Service design and knowledge management in the construction supply chain for an infrastructure programme

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Abstract

Purpose – The **focus** of this research is the extent to which service design is addressed by the client and its supply chain at a programme level into one functional capability, knowledge management, to share knowledge across projects and organizational actors.
Design/methodology/approach – The interpretative methodology employing two methods of engaged scholarship, namely action research and engaged research, is applied. The data is analyzed using cognitive mapping to identify the extent of alignment of perceptions.
Findings - The findings show that the client and its supply chain are very transactional in their management minimizing investment in knowledge management and programme management. Lack of commitment and cultural leadership are present, hence the over-reliance on individuals to take responsibility for knowledge sharing and application. Service design thinking can help develop a holistic approach to learning from projects.
Research implications – The study underlines the links between the concepts of service design and knowledge management. The findings emphasize the importance of developing a holistic approach to knowledge management through the lenses of service design. The organizations must view knowledge management as a process and build capabilities at a programme level to make knowledge sharing an integral part of the work culture across projects.
Originality/value – The study contributes to the subject of knowledge management in construction industry by mobilizing the concept of service design to examine how knowledge management systems and procedures are embedded in the client and across its supply chain.

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1 Introduction

The term Service design (SD) was brought forth by service marketing researchers and represents a customer-centred iterative approach to the creation of new services. SD is a multidisciplinary topic that incorporates contributions from operations and information technology (Ostrom et al., 2015; Patricio and Fisk, 2013). Based on the research papers on service innovation, SD is a capability that allows organizations to adapt to their changing environments and stay competitive (**e.g. Brown, 2009**; Ostrom et al., 2010; **2015; Patricio et al., 2011**). It is a rapidly evolving business practice which has caught the attention of an increasing number of researchers (Brown, 2009; Stickdorn and Schneider, 2012). However, little is known about SD as an organizational capability (Gruber et. al., 2015). There is a lack of understanding of the impact of SD on knowledge management (KM), organizational culture, structure and work practices. SD is a neglected area in many project-based industries, particularly in construction supply chains.

Main contractors and subcontractors tend to be transactional in their management, minimizing investment and expenditure to be price-competitive at a project level (e.g. Gruneberg and Ive, 2000). Yet, the extent to which this is the case at a detailed operational level is somewhat unclear. It is generally accepted that contractors configure projects around the inputs according to meeting the minimum requirements and manage the inputs in terms of time, cost and quality. Configuring these inputs and their management that maximizes the service experience during the execution stage is a value proposition that has largely been overlooked. However, there is

selective evidence of project-based firms trying to configure activities and capabilities to co-create and enhance service experience (e.g. Smyth, 2015).

There was early interest in KM in the construction literature to facilitate improvement (e.g. Carrillo et al., 2002; Anumba et al., 2005). Adoption in construction has been sporadic and partial over recent times (Smyth, 2010; Kelly et al., 2013). Primary attention has been given to the project level with less attention being paid to programmes of projects and their supply chains.

There are many definitions of KM, however based on a seemingly broader one by Davenport and Prusak (2000) organisational knowledge should be managed "through a systematically and organizationally specified process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employees to enhance organizational performance and create value". Thus, in the context of SD KM is a process of the continuous identification, creation, access, development, dissemination, use and reuse of knowledge with the goal to deliver quality services. SD is a highly visual design discipline and knowledge is an intangible asset that needs visualization to initiate in-depth discussion and support effective sense-making. The importance of SD is to embed KM systems and procedures into the organizations (Teece, 2010). **However, a systematic programme management approach, which stands above the project level, is required to facilitate knowledge transfer between projects and organizations across supply chains.**

Why are the concepts of SD and KM important? Theoretically, they provide the means to overcome the feature recognised by Dubois and Gadde (2002) that projects have no memory. Besides, in large infrastructure programmes, more relevant knowledge is generated outside the client and main contractor organizational boundaries and SD can support development of robust systems and processes to accommodate KM. SD thinking is characterized by an emphasis on a comprehensive understanding of the stakeholders' perspectives to address the functionality and form of services. It aims to ensure that service interfaces are effective and efficient from the perspectives of a main contractor and its supply chain. This requires an iterative learning and feedback process at a programme level.

The research questions are framed as:

> *'Is there a systematic programme management approach regarding KM across the main client's supply chain?' and 'Has SD thinking been applied to support development of robust systems and processes to accommodate KM at a programme management level?'*

This study is a part of a broader 2-year research programme aimed at studying the inhibitors to KM in **a** client organization that implements £5bn infrastructure programmes. An engaged and action research set of methods permitted detailed examination of large projects and megaprojects, estimated to be in the range of an infrastructure programme for a UK client. Formal and informal interviews with the key decision makers in the main client organization in the areas of KM and programme management and implementation, supplemented with background information obtained from organizational documentation (internal and industry reports) served as a basis for semi-structured interviews across supply chain (consultants, contractors and subcontractors).

The interviews were transcribed into the language of cognitive maps. Cognitive Mapping (CM) technique, a tool of soft systems thinking approach used in this research allowed capturing the thinking regarding the importance of intra- and inter-organizational knowledge management in the hierarchical manner and demonstrated the implication links among them. This helped respondents understand how ideas fit together as a whole, develop answers to strategic questions, create shared meaning, facilitate negotiations and communicate agreement about further actions.

The structure of this paper is traditional: a literature review, methodology and methods, findings and analysis followed by the conclusions.

2 Literature Review

SD is first addressed and KM is considered subsequently before being brought together. Both conceptual elements are anchored in systems thinking (e.g. Checkland, 1981, Richmond, 1994, Senge, 1990) and service science (e.g. Maglio and Spohrer, 2008). Systems thinking is defined as:

> *...the art and science of making reliable inferences about behaviour by developing an increasingly deep understanding of underlying structure* (Richmond, 1994, p. 141).

