Knowledge management as an enabler of sustainable innovation across supply chain in the construction industry

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Abstract: This paper explores the ways innovation becomes enabled through knowledge sharing which has important implications for establishing and sustaining the culture of innovative thinking in project-based firms. To date, much research has focused solely on knowledge management or innovation management per se, with very scarce attempts to examine the connectivity between the two disciplines and their implications for research and practice. We have conducted 30 interviews with those practitioners whose roles are most relevant in this connection in the settings of UK project-based construction firms; and used thematic analysis and cognitive mapping technique to analyse the interview data. The data demonstrate a strong emphasis on establishing and sustaining a culture of innovative thinking and learning; creating an environment in project-based firms where people are less risk averse and are more collaborative.

Keywords: Culture; enables, knowledge management; innovation management; innovative thinking; project-based firms; sustaining innovation culture.

1 Introduction

The ability to innovate depends largely on the way in which an organisation uses and exploits the knowledge and expertise of its employees (Anumba et al., 2005; Newell et al., 2009). Nowadays, companies have realised that their competitiveness depends on how fast knowledge and innovations flow through the organisation. The importance of knowledge as an ultimate competitive advantage for project-based organisations has been increasingly addressed by the academic literature (Carrillo, et al., 2000; Gann and Salter, 2000; Maqsood and Finegan, 2009). In project-based environments this includes facilitating knowledge transfer at the program and project levels (Duryan and Smyth, 2018). However, there is a lack of empirical research into knowledge management (KM) and its impact on innovation, especially in project-based industries such as construction (Anumba et al., 2005; Bossink, 2018).

KM is a relatively new concept for the construction industry, which has a fundamental need to capitalize on the knowledge of employees who constantly move from one project to another and work with different organisations across supply chains (Carrillo et al., 2000). The potential of KM is not yet fully recognised as an enabler to sustain innovation in project-based firms (PBFs). Much of the tacit knowledge in the industry resides in the heads of individuals and is mainly transferred through informal channels. In this paper we emphasise this and also demonstrate the impact of connectivity between KM and innovation management (IM) for sustaining the culture of innovative thinking. The construction industry provides particularly rich settings to explore KM as an enabler of sustainable innovation across the supply chain. The industry is criticized for lack of innovation and challenges to share knowledge in comparisons to other industries (McKinsey Global Institute, 2017).

To this end, there is agreement among the scholars that construction firms should make performance improvement as one of the project goals (Jashapara 2011; Love et al., 2005). Performance improvement is, in turn, depends on improving KM and IM best practices. The construction management literature emphasises the importance of innovation for organisational performance, but there is a lack of research linking innovation, learning and KM, especially in a project-based context (Maqsood and Finegan, 2009). KM with its tools and techniques can be viewed as a solution. This paper aims at studying the perceptions of professionals working in construction industry on the role of KM as an enabler of innovation.

2 Literature Review

2.1 Knowledge management

2.1.1 Tacit and explicit knowledge

Nonaka and Takeuchi (1995, p. 58) define knowledge as "a meaningful set of information". They emphasise the importance of continuous creation and application of knowledge for the organisations to foster innovation. Knowledge is a key resource for innovation in organisations (Lin et al., 2013). In practical sense, knowledge can be defined as "actionable information" (Jashapara, 2011).

Based on the work of Polanyi (1962, 1967), there are two dimensions of knowledge in organisations: tacit and explicit. The notion of tacit knowledge was first coined by Polanyi (1962) as very personal, difficult to codify or document, and is often the result of organisational or individual experience. The main issue with tacit knowledge is that not only the receiver may misinterpret what the sender is trying to convey, but also the sender may be unable to fully articulate the true or full nature of the information s/he is disclosing because "we know more than we can tell" (Polanyi, 1962, p.4). In essence, tacit knowledge becomes embedded within an organisation over period of time and it can be difficult to transform it into useable explicit form. The explicit dimension of knowledge can be codified, stored and communicated in formalised forms (e.g. documents, processes, frameworks, databases). According to Polanyi (1967) knowledge exists along a continuum between tacit knowledge and explicit knowledge.

