Research on Construction Projects Integration Knowledge Management Model Based on Collaboration Theory and Non-linear Polya Processes

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Abstract: Each construction project is unique in terms of how specialist professionals manage knowledge, but traditional pattern of construction projects lead to the fragmentation of sharing knowledge. Therefore, integration knowledge management based on collaboration is very important in the construction projects which generate a large body of knowledge for sharing and reuse within construction organization and partners. In the paper, an Integration KM Model was present and the willingness for sharing knowledge among the construction project partners was enhanced by positive feedback in the model. Finally, the integration knowledge management based on collaboration was verified by the analysis of Non-linear Polya process.

Keywords: integration knowledge management, collaboration theory, Non-Linear Polya process

1 Introduction

It is widely observed that the society we live in has been gradually turning into a "knowledge society" (Drucker [1] 1968; Bell [2]1973; Toffler [3] 1990). Knowledge as a critical asset and a primary resource is widely recognized of a firm or organization's competitive advantage in today's fast growing industries (Armbrect et al.,[4] 2001;　Goh　[5]2002).

Construction project is an interdisciplinary and multi-agent behavior process. In the process, people continue to access and create knowledge and apply it to practical work to realize the value of knowledge. Most construction projects are unique and fast moving, so work organizations are rather dynamic as they must be restructured again and again with different designs and designers, management, materials, equipment, and crews (Oglesby et al.,[6]1989; Sauer et al.,[7]2001).

Traditional pattern of construction projects lead to the fragmentation which made the communication obstacle among all the partners in A/E/C（Architecture, Engineering, and Construction）stages. Construction project team members need specific knowledge during the project execution. Different forms of knowledge exist within and across individuals and teams in construction projects [8].

Construction companies and their personnel refer to carry out their project management tasks based upon their past experiences, rather than following a textbook approach, or established analytical approaches [9]. Therefore, partners of a construction project should enhance their connection and coordination; utilize advanced information technology and means of management.

The object of this paper is to develop an integration knowledge management model of construction projects which could pursue more collaborative relations with partners and enhance competitive advantage. We then attempt to analyze the model with Non-Linear Polya processes that are stable enough to testify the expansion of the collaboration with the integration knowledge management in construction project is a positive feedbacks process.

2 The Necessity of Developing Knowledge Management in Construction Project with Collaboration Theory

Some authors mentioned many knowledge management benefits to projects management. Kamara et al., [10], Love et al., [11] state that effective knowledge management can evidently produce innovation and reduce project time, improve quality and customer satisfaction.

The potential important of managing knowledge for competitive advantage in project environments has received a phenomenal amount of attention in recent years [12]. But there is little understanding of how construction projects actually create and manage knowledge dynamically. In this paper, all the partners of the construction project are viewed as a result of a dynamic cooperation organization which requires an integration knowledge management based on collaboration theory.

Nonaka et al. [13] state that knowledge creation is a continuous process of dynamic interactions between tacit and explicit knowledge in four modes of knowledge conversion and the evolving spiral movement of knowledge through the SECI (Socialization, Externalization,

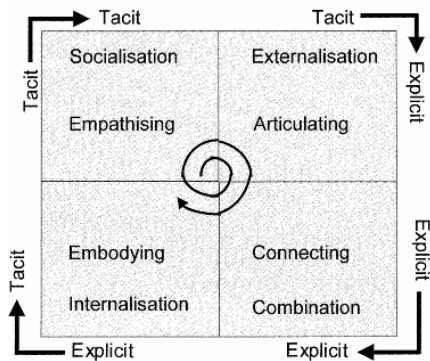Combination, and Internalization) process. Figure1 shows the SECI process model.

Figure 1. The SECI Process

In order to adapt the more complicated, dynamic and interactive construction projects, all partners should step from the internal knowledge management to an integration cross-organizational knowledge management for a strategic goal which aimed at optimization of the entire dynamic cooperation organization.