Service science can be defined as:

> *...the study of service systems, which are dynamic value co-creation configurations of resources* (Maglio and Spohrer, 2008, p. 18)

2.1 Service Design

An important part of a service science is a systematic approach to SD. SD has taken a more prominent place across industries trying to be more customer-centric and improve the service experience (e.g. Shostak, 1984; Zomerdij and Voss, 2010; Ostrom et al., 2010; 2015). It can be divided into the provision of a generic service solution and the tactical provision of service delivery. This research is concerned with the generic. In other words, it examines the system for the service provision, using KM as the focal object. Therefore, SD is a total approach, but the system for KM is the issue of examination. The system selection and how it is implemented is therefore to be considered. **For example, if the system tries to facilitate tacit knowledge transfer and develop organizational norms, behavioural codes of conduct and/or cultivate communities of practice, then behaviours and physical methods of transfer need to ensure that knowledge is shared between parallel and successive projects in the programme. The selection of these options and the shaping of them is part of the SD process.**

Prior to unpacking this aspect of SD, it is pertinent to ask, who is the design for? Who benefits from a better service experience? While efficient and effective practices tend to provide staff with more rewarding work experience, the significant aspect is the inter-organizational relationships. The main contractor supply chain interacts with the client, the intensity of which

depends upon the relationship and contractual context of exchange (cf. Macneil, 1980; Egan, 1998). **It is the role of the main contractor to be the systems integrator not only internally but also across the supply chain**

Clients employ specialist professional service firms or consultants as solution advisors (Davies et al., 2007), who will represent the client at times, yet at others may also be part of the supply chain on design and build-types of contractual relationship. Contractors are systems integrators who may undertake specialist work in particular sectors, but tend to outsource contracts to their supply chain wherever possible (cf. Davies et. al., 2007). All these parties are beneficiaries of the service experience.

Why might this be of focal concern in practice to main contractors and their supply chain? Effective interaction gives rise to opportunities to co-create the service experience, by understanding what the other parties value (e.g. Vargo and Lusch, 2016). A good service experience builds reputation that can lead to securing more work through the client or through the advocacy of the consultants. This applies to both the main contractors and subcontractors.

Reputation can also lead to growing the firm either by transferring the SD principles into other markets or by expanding the firm using the SD as a source of competitive advantage. This growth strategy requires investment, which many project-based firms have been reluctant to adopt because of their transactional finance management (**e.g. Gruneberg and Ive, 2000)**. **Investment will involve processes and any support technologies in addition to training/induction and systems refinement for the generic SD and project specific tailoring for each context. Some soft elements for the generic parts of SD may be introduced incrementally to spread investment risk, to improve employee absorption, and to embed the KM elements of the SD step-by-step.**

Yet the business model for contractors is currently broken and new management strategies are needed to transform the firms. This includes investment as a central element in order to yield an adequate return (Smyth, 2018).

SD addresses the organization of the firm (Romme, 2003). It is defined in terms of specifying an idea by developing drawings, flowcharts and other tools to ground SD in concrete ways (e.g. Gummesson, 1991; Romme, 2003; Bitner et al., 2008), **which is applied at a programme level for the generic part of SD and at a project level for specific tailored approach.** There is no single way to approach SD. One way is to break the elements of SD down as follows:

- *Blueprinting* – flow-chart or map for service visualization (Shostak, 1987);
- *Mapping processes and logistics* – detailed activity breakdown (Kingman-Brundage, 1992);
- *Visualization of the intangible service* – align provision with need, and identify co-creation potential, emergent requirements to be anticipated;
- *Service configuration* – aligns means of delivery, relationship management, assessment and evaluation criteria (Romme, 2003).

In project-based organizations SD can be overlooked in the interest of keeping short term costs down rather than stimulating yielding a return on projects and firm growth medium and long term.

2.2 Knowledge Management Theorization in Management and for Project Management

Large-scale infrastructure organizations are known for rigid boundaries between processes, functions and stakeholders (Gustavsson and Gohary, 2012). These boundaries inhibit knowledge exchange and cooperation across projects implemented by the supply chain. Large-scale infrastructure client organizations need to change their culture to boost inter-project collaboration and learning. There is a high level of agreement among both academics (Dalkir, 2005; Davenport, et al., 1997; Davenport and Prusak, 2000; Duryan and Smyth, 2018; Kelly et al., 2013; Lave and Wenger, 1991; Senge, 1990; Szulanski, 2000) and many knowledge practitioners (e.g. APQC, 2013; 2016) that the great challenge in developing effective and systematic knowledge sharing and application lies in the organizational and cultural dimensions.

It is generally accepted that communication systems and IT platforms are not the solutions for effective KM. They only support the culture for knowledge sharing and application (Bloom, 2000). However, there is something of a growth in the advocacy of 'quick fix' notions based around digital technologies such as BIM and AI, which fundamentally confuse the means and the end. No matter how intelligent the technology and the ability to 'learn', it offers a sophisticated tool to support the implementation of solutions, but does not create the solutions. KM relies on people, human systems and the culture rather than artifacts (Szulanski, 2000).

Culture is the organizational mental model for effective KM (Blackman and Henderson, 2003), with the potential to induce a shift from a transactional 'knowledge is power' to the more transformational mental model of 'knowledge sharing is powerful' (Dalkir, 2005). Organizational culture can be the facilitator or barrier and perhaps the greatest challenge for the management to address (Davenport et al., 1997). This is echoed from findings in project environments (Edkins et al., 2013; Kelly et al., 2013).