Both tacit and explicit forms are crucial for better performance as they allow knowledge to be stored from individuals and teams in one role or project and be accessed and reused by those in other parts of the business. An appropriate cultural environment can enable learning in project-based firms, leading to continuous improvement of the ability of the projects to meet business goals (De Long and Fahey, 2000; Witherspoon et al., 2013). There is a growing acceptance in project-based industries that knowledge is a key resource that gives market leverage and contributes to organisaional innovation (Nonaka and Takeuchi, 1995; Anumba et al., 2000).

2.1.2 Knowledge Management and Sharing

According to Ruggles' (1998) KM is a newly emerging, interdisciplinary business model that deals with all aspects of knowledge within the context of the firm, including innovation. He also emphasizes the role of organisational culture and practices in managing knowledge in firms. In order to ensure flexibility in reaction to continuously changing environment and to support continuous innovation, the firms need to learn how to leverage their knowledge assets (Newell et al., 2009). Innovations that are based on knowledge of employees are unique and so valuable to the organisation (Train et al., 2006).

The relationship between organisational knowledge and competitive advantage is moderated by the company's ability to integrate and apply knowledge (Bij et al., 2003). Creating an atmosphere of thinking, learning and communicating with the employees improves organisational knowledge repositories, and so the organisation's ability to develop existing knowledge, innovate and sustain innovations. It is very difficult to transform tacit knowledge that is intangible and mainly resides in minds of employees and organisational routines (Polyani, 1962). Effective verbal and written communication is fundamental to effective knowledge sharing (Davenport and Prusak, 1998). The main challenge for any organisation, however, is cultivation of a knowledge sharing culture.

2.2 Innovation management

The most commonly accepted definition of innovation is the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order (Van de Ven, 1986; Van de Ven et al., 2008). In this paper we define innovation as a new product, process or service that has a step change and creates value, e.g. economic value, environmental value, societal value etc. (Prahalad and Ramaswamy, 2003). It may be new to a firm but not necessarily new to the world. Innovation also entails the application of knowledge to new tasks and situations in order to develop new products, processes and services, and is a prime site for knowledge work (Du Plessis, 2007; Newell et al., 2009). IM is often defined as the embodiment and synthesis of knowledge in original, relevant and valued new products, processes or services (Barbaroux et al., 2016). According to Van de Ven (2017: 39):

"Managers and entrepreneurs can increase their odds of success by developing and practicing skills in learning, leading, relating, and cycling through the innovation journey."

Van de Ven calls for further process studies of how innovation journey unfolds from concept to development and implementation in different organisational settings. IM best practices and sustaining innovations have important implications for performance improvement at the level of the firm and industry as a whole. Performance of the construction industry can be improved through innovative initiatives in project delivery methods and through collaborative learning and joint risk management and partnering (Maqsood and Finegan, 2009).

2.3 The culture of learning and innovative thinking

Cultivating an organisational culture that encourages knowledge sharing has been identified as one of the most important factors contributing to success of KM and IM initiatives (Davenport and Prusak, 1998; De Long and Fahey, 2000; Ruggles, 1998). Organisational culture is considered as 'shared system of values and beliefs which become manifest in the behaviour and actions of organisational members (Hartmann, 2006: 569). An organisations culture will either promote learning and innovation, or will hinder it through stimulating defensive tendencies or individualistic behaviour among the workforce (Delong and Fahey, 2002).

One of the barriers to learning and knowledge sharing is the broad scope of large infrastructure projects that requires input from different organisations that are more concerned with pursuing their own interests rather than cultivating a culture of knowledge sharing (Train et al., 2006). Another barrier to effective KM and IM in large construction organisations is lack of senior management support (Carillo, 2013; Duryan and Smyth, 2019). A culture of innovation, learning and knowledge exchange is one where people are encouraged to work together, to collaborate and share, and be rewarded for doing so. There is a tendency in organisations to rely on the collection of data and IT depositories. IT systems and software platforms can support knowledge sharing and application, however merely establishing a KM and IM system will not automatically generate high engagement levels, a learning environment or lead to greater understanding. Organisations need to focus on human systems, where knowledge resides (Churchman, 1972; Davison and Blackman, 2005).