In SECI process model, when partners in the dynamic cooperation organization intend to socialize and externalize their tacit knowledge of projects the initial step embarking on collaborative knowledge management is to integrate their own knowledge management system. The adoption of collaboration tends to be evolutionary and the development of integration knowledge management should be separated into three stages, as shown in Figure 2: independent and distributed knowledge management, cross-organizational knowledge management and integration knowledge management based on collaboration.
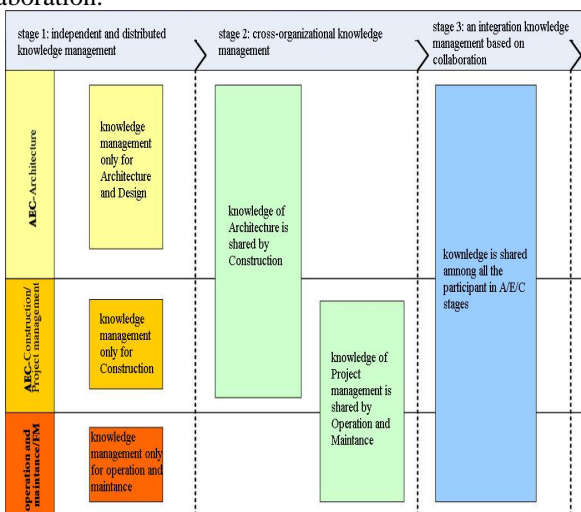

Figure 2.   The evolution towards integration knowledge management based on collaboration

Collaborative include communication、coordination and cooperation at the total life-cycle of construction project, just like stage 3 shown in the Figure 2. The potential benefits of effectively utilizing their knowledge of all the construction project team members has meant that construction companies should identify the need to implement an integration KM among all partners in the dynamic cooperation organization of construction project initiatives.

3 The Construction Project Integration Knowledge Management Model

Construction project management trends and realities have been the recognition that much higher levels of collaborative planning are needed between projects partners. The development of collaborative theory has totally changed the knowledge management, from inner organizational KM to extended cross-organizational integration KM for the dynamic cooperation organization of project partners. To summarize what we have analyzed above, a model for integration knowledge management based on collaboration is developed, as shown in Figure 3.
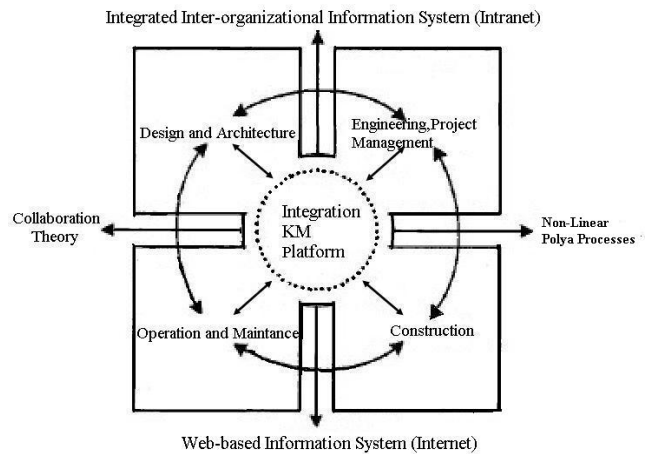

Figure 3.   Integration KM Model based on Collaboration

In integration knowledge management model, all the construction project partners will collaborate more closely, using technological tools to share knowledge and integrate their operations. Integration Knowledge Management involves a set of applications and technologies to achieve the knowledge management based on collaboration among all the partners of construction project.

As Fig.3 illustrates, in the model, Integrated Inter-organizational Information System are used as communication platform between all partners of A/E/C stages. Knowledge of A/E/C stages is saved on the Integration KM Platform which is built on the Integrated In-

ter-organizational Information System. All the partners of construction project hold the right to access the Integration KM Platform on which all the information and data are processed in a uniform format for avoiding the phenomenon of Data Island. Web-based Information System in the model provides an information channel which is named VPN (Virtual Private Network) for accessing Integration KM Platform from external system on Internet.

Therefore, the partners detain business goal congruence and are able to achieve an effective knowledge application velocity with a coordinate standard of data.

