the construction blueprint that are not necessary for the project.

> *"The construction group would pick on some small details and ask us, the design institute, to make changes; their aim is to save some money, but instead of talking to the investor, they directly contact us. The changes are actually a skill or work experience, and they are also a trouble if we don't understand what's going on... In any case, we need to explain the situation to the investor and avoid conflicts as much as possible. (TMD – I2 – 197-206)"*

When this happens, the project manager from the design institute is usually able to recognise the unnecessary request while the investment company does not have an insight of the situation due to lack of technical engineering knowledge. Thus, the project manager from the design institute should have the skill of sharing this type of corrective feedback with the investor at the right time and in an appropriate way.

Compared to social-cognitive skills, which enable one-way sharing from the project manager to project members, interpersonal skills are focused on two-way interactions between the project manager and the project team. This assists the project manager in creating strong ties with other people involved in the project, which helps to generate a knowledge sharing-friendly environment whilst constraining the occurrence of insufficient sharing due to unfamiliarity with team members.

Strategic orientation skills are goal-oriented in the sense that they support the achievement of business objectives and ensure multiple stakeholders and participants working towards shared goals whilst working together during this temporary form of organizing. They pertain to the skills of envisioning the project for its long-term success, leading the project team and sharing relevant knowledge to project members accordingly. As indicated by the project manager from the design

institute, disagreements occur among participating companies due to their different positions, and strategic orientation skills assist in generating and sharing common interests and values. This can be particularly useful in addressing problems and conflicts in interests, i.e. when conflicts in interests occur among different participating organizations and stakeholders in the project. Highlighting common interests among project members especially among different participating organizations, reaching a shared solution to the disagreements among participants who have different interests, and enhancing leadership and decision making towards the project as a whole.

> *"We have a deadline for project completion and with the changes we have a lot of extra work. Our investor had some new ideas after the construction blueprint was completed, which was not because it wasn't good enough, but because they had new ideas about something we agreed long time ago. The useful thing is that they highlighted our shared interest in the project, which is that we all hope the hotel project becomes one of the best 5-star in our city, which also remarks our design institute. (PMD – I6 – 87-94)*

Strategic orientation skills also include persuasiveness in a manner of formulating argument with the consideration of the fact that the construction market is investor-centred market, i.e. the investing company is the one who invests in the project and selects a design institute and construction company. As indicated by the example in the quotation below, when sharing knowledge about the investing company's requirement, the project manager from the design institute often finds it easier to persuade construction groups to accept the knowledge and work on the investor's requirement by making them aware of the investor-centred market.

> *"Nobody likes changing designs all the time. In my role as a project manager, I let them know that the construction industry is always an investor-oriented industry. The designer can't always insist on his own opinion, and the investor could come up with his own ideas. An investor's ideas reflect the current trend; are those they think most suitable. Since design people always sit in offices, some of the things we design might not follow closely development trends." (PMD – I6 – 147-157)*

Each construction project is generated by the need of the investor and thus the goals and demands from the investor can be viewed as the guidance for project development. This helps to make the knowledge receiver more willing to accept and apply the knowledge being shared, and assists the project manager in coordinating and directing the sharing of knowledge, especially in positioning and ensuring that the sharing of knowledge serves the needs of the business.