Cultural values shape patterns of interactions, hence influencing the willingness to share knowledge (Gray and Densten, 2005). Projects are loosely coupled from the organizational culture, forming a temporary organizational context in multi-organizational teams (cf. Cherns and Bryant, 1984). Thus, systems and procedures are necessary to cultivate and support a culture of knowledge sharing. **According to De Long and Fahey (2000), organizational culture defines what is 'right' and 'wrong' in the organization and influences they ways people interact and share knowledge and experience. Large scale project-based organizations generate a great deal of tacit knowledge (e.g. Kelly et al., 2013; Szulanski, 2000) and to remain flexible and adaptive they need to capitalize on that knowledge internally and across the supply chain.**

The notion of 'tacit knowledge' or 'tacit knowing' was first coined by Polanyi (1958) and refers to information, which is obtained through experience and is difficult to codify and transfer to others. According to Polanyi (1966) knowledge cannot be fully documented as it includes the degree of tacitness. In order to transfer knowledge stored in the heads of individuals, organizations need to cultivate a culture that facilitates social interaction (Davison and Blackman, 2005; Hayes and Allison, 1998). Some of the tacit knowledge can be made explicit (or documented) in certain circumstances. Explicit knowledge is formal knowledge that can be expressed shared in the form of data (Nonaka and Takeuchi,

1995). Formal knowledge systems and procedures facilitate the socialisation of tacit knowledge and the sharing of explicit knowledge (Nonaka and Takeuchi, 1995).

Processes for effective KM are especially important in a project setting where practices are nested in construction projects around managing change and problem solving (Senaratne and Sexton, 2008; Kenley, 2012). Bredillet (2004) links individuals' knowledge to the firm via organizational competency in project-based firms. Therefore, the firm and project are not only conceptually linked by processes to facilitate individuals and teams sharing knowledge within a project, but are also linked by systems between the project and firm for knowledge transfer between projects **(Anumba et al., 2005; Bredillet, 2004; Morris et al., 2004).**

In large infrastructure programmes, more relevant knowledge is generated outside the client and main contractor organizational boundaries rather than inside, hence the desirability of SD to improve knowledge sharing. Programmes are located above the project management level, where a range of theoretical and applied activities occur including change management, key account management and client lifetime value management, and KM (e.g. Vereecke et al., 2003; Artto et al., 2009; Smyth, 2015), to integrate and improve delivery (Ferns, 1991; Pellegrinelli, 1997). The objective is to translate project learning to an organizational resource for transfer across its programme of work (Brady and Davies, 2004).

From prior research, the extent of socialization and of knowledge transfer has been found to be variable (e.g. Carrillo et al., 2002; Smyth, 2004; Kivrak et al., 2008; Kelly et al., 2013). Compared to other sectors, the procedural steps for knowledge capture and transfer are twofold respectively whereby the project has to capture the knowledge and then the firm has to capture it from the project organization and vice versa (Smyth, 2004). First this is costly as well as incurring potential loss of effectiveness, and second, project budgets do not have the contingency to manage the process, hence projects are not enabled to have a memory (cf. Dubois and Gadde, 2002). To facilitate knowledge transfer from the firm across projects, complex support systems and processes are required. An illustration of the types of processes is set out in Figure 1.

As Figure 1 demonstrates, KM systems are capabilities requiring a) investment from finance management and the main board, b) human resource management processes to motivate and monitor staff through selection, induction annual reviews and personal development, and c) being part of a programme management capability to facilitate knowledge transfer across projects.

Figure 1 About Here

Organizational systems and procedures tend to either over-rely upon IT as 'solutions' for KM and/or have weak human systems and procedures. The procedures tend to be retrospective and engagement levels are low (Sage et al., 2010). Low engagement and the absence of a learning culture results in reinventing the wheel (Smyth, 2004). The outcome is that knowledge remains

tacit, hence residing in people working on projects (Morris and Loch, 2004; Bayer and Gann, 2006) or 'sticky' in organizational terms (Szulanski, 2000). Such habits of inaction are built in as "routines" or action to avoid an imperative for response, which then become rigidities or barriers to changing practices (Winter, 2013).

2.3 Service Design and Knowledge Management

How can SD and KM be conceptually linked together? The ability to effectively manage the two concepts in consistent ways is conceptually organizational capabilities (cf. Teece, 2010) that were largely overlooked in programme and project management.

If the client, contractor and subcontractor in the infrastructure supply chain are to implement KM they need to address the following three key dimensions to support effective SD:

- **Organizational culture**
- **Systems and procedures**
- **IT platforms, digitization and Artificial Intelligence (AI)**

Selection of the starting point will depend upon the strategy of the organizations and whether KM is part of the strategy, their business models and the extent to which they perceive SD to be important. However, it is advisable to start from human systems, rather than procedures and IT platforms, especially considering that organizational culture is "perhaps the most difficult constraint that knowledge managers must deal with" (Davenport, et al., 1997, p.14-15).

How do each of these relate to KM? Organizational culture is shared and understood rather than articulated in documents. Therefore, aligning KM as a functional process to the culture will require multiple iterations, which takes time to resolve in the development and evolution of SD for KM. As multiple organizations are involved with programmes and construction projects, inter-organizational knowledge transfer will require a degree of alignment of the organizational cultures. Conceptually SD will need to be flexible at the organizational interfaces to permit effective interactions around knowledge sharing across organizational boundaries at both the programme level and between the projects.

Formal and informal collaboration within supply chain are mechanisms that help to nurture knowledge sharing. Where there are phenomena and artifacts acting as barriers to knowledge sharing, instigating communities of practice (CoPs) across disciplines and organizations is a way to circumvent the barriers (Lave and Wenger, 1991). CoPs can facilitate KM at a high level and influence the culture at the operational level in construction (Duryan and Smyth, 2018; Sanaei et al. 2013). In large construction organizations CoPs are viewed as the most widely used technique for knowledge sharing (Carrillo et al., 2002). They become loosely coupled strategic operating systems alongside the 'business as usual' processes to encourage inter-organizational learning and problem solving (e.g. Duryan and Smyth, 2018).