Following a human-oriented approach to KM and IM, we need to pay more attention to joint experience and interaction in social networks (Newell et al., 2006). Lave and Wenger (1991) followed a "social" view of learning and developed the concept of communities of practice, where more experienced members can share their tacit knowledge with less experienced colleagues. Communities of practice can become risk-free loosely coupled operating systems that can encourage organisational learning and innovation across different functional and project boundaries and can boost creativity and effective problem solving (Duryan and Smyth, 2018).

Dulami et al. (2005) found that, on average, a supportive culture or climate fosters innovation championing behaviour, from the project managers' perspectives. Hartmann (2006) develops a framework of IM consisting of the contextual variables. The instrumental variables are described as a

firm's culture, strategy, structure and processes which shape the innovation process. The internal environment is described through characteristics of members, units and organisation as a whole. The external environment is characterised by boundaries of an organisation (e.g. market conditions, economic factors, regulations). The empirical case study comprises of several examples of 'innovations', observations of processes, questionnaires, personal interviews and group discussions. Hartmann (2006) highlights complexity and dynamism of underpinning innovation. However, Hartman's research lacks any theoretical explanation and empirical insights into the complexity and multiplicity of views expressed by practising managers. Of further interest is the extent to which practitioners' interpretations are shaped by broader contexts and how they may change over time.

2.4 KM and IM in project-based environments

Knowledge sharing and learning serve as a basis for innovation in project-based firms (Artto and Kujala, 2008). They must continuously generate new knowledge and skills to retain their competitive advantage. There is agreement among the researchers that the construction industry is slow to learn and innovate (Hertogh et al., 2008; Flyvbjerg et al., 2002; Atkin, 1999; Barlow, 2000; Latham, 1994). Despite many research papers on KM and IM, there are still challenges in capturing and transferring knowledge to enable innovation in project-based firms (Love et al., 2005; Gann and Salter, 2000; Prencipe and Tell, 2001). The firms develop a tendency to 'reinvent the wheel' when faced with similar problems in existing and new projects (Gann and Salter, 2000). The question remains as to how firms in project-based industry can overcome some of the main obstacles to knowledge sharing in individual, cultural and technological domains to cultivate a culture of learning, knowledge sharing and innovation.

The construction industry is knowledge intensive, considering a high level of expert knowledge and know-how required to solve problems (Carrillo et al., 2004; Castro et al., 2012; Dave and Koskela, 2009). Complex and ill-defined problems require innovation and problem-solving skills drawing upon an organisational knowledge base. However, the fragmented, temporary and unique nature of the projects, pressure to complete and lack of incentive to improve project delivery make it difficult to form a culture of continuous knowledge flowing system. This is particularly critical considering that the processes and products of project-based firms are often more unique and design-driven (Gann and Salter, 2000; Hobday, 2000; Turner and Keegan, 2001) and the tacit form of knowledge is predominant due to the non-repetitive nature of much project work (Kelly et al., 2013; Szulanski, 2000). Besides, project team members in project-based firms, especially in the construction industry, bring expertise and innovative problem solving from other firms in order to deliver their own technical and social capabilities (e.g. Kelly et al., 2013).

At the end of each project, employees are often moved on to the next project before the analysis of lessons learned from past experiences. The pressure on employees to deliver the project on time and within the budget prevents them from making the necessary effort to meet and share the knowledge and experiences produced by previous projects (Love et al., 2005). As a result, knowledge and lessons learned are dispersed and not captured deleting the organisation's knowledge, which creates barriers to learning and reusing knowledge in future projects and often leads to poor performance (Gann and Salter, 2000; Castro et al., 2012; Train et al., 2006). Thus, there is more urgent need for project-based firms to integrate both project- and business processes to be able to capitalise on knowledge generated from projects and enhance the firm's innovative capabilities (Gann and Salter, 2000).

For the construction industry firms to capitalise on the 'know-how' acquired in previous and current projects they need to manage knowledge more holistically and purposefully, combining techniques from executive management, human resource management, KM and IM disciplines themselves (Davenport and Prusak, 1998). The organisations do not have to reinvent the wheel every time they start a new project if the lessons learnt are systematically incorporated into organisational standards and processes and are shared with all stakeholders involved in projects (Carrillo et al., 2004; Castro et al., 2012; Dave and Koskela, 2009).