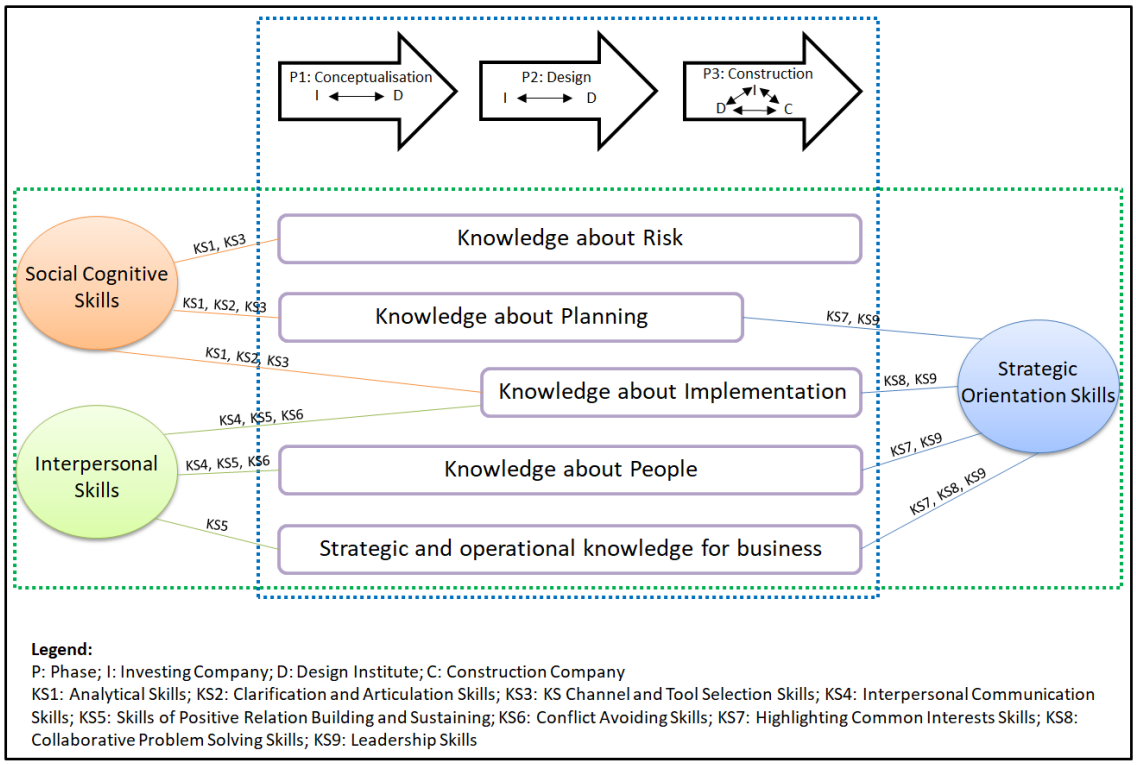
An important finding emerged from the data analysis is the different knowledge shared skills identified are relational and mutually reinforcing. The development of social cognitive skills can help to improve the effect of interpersonal skills, as they are used to generate ways of providing and sharing common meanings and mutual understandings when different interpretations on project work and tasks exist. Social cognitive skills are also the base and foundation for being able to develop and apply strategic orientation skills, such as being able to analyse, clarify and select appropriate methods to share; these are fundamentally important and basic skills when addressing higher-level strategic issues. Strategic orientation skills, in turn, make it easier to apply social cognitive skills in sharing knowledge when conflicts are addressed, and common goals are agreed. Interpersonal skills function as an extra layer in improving the effectiveness of social cognitive skills and strategic orientation skills, because a positive project environment and relations make members and participants more willing to listen and understand the knowledge being shared. Meanwhile, social cognitive skills and strategic orientation skills help to improve the efficiency of interpersonal skills by addressing differences in understanding and interests.

4.3 An integrative framework of knowledge domains and skills

To conceptualize the findings presented above, an integrative framework is generated and presented in Figure 4. This conceptual attempt at integrating knowledge domains and skills contributing to knowledge sharing for construction project management comprises three main dimensions: the phases of a construction project; the domains of knowledge that need to be shared within the project; and the skills for sharing knowledge. The framework also features two areas of interaction indicating the interrelations between knowledge domains and project phases, and between knowledge domains and skills.

The integrative framework spans through three distinct phases of a construction project: the conceptualisation phase where knowledge sharing takes place between the investing company and the design institute; the design phase with interactions mainly between the investing company and the design institute; and the construction phase where knowledge is shared among all three companies. These three phases are regarded as the temporal context from which various knowledge domains are formulated and shared, and from which the relationships between the knowledge domains and the skills dynamically occur.