Systems and procedures, that comprised the third option, offer an intermediary between the rigidity of IT platforms and the fluidity of organizational culture. Infrastructure programme management is a system of coordination mechanisms in the client organization, where the KM sub-system would reside. Similarly, the main and sub-contractors can also develop programme management in order to coordinate and disseminate knowledge. Construction lags behind other industries in programme management (Delaney, 2013). There is a lack of clarity about the purpose programme management (Shehu and Akintoye, 2009). SD can help clarify the role of programme management and design the system to accommodate KM.

IT platforms can take the form of intranet fora, social media apps and fora, although these are not widely used for KM, yet may become more commonplace in the future. Social media are means that have potential to facilitate the sharing of some of the tacit knowledge and thus make it partially explicit between teams and organizational boundaries **(e.g. Carlile, 2004)**. Intranet can provide more systematic storage and interrogation for mobilising information and knowledge. However, the most common form of KM under the IT option is the application of standard IT software packages, which allow little or no scope for tailoring to context. There is scant opportunity for SD around IT platforms.

In summary, it is important to have a systemic approach to KM through the lenses of SD to make knowledge sharing a part of organizational DNA. Service design thinking can help cultivate a culture of knowledge sharing, design appropriate systems and procedures and align them with relevant IT tools and systems to effectively build capabilities at a programme level.

3 Methodology and Methods

The aim of this study is to examine the extent to which knowledge sharing and application is embodied into SD at a programme level as a capability to improve project performance in and across supply chain that implements a large infrastructure programme. A single client infrastructure programme in the region of £5bn in value, which comprises a series of parallel and sequential large and complex projects and megaprojects, relies on an extensive supply chain to deliver its construction programme of projects. The client, a large infrastructure company supported by government funding, is under close scrutiny for cost accountability and the supply cluster operates in a multi-organizational environment of new provision, renewal and maintenance comprising complex overlapping and interlocking project and operational systems. Part of the complexity arises from the type of work that has not been undertaken in the UK for 25 years. This renders SD and capturing lesson learned (LL) for reapplication of particular importance for efficient and effective execution of the engineering and construction work.

An interpretative methodology is used (see for example Miles and Huberman, 2002), which is appropriate for a topic embracing explicit and tacit aspects of knowledge sharing and application. SD is a matter of configuring KM to improve effectiveness of managing knowledge and hence deliver benefits for the programme realization.

Methodologically, interpretation has the benefit of not forcing a singular theoretical approach to SD or KM. While prior theory informs the collection of empirical material, it acts as a guide

rather than providing a determined model or framework. This aligns with the more inductive approach that reviews and uses the available theory to inform the research, and then builds up understanding and practice from the bottom-up (Eisenhardt, 1989). There was no guarantee in advance that new theoretical insights would be induced, yet the approach permitted understanding of the extent of practices relevant to the theory and concepts around SD and KM. However, this approach is not merely constructed for the purpose of data collection, it was required as part of the application of engaged research methods and action research to not only gauge the extent of SD and KM practices, but to develop KM practices in particular through effective SD.

Engaged scholarship helps facilitate a deeper understanding of the context of operation and can aid the collection of rich data sets (Van de Ven, 2007). The engaged research combines two elements. First is the engaged research with the client and supply chain members, involving collaboration to consult, inform and influence reflective practitioners as part of their learning process (Van de Ven and Johnson, 2006; Barge and Shockley-Zalabak, 2008). Second is specific form of engaged research termed action research, which is undertaken through embedded activity to induce outcomes in line with the goals set in the research contract (Reason and Bradbury, 2001). The two elements led to soliciting qualitative data for analysis.

The sensitive issue about action research is the ability to understand the context and perceptions of the actors with the reality they are dealing with on the ground. This embraces the range of issues from organizational culture to tactical operational tools applied in construction. Besides, because of constructivist and narrative nature of knowledge, it arises from what actors think and say about the world (Gergen, 1992). Therefore, the detailed method had to be both systematic in approach yet sensitive to the perceptual context. Thus, the evidence from the interpretative analysis of the interview data is reinforced using CM, a visual technique to show perceptions, patterns and causal relations between the issues (Ackermann and Eden, 1994). Axelrod (1976) first used cognitive maps as an approach to understanding managerial decision-making processes in organizations.

The prime aim of the action research is to change current practice (e.g. Eden and Ackermann, 2018) and understand a problem of a specific client (e.g. Van de Ven, 2007), therefore being embedded in the organisation is necessary. With supply chain members a more independent yet engaged research approach was needed and semi-structured interviews were conducted using engaged research methods. On the ground there was no difference in the questions asked but the position from which they were asked and were received by the interviewees was important for soliciting rich data. The data was solicited in two phases. The first phase involved studying internal and industry reports and conducting formal and informal interviews with the key decision makers in the main client organization in the areas of KM and programme management by the embedded **university** researcher, which was an action research based in terms of the interview method.

Initial analysis involved research interpretation of interview material (Denzin, 2002). The process was to identify patterns and individual processes and events of significance that influenced outcomes (Smyth and Morris, 2007) and to design the second phase of an engaged research. The initial analysis was also used for feedback to supply chain members and the client

through institutional fora and learning workshops at an industry conference as part of the engaged research.

The second phase was led by the principal investigator as an engaged researcher who conducted semi-structured 1,5-hour interviews with 23 decision makers in KM and programme management and implementation from 6 supply chain case companies, comprising 2 consultants, 2 contractors and 2 subcontractors (Table 1, cf. Eisenhardt, 1989).