Project-based firms are fundamentally about innovation and learning, whether the projects these firms deliver are about setting out to advance technology, or whether they seek to combine existing technologies is a novel way to meet the client's business case (Davies *et al.*, 2009; Davies *et al.*, 2017). Collective practice, learning and innovating are different facets of each other. Innovations can only be done collaboratively across client and supplier firms and people there within, and orchestrating such collaboration is one of the great challenges of project organising (Winch, 2014). It is hence critical to understand how project-based firms build and enhance their KM and IM capabilities, as well as how they establish and sustain a culture of learning and innovative thinking.

4 Methodology

We followed the approach adopted by Newell et al. (2009) drawing mainly on research on innovation – central to knowledge work. Thirty semi-structured interviews were conducted in order to explore managers' perceptions of innovation. The interviewees were practitioners whose roles are most relevant in the connection between innovation and knowledge (e.g. innovation knowledge managers, R&D managers, innovation managers, business improvement managers and others in senior positions) in the settings of UK construction contracting (project-based) firms. Examples of interview questions were formulated as: "What are the factors that shape the innovation process?", "When is it evident that innovation is recognised in an organisation?", "To what extent do individuals play a role in shaping the context within which innovation can take place?", "Do past experiences influence present and future innovations?", "Do you think it is increasingly important that an organisation has a culture of innovation?".

The interviews were audio-taped and then transcribed. The analysis commenced with a detailed reading of the transcripts several times over, noticing and looking for patterns of shared meaning. The analysis of the interview transcripts involved coding the textual material, identifying one or more passages of text that, in some sense, exemplify the same theoretical idea. The codes cut across interviews and thus represent recurring themes. The identified themes were cross-referenced across the interviews. The interview data were consequently analysed using the cognitive mapping technique. Cognitive map (CM) is the term used to refer to one's internal representation of the experienced world (Eden and Ackermann, 1998). It is a problem structuring method of the SODA (Strategic Options Development and Analysis) approach that has been developed through 'JOURNEY Making' (Jointly Understanding Reflecting and Negotiating strategy) (Eden and Ackermann, 1998). The idea of CM is based on Kelly's (1995) personal construct theory that aims at understanding of how people perceive their world by seeking to manage and control it (Eden, 2004).

CM is a structured, two-dimensional directed graph that represents the issues from the perspectives of interviewees and visually demonstrates why a situation is problematic and what can (or cannot) be done about it (Eden, 2004). The links between the nodes demonstrate the implication (or causal) links among them and allow exploration of detailed and holistic properties (Eden and Ackermann, 1998). The objective of the analysis of the maps is to highlight the most important fields of concern from the perspectives of the key stakeholders. The content of a map can provide rich insights into the meaning of specific concepts. The technique helps mapping people's tacit knowledge about a certain problem without reducing the complexity. It allows seeing how the concepts mentioned by the participants are interrelated.

5 Discussion and Analysis

The heads of a map, the concepts represented by the nodes that have only arrows going inside, demonstrate the goals expressed in terms of final ends or effects. The concept 'improve organisational performance' is a head of the merged cognitive map, which means that from the interviewees' perspectives, enhanced capabilities in KM and IM will lead to a better performance (Figure 1).

Domain (Table 1) and centrality (Table 2) analyses were used to identify the key issues in the models. Density of the direct links around the concepts helps in identifying best elaborated ones. The nodes

with complex domain (high density) are considered to be the potential key issues from the perspectives of the interviewees (Eden, 2004). They can become the subjects for further examination.

The top 10 concepts for the merged map in descending order of value:

Table 1

	DOMAIN ANALYSIS	
1.	[Node 9] establish and sustain a culture of innovative thinking…1 drive innovation through "super-heroes"	17 links around
2.	[Node 1] enable innovation in construction industry	16 links around
3.	[Node 16] share knowledge and experience	11 links around
4.	[Node 2] improve knowledge management in construction industry	10 links around
5.	[Node 21] cultivate a culture of learning	
6.	[Node 42] create a collaborative working environment	
7.	[Node 33] choose clients who have the same mindset regarding innovation	8 links around
8.	[Node 65] capture knowledge	
9.	[Node 37] create environment where people are less risk averse	7 links around
10.	[Node 108] design innovation strategy	6 links around
11.	[Node 14] consider multifacetedness of organisational innovation	5 links around
12.	[Node 30] ensure support from leadership	