Figure 4: An integrative framework of knowledge domains and skills contributing to knowledge sharing



A key component in the framework is the categorisation of five high-level knowledge domains, which addresses the first research question - *what are the domains of knowledge that project managers need to share in a typical construction project*? These knowledge domains illustrate the areas where project managers need to share knowledge with participating members. They are largely aligned with the temporal frames and phases of the project – planning knowledge is mostly emphasized in the conceptualisation and the design phases (also present at the construction phase, although not so prevalent), implementation knowledge is mainly shared in the design and construction phases, and risk, people, and strategic and operational knowledge are shared throughout the three phases. As such, sharing knowledge pertaining to the five domains has a dynamic nature.

Skills facilitating knowledge sharing are another key component of the framework, which addresses the second research question - *what are the skills that contribute to their knowledge sharing practices*. Three sets of skills, together with their relationships with knowledge domains, are presented in the framework. The skills need to be developed and applied by project managers with the aim of sharing the domains of knowledge more efficiently with project participants. The three sets of skills contribute to knowledge sharing from different levels and perspectives – social cognitive skills focus on interpreting different understandings among individuals and reaching shared meanings;

interpersonal skills are aimed at creating a positive working environment for sharing knowledge; and strategic orientation skills assist project managers in sharing different organizational interests among participating companies, and collaboratively reaching agreements and solving problems. The skills are therefore relational and mutually reinforcing.

Important relationships between knowledge domains and skills are also demonstrated in the framework via the links between them, and this addresses the third research question - *how do these domains and skills interrelate across different phases of a construction project?* Each link illustrates which dimensions of a specific set of skills are particularly useful in sharing relevant domains of knowledge. The relationships indicate the interconnections between skills and knowledge domains and show that specific skills are more aligned with each knowledge domain, and that the need to share knowledge pertaining to a particular domain triggers the application of particular skills. For instance, interpersonal skills enable project managers to be sensitive to other's knowledge needs and to understand them, and thus are more effective in sharing knowledge of people. Domains and skills should be understood as interrelated, overlapping and intersecting through specific situations and activities project managers engage with during the project.

5. Discussion

This paper presents and discusses an integrative framework of knowledge domains and skills contributing to knowledge sharing in construction project management. The novel contributions of the integrative framework are a categorisation of domains of knowledge that need to be shared, a categorisation of skills that contribute in terms of how to share knowledge effectively in the context of construction project work, and the interactions and relationships between the knowledge domains and skills across different phases of the project. Furthermore, the dynamic nature and different perspectives on knowledge sharing for project managers, how they change across different phases of a project, together with different positions of organizations within the project, are illustrated by the integrative framework. This contributes to addressing an identified gap in that studies about knowledge domains and skills, given previous literature usually take the approach of considering these two subjects separately without exploring specific relationships between them (Navimipour and Charband, 2016). In the domain of human capital research, it illuminates context-generic and context-specific KSAOs (Ployhart & Moliterno, 2011) of construction project work, with an emphasis on particular conditions under which construction projects can develop knowledge outcomes (Mayer et al., 2012) through interdependencies and interactions amongst co-workers (Ployhart et al., 2014).

While developed inductively, the framework of knowledge domains and skills supports the idea that KSAOs enable construction project managers' ability to communicate and coordinate work across units through relational, performance-oriented linkages – a finding that is consistent with a resource-based view of KSAOs as precursors of work outcomes through cross-group articulation and coordination of work (Raineri and Valenzuela-Ibarra, 2021). Indeed, the framework of knowledge domains and skills operationalises KSAOs as the basis for construction project management individual and group performance, overcoming the criticism that KSAOs tend to be vaguely defined (Shippmann et al., 2000), and contributing to the identification of specific KSAOs potentially requiring development and mobilisation (Zhang & Morris, 2014).

Three main arguments can be put forward in terms of the theoretical contribution made by this integrative framework to understand the nature of knowledge domains and skills involved in knowledge sharing in construction projects and how the emphasis on these knowledge domains and skills changes across the different phases of a project: the first argument is that the combination of skills for sharing knowledge pertaining to certain domains evolves and changes throughout the project, as a response to the dynamic nature of the project and to the uncertainties that characterise projects; the second argument is that the skills and the sharing of knowledge pertaining to different domains are relational and interact throughout the duration of the project; the third argument is that knowledge domains and the application of skills in construction projects are shaped by the dynamics between organizations who hold different priorities in terms of temporal orientation and task focus and are open to different understandings and interpretations by actors in these organizations. We develop these arguments in turn in the following paragraphs.