Table 1 About Here

The interviews were recorded and transcribed into the cognitive maps to depict interviewees' perception of the prevailing situation. The individual maps were merged into a single map to develop a unified view of multiple perspectives after content validation during follow-up meetings (Eden, 1989; 2004).

Essentially, a cognitive map provides a comprehensive picture of an individual's overall perspective, at the same time keeping all the connections between wholes and parts, 'the forest and the trees'. The formal basis for cognitive maps derives from Kelly's (1991) personal construct theory which proposes that people 'make sense' of their world by seeking to manage and control it. CM helps understanding the context in preparation for SD of KM. In this sense, CM was part of the research design and akin to SD in the construction context. The cognitive maps were analyzed with the help of Decision Explorer software (Brightman, 2002). Of the various analytic tools that were available, the most valuable ones for this case study were *head, centrality, domain* and *cluster* analyses.

In cognitive maps, *head* analysis helps to identify goals in terms of final effects from perspectives of the interviewees. The *heads* are the concepts represented by the nodes that have only arrows going inside. *Domain* (density of the direct links around the concepts identify) and *centrality* (considers both, direct and indirect links) analyses help to identify the key issues from the perspectives of the interviewees. *Centrality* analysis extends *domain* analysis by measuring the complexity of the concept's implication chain (Eden, 1989). If a concept appears in both, *domain* and *centrality* analyses, it "confirms its position at the core of a potential key issue" (Eden and Ackermann, 1998, p. 405). Decision Explorer software, used for the analysis of the merged map, allows detecting clusters that can be analyzed separately from the rest of the map (Eden, 2004). The output of the *cluster* analysis are hierarchical sets/groups based on a specified set of concepts. The analysis takes the key issue and drills down all the chains of argument affecting the key statement.

4 Findings and Discussion

KM initiative must be planned, designed and systematically implemented throughout an organization to transform the culture and business-as-usual routines (Davenport and Prusak,

2000; Kelly et al., 2013; Lave and Wenger, 1991; Senge, 1990; Szulanski, 2000). However, based on the data collected in the main client organisation and across its supply chain, it was an unsystematic, hence uncoordinated project and programme management approach regarding KM. Overall, it was stated that programme management and the strategic project front-end were driven on the client side by organizational factors in ways that constrained KM in the supply chain. Both the client programme and the supply chain members lacked coherent systems and procedures for developing management capabilities at a programme level.

Current practice will be reported upon first followed by more detailed analysis of the semi-structured interviews with the 23 key decision makers in the areas of KM and programme management and implementation in 6 supply chain companies of the same main contractor based on the cognitive maps and barriers to change.

4.1 Current Practice

To what extent was there engagement with KM and how was KM practiced? It was found that there was common agreement of the shortcomings of KM practices across the organizations. This was evident in the cognitive map (see Figure 2 and supporting evidence from the map below), showing alignment between individuals across organizational boundaries.

It was repeatedly reported that the client and supply chain extensively relied upon individual initiative. Where there were required processes, for example post-project LL, monitoring and compliance levels were very low. Where captured, the knowledge generated within one project, i) was often of little value as the details had been lost between the time of learning and reporting within the supply chain, ii) was lost because people were moved to another project, left the company or retired, iii) was buried in unread reports, and iv) not loaded up to the client programme platforms or was stored on platforms unavailable across the client programme.

4.1.1 Organizational culture

The culture for sharing tacit knowledge is an important issue to examine for knowledge transfer and application and relates to the social perspective of systems thinking (Senge, 1990). Management by objectives and hierarchically structured social relations **in large infrastructure organizations** discourage knowledge sharing **(Argyris and Schön, 1978; Bennet, 2006; Josserand, 2004; Mintzberg, 1993; Senge, 1990).** The findings were reported in the context of hierarchical management being dominant in the organizations and in terms of power between them. As one key decision maker in a subcontractor stated, the client adopts a "policeman type role" in managing their stakeholders or as another respondent reported, "it's a little bit command and control".

The hierarchy was also said to invoke accountability criterion, 'silo' effect and adversarial behaviour, including the propensity to blame others (e.g. Thiry, 2004). The client was perceived to fail to understand the impact they had on constraining the sharing of LL: "Defensive behaviour is to just not share or only share what is safe". It was further stated, "Trust needs to be improved…. There is no real consequence for bad behavior".

From practical-based perspective, knowledge is deeply rooted in practice and cannot be fully captured, codified and transferred **(Kelly et al., 2013; Polanyi, 1966; Szulanski, 2000).** Based on the interviews with the client and across the supply chain, CoPs can provide a solution to

hierarchical constraints (on the client side) and to the lack of systems and procedures for inter-organizational tacit knowledge exchange. The respondents mentioned that CoP members, subject-matter experts, can validate LL from projects and come up with recommendations on the most appropriate boundary objects for knowledge externalization/visualization/blueprinting and sharing. CoPs can also improve decision making processes in the client organization, improve collaboration, build trust across supply chain and eventually change behaviours (APQC, 2016; Davenport, et al., 1997; Davenport and Prusak, 2000; Duryan and Smyth, 2018; Josserand, 2004). Based on the perspectives of the respondents, CoP cultivation would address the majority of the key strategic options (Table 2).

4.1.2 Systems and procedures

To facilitate effective KM, complex support systems and processes are required (APQC, 2013; Carrillo et al., 2002; Davenport et at., 1997; Davenport and Prusak, 2000). The respondents reported shared perception as to the importance of KM and extensive management reliance on transactional risk and cost control at the expense of transformational practices across the supply chain. This was underpinned by low firm investment to develop business and technical capabilities. There were no programme capabilities to spread and embed learning for subsequent application across supply chain. Finance and Commercial Directors applied transactional management to project and functional budgets, failing to understand the transformational KM benefits for complex projects.