By analysing only the immediate domain of the concept by itself, we do not consider its wider context; hence, we need to conduct centrality analysis. Centrality analysis (Table 2) extends the domain analysis by considering both, direct and indirect links. It reflects the downstream effect and allows a more accurate view of key issues than domain analysis (Ackermann and Eden, 2010). Centrality analysis measures the complexity of the concept's implication chain, considering that the greater the complexity, the more central is the concept. Concepts with the highest centrality scores usually strengthen the ideas expressed by concepts with the highest domain score.

Table 2

	CENTRALITY ANALYSIS	
1.	[Node 1] enable innovation in construction industry	50 from 103 concepts*
2.	[Node 9] establish and sustain a culture of innovative thinking ... drive innovation through "super-heroes"	49 from 97 concepts.
3.	[Node 21] cultivate a culture of learning	42 from 87 concepts.

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1 "…'" – rather then

6

4.	[Node 2] improve knowledge management in construction industry	38 from 84 concepts.
5.	[Node 118] promote cultural 'openness' in teams	35 from 80 concepts.
6.	[Node 42] create a collaborative working environment	35 from 75 concepts.
7.	[Node 30] ensure support from leadership	34 from 78 concepts.
8.	[Node 14] consider multifacetedness of organisational innovation	33 from 76 concepts.
9.	[Node 16] share knowledge and experience	31 from 67 concepts.
10.	[Node 101] look back and reflect on what has been done to understand what was innovative	30 from 71 concepts.
11.	[Node 37] create environment where people are less risk averse	30 from 70 concepts.
12.	[Node 33] choose clients who have the same mindset regarding innovation	30 from 64 concepts.

* for the Node 1 cent score is 50 and the total number of concepts traversed is 103 (max band number is 7)

Some concepts that were characterised by the highest domain score also have the highest centrality score. If a concept appears in both analyses, it means that it is both 'locally and globally significant, confirming its position at the core of a potential key issue.' (Ackermann and Eden, 1998, p. 405). Those concepts represent strategic directions (Table 3) that, from perspectives of the interviewees, contribute to achievement of the goal, which is 'improve organisational performance' (Figure 1, node 22).

Table 3

	CONCEPT	DOMAIN	CENTRALITY
1.	[Node 1] enable innovation in construction industry	16	50
2.	[Node 9] establish and sustain a culture of innovative thinking ... drive innovation through "super-heroes"	17	49
3.	[Node 21] cultivate a culture of learning	10	42
4.	[Node 2] improve knowledge management in construction industry	10	38
5.	[Node 42] create a collaborative working environment	10	35
6.	[Node 14] consider multifacetedness of organisational innovation	8	33
7.	[Node 16] share knowledge and experience	11	31
8.	[Node 37] create environment where people are less risk averse	7	30

According to the interviews the emergent issues (or strategic directions), in descending order of importance, are: 1) 'enable innovation in the construction industry'; 2) 'establish and sustain a culture

of innovative thinking, rather than drive innovation through "super-heroes"', 3) 'cultivate a culture of learning', 4) 'improve knowledge management in the construction industry', 5) 'create a collaborative working environment', 6) 'consider multifacetedness of organisational innovation', 7) 'share knowledge and experience' and 8) 'create environment where people are less risk averse' (Table 3).

The findings demonstrate that there is a shared understanding on the significance of the impact of KM and IM on organisationsl performance (Table 3, nodes 1&2). There was consensus among respondents that improvement in KM (node 2), cultivation of a learning culture (node 21), knowledge sharing (16) and learning from failures (node 36) will help to enable innovation in the construction industry. PBFs need to integrate both project- and business processes to retain and apply knowledge generated from projects to enhance the firm's innovative capabilities (Gann and Salter, 2000).