To begin with, the three-phase construction project is a collective and interactive process that involves dynamic sharing of knowledge and relational application of skills. Knowledge differences between actors are not just in degree, but also in type (Carlile, 2004). The variety of knowledge domains and the fluid sharing of knowledge pertaining to different domains, throughout different phases, illustrate one key aspect of the dynamic engagement of different actors within the project. Domains of knowledge are distinguished by their content and focus; as the project evolves through different phases and temporal frames, the focus of a knowledge domain can change according to specific situations. Besides, construction projects have the characteristic of uncertainty, i.e. unexpected events can occur (Pirzadeh and Lingard, 2017); this leads to the development of an evolving context in which different knowledge needs to be shared dynamically and in a timely manner to address unexpected events. With the increasing demands and complexity of construction projects, the conceptualisation, design and construction phases have become progressively more sophisticated

(Chan, 2016). With different participants with different agendas and different time orientation engaged in the three-phase development of the project, the combination of which skills to apply for sharing knowledge pertaining to certain domains, constantly changes throughout the project. Also, as each phase has varied objectives, the combination between the domains and skills can emerge dynamically in response to varying needs.

'Dynamic' indicates change, energy and productivity; knowledge is considered to have a dynamic nature because it constantly changes and evolves with experience and learning (McInerney, 2002). This dynamic nature can be a force for solving problems. The dynamic interactions between knowledge domains and project phases, and between knowledge domains and skills, contribute to facilitate knowledge sharing actively within the project. This can help to address problems that occur, and thus shape project orientation. Knowledge sharing in projects can extend from merely sharing knowledge about a particular issue to enable discussions among stakeholders and then reach a mutual understanding. Understanding project-wide stakeholders is critical for project success and yet not fully investigated (Nahyan et al., 2019). In this research context of a construction project, the sharing of different knowledge among the diverse range of stakeholders can provide a way to demonstrate their individual needs and expectations, throughout three main stages of construction. It is an ongoing practice, constituted and reconstituted as stakeholders and actors engage with the work (Orlikowski, 2002). It is also a form of shaping work frames and time frames (McGivern et al, 2018).

The second argument is based on the suggestion that the application of skills and the sharing of knowledge pertaining to different domains do not operate independently of each other, but overlap and interact over the duration of the project. In organizational studies, dependence is considered as a condition where two entities, in order to meet their goals, need to take each other into account (Carlile, 2004). A collective and relational nature exists both in and between knowledge domains and skills that contribute to knowledge sharing. The different knowledge domains cannot be separated from one another and the application of skills is interconnected. More importantly, the interrelations between domains and skills cannot be considered in isolation. The application of certain skills, as shown in the integrative framework, can facilitate the sharing of certain knowledge domains. Knowledge sharing between different actors in conducting their work is not merely a matter of following rules or processes, but involves negotiating and engaging with what is valued professionally (Bakker et al., 2016).

The final argument is that the sharing of knowledge domains and the application of skills are shaped by organizations who hold different positions within the project. In a construction project, participating organizations have their own priorities in terms of temporal orientation and task focus,

which impinges on what knowledge domains and skills are privileged. They are also open to different understandings and interpretations, according to the organizational position of participants within the project, and are shaped by individual agency. After taking into consideration the different understandings and positions, project managers can make adjustments to the different decisions they have made in terms of which knowledge to share and which skills to adopt and apply in order to do so. Furthermore, the variety in domains and skills also contributes to understand that knowledge sharing as a practice is not merely about the moment of sharing with others. Being able to identify appropriate knowledge, to assimilate it, and to organise it in a clear structure in advance can also significantly influence the outcome. Knowledge sharing is rooted in experience and can be developed through practice.