4.1.3 IT platforms

It was repeatedly reported by the respondents that there were low levels of engagement with the client and supplier IT platforms for KM, mainly because they were unsupported by parallel human systems. As a result, the LL were not validated by subject-matter experts, neither were they structured and updated. The documents were inaccessible and hard to interrogate. Besides, not all supply chain members had platforms for storage and uploading files.

4.2 Cognitive Map Analysis

A more detailed level of analysis of the interviews with consideration of the linkages and interdependencies between the issues is depicted in Figure 2, highlighting the shared thinking across organizational boundaries. Based on the results of the map analysis, the nodes 'improve KM' (node 27) and 'improve collaboration between the client and supply chain' (node 2) are the heads of the map. They are the goals expressed in terms of final ends or effects. That means that supply chain members agree that there is an urgent need to improve collaboration with the client and the way they manage knowledge. Domain and centrality analyses of the map were used to identify the key strategic directions leading to the goals. The first ten commonly raised strategic issues are shown in rank order with numbered cross-referencing to Figure 2 (Table 2). This confirms that there is willingness in and across the supply chain and client organization to collaborate towards effective KM in systematic ways.

Improvement of decision-making processes in the client firm is among strategic objectives aiming at improvement of collaboration and knowledge exchange between the client and the supply chain (Table 2). The respondents mentioned that the management of the client should eliminate inconsistency in decision-making and be more flexible in dealing with supply chain rather than using the "power of veto". A knowledge-sharing culture requires appropriate

organizational climate (**e.g. Davenport and Prusak, 2000**), so the respondents emphasized the importance of a 'better working atmosphere' and an 'environment of trust'. To encourage the supply chain to share knowledge, the client "needs to build trust" by efficient execution of promises.

Table 2 About Here

The respondents emphasized the importance of identifying generic lessons, particularly for bidding (node 39) with the focus on clients, rather than only on projects (node 40). They mentioned that it is crucial to allocate sufficient time to add value through KM and to visualize that knowledge. The *Blueprining* techniques of SD can be translated into KM language and renamed as *Explicit Knowledge* and the boundary objects like models, drawings, maps, charts, software programmes, spreadsheets and events can serve as tools to *Visualize* knowledge.

Based on the interviews in the client organization and across supply chain, the respondents prefer face-to-face knowledge exchange and/or via structured visual forms, rather than piles of documents "they have no time to read". Knowledge visualization is especially important in project-based environments to make tacit knowledge developed within the project explicit and to share it across boundaries to provide context for strategic discussions. The question is how to visualize knowledge generated as a result of collaboration within project teams and to share it across supply chain. SD can help design the system for capturing, validating and visualizing knowledge from projects to provide a bridge between project work and wider organizational processes.

Figure 2 About Here

The map analysis revealed those concepts that support the achievement of more than one goal. Potency analysis is based on the assumption that the more goals a concept supports, the more potent this concept is (Eden, 1989). It allows prioritizing options that have consequences for the bigger number of key issues.

The most influential options that have consequences for the bigger number of strategic objectives listed in the Table 3.

Table 3 About Here

The concepts that support the achievement of more than one goal are mainly in 'collaboration' domain (Table 3). From the perspectives of respondents more room for manoeuvre and influence in decision-making, better collaboration across supply chain, supported by a better knowledge exchange environment, can reduce the tension between partners and in the long run may eliminate the 'silo' mentality that exists between functions.

4.4. Barriers to Change

A reported tendency was that the client proceeded to delivery prior to completing the scoping, defining and specifying of each project. The main contractors described this as a major disincentive to engage with effective KM due to the subsequent constant change.

Main contractors displayed some effective KM practices. These were largely focused upon cost savings and efficiency gains. However, that focus was inward facing rather than concerned with adding value to serve or save costs for the client. While indirect benefits may accrue at times, this is fortuitous rather than through designed service improvement.

Based on the analysis of the interviewees with the client organisation and across its supply chain, a series of specific operational barriers to effective knowledge sharing and application **were identified**: i) insufficient time is allowed for early contractor involvement and for bid managers to apply LL; ii) untimely and confused client decision-making during execution due to poor management of the project front-end; iii) client confusion between collaboration and intervention to manage projects which reduces the room for flexible responses among suppliers.

The lack of a common professional language across functions within the supply chain and across the organization increased the complexity of creating a collaborative environment internally and externally. Shared understanding of each other's' perceptions may create the foundation for more effective and efficient collaboration, knowledge exchange and application between the client and supply chain. The systems thinking was therefore absent to support systems application in general and for KM.

5 Conclusion

Large-scale infrastructure client organizations with their supply chains generate a great deal of tacit project knowledge outside the client and main contractor organizational boundaries. At the same time, projects are not enabled to have a memory, thus systems and procedures are necessary to link projects at a programme level to support a culture of knowledge retention, validation and sharing. This renders SD of particular importance for supporting development of robust systems and processes to accommodate KM. SD can help clarify the role of programme management and design the system to accommodate KM. The ability to effectively manage the two concepts in consistent may provide an end-to-end process understanding of capability development in modern organizations. The goal of this study is to understand how SD is addressed by the main client organization and its supply chain at a programme level into one functional capability, KM, to capitalize on knowledge from projects.

The findings of this research demonstrate that programme management and the strategic project front-end on the client side constrained KM in the supply chain. Although there were commonly held perceptions about the importance of knowledge sharing in collaborative relationships of trust and robust governance, both the client programme and the supply chain members lacked coherent systems and procedures for developing management capabilities at a programme level. The suppliers had an extremely defensive culture in the challenging context of infrastructure provision, client actions and market drivers. The management of a public client firm, who is constrained by the regulatory, government and public policy environment, is not always able to respond to the problem situation in a prompt and efficient manner.