Majority of respondents emphasised the importance of sharing knowledge and experience. One of the interviewees, a Group Innovation & Knowledge Manager of a large infrastructure firm mentioned that it is important to create an environment where people are encouraged to learn about good practice:

> "What is good practice here? What does it look like? How could we improve on that? What would we do differently? It is that mind-set. And because they [project members] are coming from different backgrounds, different experiences and different learning… they bring innovation into a way they think…
>
> …
>
> We actually learned from failures"

A high level of expert knowledge that comes from the different organisations that take part in construction projects makes construction a knowledge intensive industry that relies on professional knowledge or expertise relating to a specific technical or functional domain (Castro et al., 2012; Carrillo et al., 2004; Dave and Koskela, 2009). At the same time, the fragmented, temporary and unique nature of the projects creates obstacles for creating a culture of continuous knowledge flowing system. KM should be viewed as a process to make knowledge sharing "an integral part of the organisational work culture" (Duryan and Smyth, 2019, p. 132).

There was a shared agreement among the respondents on the need to establish a culture of learning (node 21) and encourage employees to share knowledge and experience (node 16). Some of the interviewees came up with recommendations to achieve that by creating an environment where people are less risk averse and more willing to share failures, especially considering that much of the learning comes from failure, which is inevitable in a complex world of projects. "This is precisely why learning from mistakes is so imperative" (Syed, 2015, p.58). From the perspectives of the interviewees in order to create the risk-free environment that will encourage constructive criticism and will facilitate learning from failures, a leadership support is essential (nodes 37 and 30). Support and encouragement from the leadership directly contributes to improvement of KM and IM.

One of the respondents mentioned that for the success of KM it is important to help leaders realise that lack of failures means that the organisation is too conservative (node 96) and is not flexible to constantly changing environments.

The lack of understanding the difference between data, information and KM is another issue raised by one of the respondents (node 98):

> "Sticking all your documents on your company website is not knowledge management. That is data storage with some headings. That is not the same thing… People believe they have knowledge, but they have information."

Capitalising on people's knowledge is crucial for the company's performance (Bij et al., 2003). There is a growing understanding in the industry that organisations need to focus on human systems to share knowledge that resides in human minds (Churchman, 1972; Davison and Blackman, 2005; Polanyi, 1962).

There was unanimous agreement amongst interviewees that organisational context shapes innovation (Table 3, node 9). The culture of innovative thinking needs to be cultivated and sustained, rather than be driven through 'super-heroes' (Table 3, node 9). The characteristics of organisational culture, including freedom and empowerment, were described by many interviewees as facilitators to 'innovative thinking'. Organisational culture was described as a supportive and helpful factor in enabling creative inspiration and the taking of steps towards innovative practices. The cultural issues and need to be addressed to build the capabilities at organisational and project levels (e.g. Davies and Brady, 2000; Principe and Tell, 2001).

The respondents mentioned that in order to establish the culture of innovative thinking, among other actions, it is important to create a collaborative working environment (Table 3, node 42), cultivate a culture of learning (Table 3, node 21), establishing R&D department (Figure 1, node 39), reduce control and encourage risk-taking (Figure 1, node 25) and celebrate innovation (node 129).

Many interviewees contended that many construction innovations originate from the supply chain (e.g. suppliers, manufacturers and sub-contractors). Those who shared this position argued that SMEs are more flexible and are more able to innovate than larger construction firms. Overall, there was an agreement between the interviewees that work environment shapes innovation (Figure 1, node 42). The respondents especially emphasised the importance of sharing knowledge with the client (node 44), engagement between suppliers and contractors at early project stages (node 64), aligning objectives among all involved parties and taking a more holistic approach to how processes are engaged with one another (node 78).

Figure 1

22 improve organisational performance

1 enable innovation in construction industry

2 improve knowledge management in construction industry

45 transfer innovation through knowledge management ... through personal relationships

18 create opportunities for employees to look for new ways of doing things

85 create a culture of continuous improvement

86 come up with KPIs for innovation

84 overcome time pressure

87 process KPIs

88 result KPIs

98 understand the difference between knowledge management and data management

105 avoid repeating the same costly mistakes

32 invest in knowledge management

20 help employees learn from their past experience

82 achieve a better organisational adoption to change

103 be prepared that not all innovations succeed

14 consider multifacetedness of organisational innovation

115 promote innovation across multiple-layered supply chain

114 link it to organisational strategy

99 beware that "sticking all your documents on your company website is not knowledge management"