Our conceptualisation of knowledge domains and skills extends the applicability of the notion of "on-going" temporality (Schultz and Hernes, 2013) to the construction industry setting – i.e. an agentic perspective where organizational actors are continuously interpreting and re-interpreting the present in light of their readings of the past and the future (Kaplan and Orlikowski, 2013). The integrative framework put forward reveals how, in a construction project context, temporality is manifest as an active effort of project managers to maintain project continuity by mobilizing knowledge domains and enacting skills that support knowledge sharing, to flexibly make connections across past, present and future. In a setting where project managers are challenged by emerging new situations, they are confronted with the needs to connect past (project experience), present (response to new circumstances and possibilities) and future (the demands of perishing project time), and reinterpret them (Kaplan and Orlikowski, 2013), in order to maintain continuity.

6. Conclusion

6.1 Theoretical implications

This study contributes to the understanding of the dynamic nature of knowledge sharing in construction projects, by addressing the questions of i) what are the domains of knowledge that project managers need to share in a typical construction project, ii) what are the skills that contribute to their knowledge sharing practices, and iii) how do these domains and skills interrelate across different phases of a construction project. It does so by proposing an integrative framework of knowledge domains and skills contributing to knowledge sharing in construction project management, which provides a novel categorisation of domains of knowledge that need to be shared and of skills that contribute to share knowledge effectively, and demonstrates how these shape each other and evolve across different phases of the project.

The integrative framework proposed here makes three main theoretical propositions. Firstly, the combination of skills for sharing knowledge pertaining to certain domains is dynamic and evolves throughout the project time frames as a response to the interactions between different actors and to the uncertainties that characterise projects. Secondly, knowledge domains and skills are relational and interact throughout the duration of the project. Thirdly, they are shaped by the dynamics of organizations with different agendas and priorities, in terms of temporal orientation and task focus. They are also open to different understandings and interpretations by actors in these organizations. In the construction project context, actors continuously interpret and reinterpret situations in order to maintain project continuity and direction, by mobilising knowledge and enacting skills to do so. These propositions reinforce a relational and dynamic orientation in understanding the nature of human capital in construction projects by emphasizing change, interdependencies, and interactions of knowledge and skills throughout different project time frames.

6.2 Practical implications

This study has several practical contributions regarding project managers and knowledge sharing activities. Firstly, project managers in the construction industry should place importance on the variety of knowledge domains, being aware of sharing certain domains of knowledge at relevant phases of the project (e.g. hidden risks at the first phase and regulation interpretation at the third phase), as each knowledge domain has intensified usage and importance in different phases of the project. They should also be aware that the management of such knowledge domains at different phases is of equal importance. Secondly, project managers can perform a self-assessment of their skills based on the integrative framework presented in this study. They can evaluate the skills they have and identify potential skill gaps that they need to address, in order to 1) enhance individual competitiveness, 2) enable better knowledge sharing practices, 3) perform managerial roles more effectively, and 4) increase the possibility of project success. Furthermore, the relationships illustrated in the integrative framework can assist project managers in applying relevant skills to share knowledge pertaining to different domains. The final practical implication pertains to the multiple perspectives towards knowledge domains and skills identified in this study, which require specific awareness from project managers. Differences in perspectives and interpretations indicate the positions and focuses of each organization within the project. This can potentially assist project managers and provide them with guidance in terms of effective negotiation and the successful evolution of the project.

6.3 Limitations and future direction

This study has limitations in three different aspects. To address the limitations, three corresponding directions have been identified which future studies can further explore. The first limitation is that this study followed a snapshot approach. The data collection took place directly after the case project was completed. A different way to research this in future would be to conduct a longitudinal study that captures the dynamics of a live project. Another limitation is the fact that this study is focused on a project management perspective. The results of this research are constrained by, and pertain to, the perceptions of project managers. Further research could explore this from the perspective of multiple actors that are part of the project.