Senior management in the client organization and across supply chain failed to understand the transformational KM benefits for complex projects. There was a lack of investment in programme management capabilities. Besides, the culture was transactional and very defensive with a focus on risk around time and cost control. As a result, lessons from projects were assimilated and transferred on an ad hoc basis, relying upon individuals taking responsible action. Investment and leadership was absent both on the client side and in the supply chain.

The theoretical contribution of this research is the development of the conceptual link between SD and KM **for board level decision making and around investment and systems and implementation at the operational level.** There are also a number of implications for future practice. The findings of this research demonstrated that the senior management needs to develop a holistic approach to KM implementation with SD. There is a need for a strategic approach to managing learning from and between projects, rather than the tactical rapid configuration of inputs at the start of project execution by the supply chain. KM needs to be viewed as a programme management capability. It needs investment, leadership and robust human resource management processes (Figure 1).

There should be a lifecycle approach to learning from projects. Captured and validated knowledge from projects should be built into mainstream functions and activities. Also more flexibility on a management level can improve decision-making processes in the client firm and improve collaboration with the supply chain. The process of collaborative learning and problem solving should define and assess changes in organizational systems and practices.

KM should be viewed as a process, rather than a tool or a static resource, to make knowledge sharing an integral part of the organizational work culture. Organisational culture has limitations but SD can develop forum, such as CoPs, to help overcome some of the

To conclude, this research was conducted during execution stage yet the nature of effective KM cannot be confined to programme or project execution. The front- and back-ends have to be taken into account and the processes for implementing effective KM also reside above the programme level in the organisation. **This limitation also provides an opportunity for further research and improved practice.**

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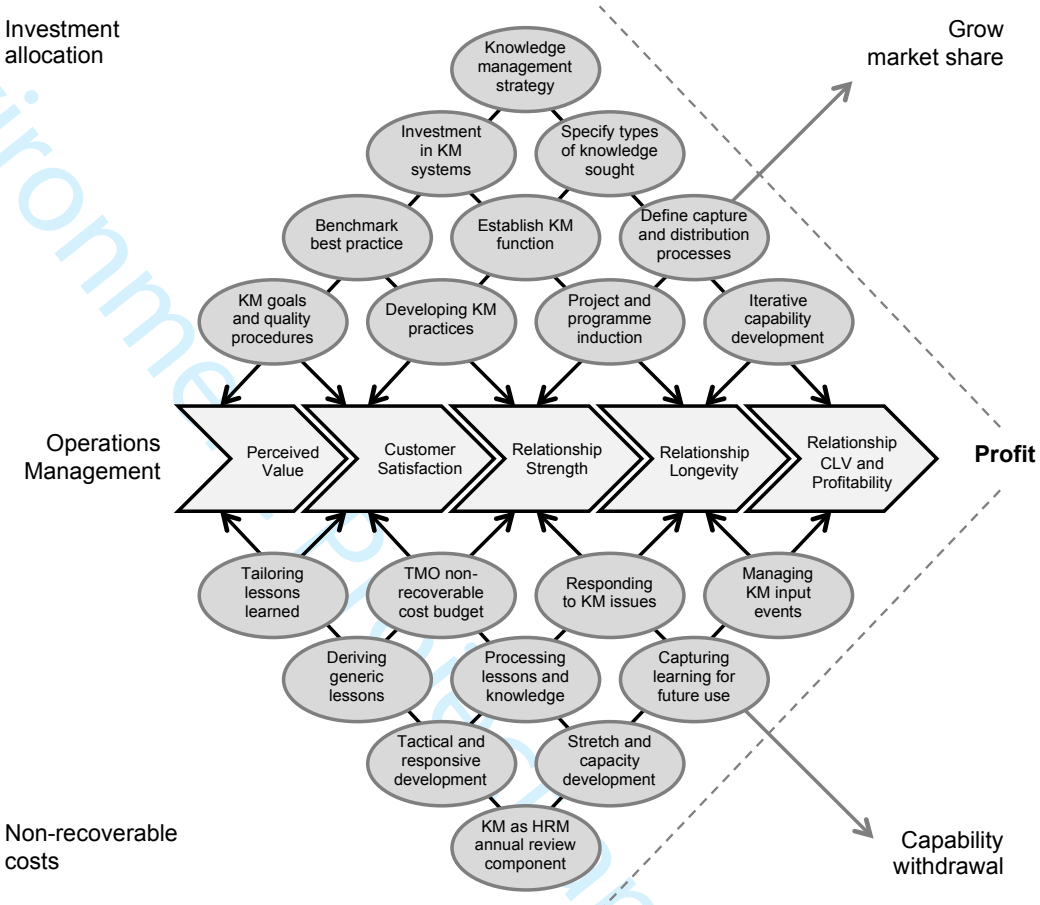

Source: adapted and developed from Smyth, 2015
(CLV - Customer Lifetime Value; TMO - a Temporary Multi-Organizational team)