48 retain knowledge when people retire

51 encourage junior members of staff to learn from potential retirees

104 distribute knowledge across the organisation

57 reward those who share knowledge

21 cultivate a culture of learning

26 capture what has been already done in the industry

83 learn that things may not work well

92 do not block innovation

116 allow time to innovate

66 capture innovation

61 establish long-term relationships with supply chain

108 design innovation strategy

50 avoid the risk of losing a huge amount of knowledge

65 capture knowledge

133 offer professional trainings

130 good idea can become an innovation

93 set up a performance-based or outcome-based specifications ... ask to deliver at cheaper costs

107 train innovation champions (safety environmental champion, sustainability and others)

31 invest in innovation

95 [main contractor] allow the companies to add value

79 check whether it was successful

30 ensure support from leadership

111 on culture

110 around technological solutions

67 learn about clients

132 make it a part of a daily job

16 share knowledge and experience

19 consider that people come from different backgrounds

117 allow time for knowledge exchange

36 learn from failures

101 look back and reflect on what has been done to understand what was innovative

121 at the site level

122 at the functional level

120 at the project level

15 innovation as a process

4 help them see the benefits of innovation

62 do not procure for one project only

28 understand challenges

70 ask for retrospective feedback from the client

43 learn from other industries

94 [main contractor] define the boundaries and give more freedom to achieve the best results

6 assess the impact of innovation

80 see if other people want to replicate your success

113 on capability

29 understand needs

68 capture procurement approach

38 share failures to encourage collective learning

12 create an environment where people are encouraged to learn about the good practice

91 overcome barriers put by traditional "we do not normally do it like that" thinking

33 choose clients who have the same mindset regarding innovation

17 innovation as an object and as a product

7 measure the process

109 around delivering efficiencies

72 learn from manufacturing industry

100 use case studies as examples

106 overcome 'not invented here' syndrome

118 promote cultural 'openness' in teams

9 establish and sustain a culture of innovative thinking ... drive innovation through "super-heroes"

41 align your cultural beliefs with the clients and across supply chain

35 employ the right sort of contract

5 measure the outcome

112 on collaboration

69 capture performance of construction process

96 help leaders understand that lack of failures means the organisation is too conservative

119 encourage cross-functional learning

37 create environment where people are less risk averse

25 reduce control to encourage risk-taking

126 avoid dealing with clients who want the cheapest possible building

3 introduce a new technique that was not experienced before

13 consider that every project design may have an element of innovation due to unique nature of projects

53 use IT systems to organise [virtual] communities of practice

102 encourage constructive criticism

52 make it easy to find professionals in different areas

42 create a collaborative working environment

44 share knowledge with the client

64 ensure early suppliers - contractors engagement

10 cultivate an innovative approach to business

11 there is no 'universal law for innovation'

73 avoid them blocking innovation because of procurement approach

8 check if there is a return on investment

125 acknowledge that construction is a high-risk industry

47 help professionals build their networks of relationships

78 a much more holistic understanding of the way in which processes are engaging with one another

123 overcome the barriers of a fragmented industry

129 celebrate innovation

24 recruit people with great experience

39 have your own R&D department

63 understand where the drivers for innovation are for the client

127 exercise control of the risk

134 measure the risks from the beginning

135 reward and encourage those who try to come up with new ideas

54 include networking in their annual reviews

124 ensure that all parties have common objective

81 organisational culture drives innovation

131 invest in R&D

77 have the right people at the table at the right time to make changes in a project

97 consider that there is a poor record of investment in R&D in the construction in the UK

90 should not necessarily be financial rewards

56 encourage people to create their personal profiles

55 include questions like "have you updated your personal profile?"

10

As a Property Services Director from an independent social business mentioned:

> "Work environment is really important because the culture of our organisation is very much about empowering people. My boss is the chief executive and his management is very much 'you can do what you want'. He does not interfere. That sort of empowers me to make a difference. That culture continues all the way up to our board. People in our board are 'pushers'; they are 'stretchers'; they are 'challengers'. That helps to push and drive an innovation. They are not asked for an innovation, but they are embraced. The whole culture if it works every way down then everyone will work towards the same goal."