Lastly, this study is conducted within a context specific research setting. It aims at exploring the case project and generating an integrative framework that is applicable to the case project. The categorisations of knowledge domains and skills in this research can provide insights into relevant knowledge sharing issues in other construction companies in the context of China. Some categories are likely to be applicable or transferrable through further investigation and with careful consideration with the particular context. While the emphasis on specific domains and skills may change in different contexts, the core properties of the framework, for example the mutual influences between knowledge domains and skills are likely to be transferable. An interesting development would be to explore this in different project management contexts beyond the construction industry that involve essential interactions and collaborations across multiple organizations.

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Appendices

Appendix 1. Exemplar quotations for knowledge domain categories

Category	Quotation	Interviewee & phases
Knowledge on risk	Our work (architecture) is very technical and complicated. For some required changes, when another functional area requires my functional areas to make changes, or come up with something, we need to coordinate and make the changes together.	PMD - I12 -40-35 1st phase
	There are no small issues for interior fixtures. Any small issue can cause a big problem. For example... We have to share ideas about preventing risks in the beginning to avoid waste of time and investment.	PMI - I5 - 73-75 3rd and 2nd phases
	Construction workers are more concerned with finishing the job rather than what might happen afterwards e.g. maintenance problems. I need to notify them of potential problems that may occur after they have completed the work; these types of issues must be detected. Construction workers may not be aware of potential problems.	PMI – I15 – 127-130 3rd phase
Knowledge on planning	The five-star hotel relies on the points system... when we reach a certain number of points we can be rated as a five-star hotel. In the beginning we were planning to build a swimming pool on the 4th floor, but then decided the level below the ground floor would be better. We were planning to build a fountain and then decided to do something else instead. We went to visit other hotels and made some changes in our ideas such as the style of air conditioning etc.	PMD-I13-88-96 1st and 2nd phases
	Our city is the most historical city in this province. For example, the culture of the 'well' character includes the idea that well means water, and water brings fortune. We need to share and discuss the culture issues in our planning.	PMI - I4 - 55-29 1st and 2nd phases
	The investor may see appearance or beauty as the priority. ... Safety is important for everybody; then among economy and beauty and usage, the investor has its options and priorities. In some cases the investor can give up some space to create a stylish design – he spends money for beauty. As designer I need to let the investor have their preferences and priorities. If they give priority to beauty rather than economy or usage, we design people cannot point out that it is wrong. Design itself can be an art.	PMD-I16-161-164 2nd phase
	Time needs to be coordinated, so that after work A is completed, B enters the field; B does not interfere with other construction works, etc... There are sometimes changes to the blueprint which require coordination between companies... If there are more changes, more work will be needed and thus more days would be added.	PMC – I18 – 77-86 3rd phase
Knowledge on implementation	The basis is not to affect the building appearance, which in other words is to, trying to keep the original look. If we have to change, we need to call the design people and construction project managers, together with us (from the investing company). We have to remind them not to affect the appearance of the building.	PMI – I11 – 137-138 and 226-229 2nd phase
	Both technical and management. In management, it involves construction sequences, speed of production, etc. In technical perspectives, it contains construction blueprint and techniques in producing. … When deciding time length, we usually accord to the level of difficulties. As we did many projects previously, we have our knowledge and estimations.	PMC – I18 – 6-11 3rd phase
	Sometimes the construction teams want to save money so they would purchase something cheaper to replace the required materials. At this moment you need to talk to them to say 'no' and insist on your principle. For example the leather they purchase can be artificial leather rather than real leather. Then we would explain to them our interests and make it clear	PMI – I11 – 257-261 3rd phase