Figure 1. Service Design and Programme Capability for Knowledge Management

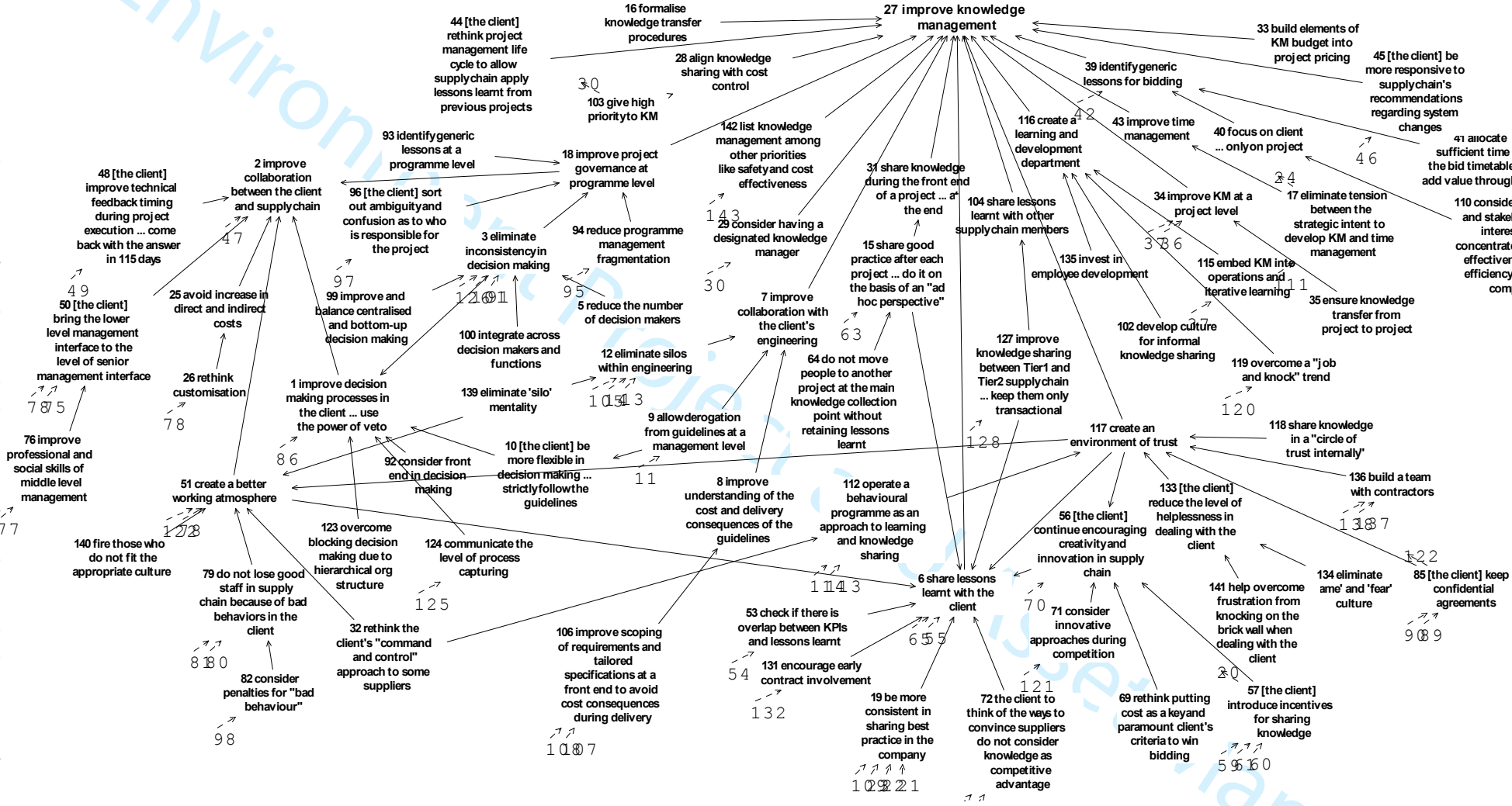

Figure 2: Cognitive map of interviews with client supply chain (*dotted lines represent the links to hidden nodes*)

Firm Alias	**Primary Activities**	**Divisions Interviewed**	**Interview Respondents**
GloCo	Consultant	Division for an Infrastructure Sector	Director of the Division; Systems Practice Manager
WayCo	Consultant and Specialist Subcontracting	-	Managing Director; Access Service Manager
BudCo	Construction, Engineering and Asset Management	Construction and Engineering	Head of Sector Operations; Director of Business Development; Director of Bid Management; Compliance and Operations Manager; Project Director; Supply Chain Manager; Materials Manager
RhoCo	Specialist Engineering & Electronics	Engineering Subcontractor and Contractor	Director of the Division; Head of Business Development; Project Director; Project Manager; Bid Manager; Head of Commercial; Business Improvement Manager
ElecCo	Specialist Engineering & Electronics	Engineering Subcontractor and Contractor	Head of Business Development
Entco	Institutional Provider and Contractor	-	Head of Stakeholder Management

Table 1: Schedule of case study contractors and personnel

Rank	Key Strategic Objectives	Reference on the map (Fig. 1)
1.	Share lessons learnt with the client	6
2.	Create a better working atmosphere	51
3.	Create an environment of trust	117
4.	Improve project governance at programme level	18
5.	[The client] continue encouraging innovation in supply chain	56
6.	Improve collaboration with the client's engineering	7
7.	Improve KM on a project level	34
8.	Identify generic lessons for bidding	39
9.	Be more consistent in sharing best practice in the company	19
10.	Improve decision making processes in the client rather than use the power of veto	1

Table 2: Key Strategic Options in Descending Order

Rank	Key Potential Options	Reference on the map (Fig. 1)
1.	Eliminate inconsistency in decision making	3
2.	Allow derogation from guidelines at a management level	9
3.	Eliminate 'silo' mentality	139
4.	Rethink the client's 'command and control' approach to some suppliers	32
5.	[The client] keeps confidential agreements	85
6.	Be strategically more proactive especially at the front end	78
7.	[The client] introduces incentives for sharing knowledge	57
8.	Make knowledge from site operations across projects more explicit	37
9.	Share good practice after each project rather than do it on the basis of an 'ad hoc perspective'	15
10.	Improve knowledge sharing between Tier1 and Tier2 supply chain rather than keep them only transactional	127

Table 3: The Most Influential Options in Descending Order