Work atmosphere attributes, including empowerment and a freedom to pursue one's own interests, were described as incentives towards 'innovative thinking'. Organisational culture was viewed as a shared belief among each stakeholder that contributes to achieving organisational goals. The above argument was reinforced by the Design Manager from a civil engineering contractor firm who described the 'king sheet pilling' project as an innovation:

> "I regard myself not necessarily as being innovative, but certainly as a lateral thinker. And my line manager allowed me a freedom to pursue my ideas. I did not have day-to-day monitoring. If you are lucky to be in the culture of the organisation that is sort of hiring the individuals, allowing the individuals to pursue their own interest. You have to do your day jobs as well as pursuing your own interest. That is important for innovation to succeed."

A few interviewees expressed their views on innovation champions (Figure 1, node 107). They emphasized the importance of investing in training innovation champions on safety, environmental, sustainability and other key areas of the industry at different levels (site, functional and project). Of particular note is that the respondents often recognise other people as innovation champions, and not necessarily themselves. For example, the group innovation knowledge managers from a building contractor firm described a CEO as an innovation champion:

> "If people cannot 'innovate', then they would phone me and say: "This is not working". So, it is down to me then to work on those processes and change it and understand why the problem is. As a culture, you have got a prime person in the business as a "cultural leader" and a "champion". It goes to a chief executive board and our investors. Also it goes to people employed, down to their careers, down to their career development, training department. So, that is everyone's responsibility."

A significant percentage of interviewees contended that they worked in organisations which had a 'culture of innovation' and collaboration with the supply chain. This tendency was articulated especially clearly by the manager from a building contractor firm who emphasised that the firm had a sort of own identity that he and others were especially proud of:

> "In our DNA how we do stuff - to do things differently, to try and engage with whole supply chain, the whole design, the whole process to make sure that we deliver something that is innovative. We were proud of it; we have done it."

The above quotation demonstrates the perception of organisational identity as 'innovative' by the interviewee. Establishing mutual understanding and trust within supplier networks has long been a central concern for the management and success of co-learning (Orange et al., 1999) and effective supply chain management (Love et al., 2004).

As the map demonstrates, establishing long-term relations and aligning cultural beliefs with supply chain (nodes 41, 61) promotes innovation across multi-layered supply chain (node 115), which eventually contributes to enabling innovation in the construction industry (node 1).

6 Conclusions

In this paper we explored the ways innovation becomes enabled through knowledge sharing and its important implications for establishing and sustaining the culture of innovative thinking in project-based firms. The research findings demonstrate a lack of investment in managing knowledge and innovation, lack of leadership commitment and the over-reliance on individuals (knowledge champions) and teams to take responsibility for knowledge sharing. The research findings confirm that knowledge is central to innovation work. The project-based firms under the scrutiny are in their journeys of becoming 'learning' and 'innovative' organisations. We conclude that KM and IM might be seen as systems for improving organisational performance. KM helps project-based firms identify new, innovative knowledge internally and across its supply chain and incorporate it into the work practices. KM also enables innovation by suggesting processes that can help organisations to obtain, adjust and use external innovative knowledge. The project-based firms need more strategic approach to managing learning from and between projects. KM and IM should be viewed as programme management capabilities, which requires investment, robust processes and leadership support. Our research has contributed to the existing body of knowledge by effectively linking the disciplines of KM & learning and IM. It emphasises the importance of cultivating a culture of knowledge sharing and learning for enabling innovation in project-based environments.

Our research has important implications for practising managers. This research provides a foundation for project practitioners to critically reflect on their KM and knowledge sharing practices to cultivate a culture of learning and innovation. Considering the importance of KM and learning for innovation, the leadership of project-based firms should encourage risk-free culture to foster inter- and intra-project collaboration and learning from successes and failures. It is well-known that construction innovations mainly originate from the supply chain, thus collaborative learning across projects can facilitate also joint risk management, boost creativity and contribute to effective problem solving. For KM and IM

initiatives to be successful, they need to start by understanding and aligning the mental models of the senior managers.

Further research is needed to explore the culture of learning and innovative thinking in project-based firms. More attention is merit to the social networks of innovation and knowledge managers in the construction industry as a whole. The job role and professionalism of innovation knowledge managers needs further research.

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