	that we only use the same quality of product as we require. If you don't purchase the same ones, we would purchase them ourselves.	
	In my perspective, it's often about the understanding of regulations when it comes to structure. There are times when myself and our chief engineer disagree about items in the regulations. Sometimes we even argue, but ultimately one person always persuades another. Our understanding of some project cases and regulations may differ.	PMD – I1 – 191-193 2nd phase
Knowledge on people	It is always about coordinating project members and resolving conflicts inside the project... Sometimes when PMs coordinate themselves they might have conflicts; if we ask the construction teams it can be troublesome too. This is for the main purpose of speeding up the construction processes.	SMI – I13 – 111-117 3rd phase
	There are some issues in the project that I haven't dealt with before. The project manager may tell me there was a similar project in the past and refer me to relevant people who were involved with that work. The PM would provide a way and a method, and I would solve the problem accordingly. This saves my time and works effectively.	TMD – I3 – 335-337 1st and 2nd phases
Knowledge on business strategies and operations	Our main goal is to explain our own reasons to the investing company's project managers and try our best to convince them. The building appearance is almost as important as safety in a five-star hotel. But the design institute emphasizes safety way above appearance. It also adopts a traditional approach that gives away the innovation and nice appearance.	CED – I4 – 139-142 2nd phase
	Usually the design institute always does things according to books or regulations. We may not know much about these books or regulations, and thus we think there shouldn't be any problem to do things this way. But the design institute insists to do things according to the books and regulations. This is the time when conflicts can happen.	PMI – I10 – 132-134 2nd phase
	Another thing is you need to understand hotel operation. For example for interior and exterior fixture, PM needs to consider space arrangement when communicating with designer. If the PM is expertise in this area, he would understand immediately when the designer shares knowledge with him, and it is easier to reach agreement. If he's not expert, it would be more difficult.	SMI – I13 – 248-251 all phases

Appendix 2. Exemplar quotations for skills categories

Category	Quotation	Interviewee and phase
Social cognitive skills	Sometimes, things are not only in my functional area, so I need to know about other areas in more detail. Having experience in other areas is important.	PMD –I2 – 103-104; 2nd phase
	As an example, we studied fixture styles in other cities and sites initially. Many people make mistakes during the hotel's preparation. For example, WF Hotel (another five-star hotel in the same city) had many difficulties due to inexperience… They teach us many things; it can be viewed as work experience, or failure lessons.	SMI – I13 – 172-178; 1st phase
	We would draw the regulations on paper and explain the technical aspects if the investor doesn't understand. Be detailed and concrete. The investor may not understand if you just say it doesn't work according to regulations. Sometimes rules are drawn to explain.	TMD – I2 – 222-227; 2nd &3rd phases
	Since last year, we use a collaborative design software. Architecture is the basis for all other functional areas of the design process. Whenever an architecture design changes, the designer should inform others of the change and make changes accordingly, so we can avoid inconsistencies, especially if time is short.	TMD – I2 – 307-312; 2nd phase

Interpersonal skills	I tend to show my care for team members. I treat them to dinner sometimes if the work is tiring, so we can communicate. I would mention my bad attitude during dinner if it existed earlier.	PMI – I10 – 232-236; all phases
	There are ways to criticise when negative information needs to be expressed. If there's something you did wrong, I would point it out privately or personally if there are many people present.	SMI – I13 – 240-242; all phases
	The construction group would pick on some small details and ask us, the design institute, to make changes; their aim is to save some money, but instead of talking to the investor, they directly contact us. The changes are actually a skill or work experience, and they are also a trouble if we don't understand what's going on... In any case, we need to explain the situation to the investor and avoid conflicts as much as possible.	TMD – I2 – 197-206; 3rd phase
	Better coordination must treat them fairly, without favoring any team. We stand up for the team with good reasons. For example, if one team purchases a higher quality product at a higher price, we would use the better quality one.	PMI – I15 – 175-178; 3rd phase
Strategic orientation	We have a deadline for project completion and with the changes we have a lot of extra work. Our investor had some new ideas after the construction blueprint was completed, which was not because it wasn't good enough, but because they had new ideas about something we agreed long time ago. The useful thing is that they highlighted our shared interest in the project, which is that we all hope the hotel project becomes one of the best 5-star in our city, which also remarks our design institute.	PMD – I6 – 87-94; 3rd phase
	Nobody likes changing designs all the time. In my role as a project manager, I let them know that the construction industry is always an investor-oriented industry. The designer can't always insist on his own opinion, and the investor could come up with his own ideas. An investor's ideas reflect the current trend; are those they think most suitable. Since design people always sit in offices, some of the things we design might not follow closely development trends.	PMD – I6 – 147-157; 2nd and 3rd phases