4 Analysis of Integration KM Model with Non-Linear Polya Processes

The movement of any system has two tendencies; one tends to be spontaneous unordered movement, and that is the ultimate reason why the system goes to disintegrate; the other tendency is the cooperation of the subsystems leading to coordination and harmony [14, 15]. Compared with the isolated KM in partners of construction project, the integration KM model has more attributes of positive feedbacks. Nonlinear Polya (NLP) processes have been mainly used to model positive feedbacks in economy [16]. The partners of construction project in the integration KM model are complicated nonlinear relationship. We suppose that there are N kinds of partners in construction project, and every time only one new partner will join the integration KM platform and be a member of the KM alliance for the dynamic cooperation organization on one's own initiative.

We consider a simple situation as follows:

1)

In this paper, we assume that every time only one new member will join the Integration KM Platform，except for the first time while N members joined .We use a vector $X_n = (X_n^1, X_n^2 ..., X_n^N)$ to denote knowledge management grade of the initial members on the integration KM platform when the member "N" is added at the nth time. The probability of the partner "i" will share knowledge and collaborate with the new member of the Integration KM Platform at the nth time is $q_n^i(X_n)$;

2)

We use a vector $b_1 = (b_1^1, b_1^2, ..., b_1^N)$ to denote the number of the activities of the initial members' knowledge sharing and transfer. Therefore, the total number of knowledge sharing and transfer activities is r ($r = \sum_{i=1}^N b_1^i$);

3)

At the nth time, we suppose

$$B_n^i(x) = \begin{cases} 1, & \text{When probability is } q_n^i(x) \\ 0, & \text{When probability is } 1 - q_n^i(x) \end{cases}$$

(i =1,…,N)

When the member "i" on the platform to share and transfer knowledge, the number of activities is a kind of recursive relation, as the equation (1) shown:

$$b_{n+1}^i = b_n^i + B_n^i(X_n) \quad i = 1, ..., N \tag{1}$$

So, the grade of number "i" on the Integration KM Platform will be a recursive relation, as shown in equation (2).

$$X_{n+1}^i = X_n^i - \frac{1}{r+n}[X_n^i - B_n^i(X_n)] \quad n=1, 2, ... \tag{2}$$

We can make a transform of equation (1), as shown in equation (3).

$$X_{n+1}^i = X_n^i - \frac{1}{r+n}[X_n^i - q_n^i(X_n)] + \frac{1}{r+n}m_n^i(X_n) \tag{3}$$

The define of $m_n^i(X_n)$ is

$$m_n^i(X_n) = B_n^i(X_n) - q_n^i(X_n)$$.

From the definition of $B_n^i(X_n)$, we know that the expectation of $m_n^i(X_n)$ is zero. So we can get the expectation of random process:

$$E\{X_{n+1}^i | X_n\} = X_n^i - \frac{1}{r+n}[X_n^i - q_n^i(X_n)]$$.

We can obtain another recursive equation (4) from equation (3).

$$X_{n+1}^i = X_n^i + \frac{1}{r+n}[q_1^i(X_n) - X_n^i] \quad i=1, 2, ...,N \tag{4}$$

Generally, $q_n^i(X_n)$ are nonlinear, and it is determined by the proportion of the contribution or relevant right of the partner on the integration KM platform. For the partner i (i=1, 2,…, N), there is an equation set composed of N equations. So we can use vectors to express, and obtain a NLP process, as equation (5):

$$X_{n+1} = X_n + \frac{1}{r+n}[q_n(X_n) - X_n] \tag{5};$$

4)

The value of $q_n(X_n)$ varies with n, and the integration KM in dynamic cooperation organization composed of construction project partners is a dynamic process which is affected by the value of $q_n(X_n)$-X_n. When the value of $q_n(X_n)$ equal X_n, the co-win intersection is steady and the NLP process converges to the co-win intersection.

Integration knowledge management based on collaboration is a kind of recursive process and is a positive feedbacks related to the density of the partners on the Integration KM Platform and the technology of Information. So during the construction project process of the implementation of collaborative knowledge management, we should fight for the benign circulation of positive feedbacks.

Scientific Research

5 Conclusions

One key factor for increasing the productivity of construction companies is skills development and innovation, gained by the construction project partners' experiences and knowledge, and sharing knowledge. In conclusion, the importance of knowledge and its management for the construction sector is apparent. Thus, this paper proposes an Integration KM model based on the collaboration theory and information technology. By analyzing this model with NPL process, we conclude that the support to knowledge management in A/E/C stages for collaboration is greatly enhanced.

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