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WEB-BASED CONSTRUCTION KNOWLEDGE MANAGEMENT PORTAL

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ABSTRACT: As a knowledge-based economy is emerging, knowledge management (KM) is being rapidly disseminated in both academic circles and the business world. Accordingly, how to effectively manage knowledge is vital to the survival and advance of a company, particularly in project-based industries such as construction. For these reasons, construction companies have adopted IT-based Knowledge management systems (KMS), which is the technology platform and infrastructure that an organization employs to support knowledge management. However, many construction companies have spent resources on developing a KMS that only focus on codification. Furthermore, small and medium-sized companies have limited resources to afford extensive investments. This research addresses the problems found in the current KMS and develops a web-based construction knowledge management portal (CKMP). To achieve these objectives, a case study is conducted and requirements for implementing KM are identified. Based on the identified requirements, this paper builds CKMP using Expert Index (EI), blog, ontology based knowledge retrieval, and wikiblog. The most important functionality of CKMP is their fundamentals to synchronize and support KM process. In order to validate the CKMP, a pilot test with actual users is conducted, and the usability of the system is compared with the current systems. This study is relevant to both the construction industry and academia, as it provides a means of enhancing the performance of KM.

Keywords: Knowledge Management, Construction Portal, Knowledge Management Process, Blog, Expert Index, Ontology, Wikiblog

1. INTRODUCTION

In today's emerging knowledge-based economy, knowledge management (KM) is being rapidly disseminated in both academic circles and the business world. Accordingly, how to effectively manage knowledge is vital to the survival and advance of a company, particularly in project-based industries such as construction. In this context, the importance of KM is emphasized in the construction industry due to the industry's unique nature. Construction projects are unique and are carried out by temporary allianced multidisciplinary teams. The knowledge gained and the lessons learned during the project execution are lost or dispersed at the end of the projects if not recorded or shared properly [1] [2] [3]. Therefore, effective KM is vital for construction companies to prevent such losses. Effective KM also has its positive impact on the construction company's performance at the corporate level [4]. Knowledge is a critical resource, not only for carrying out projects successfully, but also for choosing the right projects and preparing winning bids.

For these reasons, construction companies have adopted IT-based knowledge management systems (KMS), which are used as a technology platform and infrastructure to support knowledge management [5]. While IT does not address all of the issues of KM, it can support KM in various ways. Meanwhile, two types of strategies, which are codification and personalization, can be applied to developing KMS. Codification strategy relies upon the explicit knowledge and is more focused on the sharing of knowledge mainly through reutilization of existing knowledge. IT can contribute to this strategy by providing the means for storing the knowledge objects in databases and allowing for people to retrieve these objects without having to get in touch with the original creator [6]. The personalization strategy, on the other hand, relies on person to person contact to allow sharing experiences and knowledge directly between the organization's workers. This strategy facilitates a controlled approach to information retrieval by letting the employees collectively arrive at deeper insights by going back and forth on problems they need to solve [6].

However, the problem is that many construction companies have spent resources on developing KMS, only focusing on the codification strategy. This approach is more appropriate in organizations where products or services are provided or performed in exactly in the same manner over and over again. This is known as the primary reason for most construction KMS, not to have been widely used so far. It is important to understand that in construction KMS there needs to be emphasis on both

codification and personalization. Best practice is to utilize an approach which allows for a mix of both strategies. Furthermore, small and medium-sized construction companies (SMCs), which predominately comprise of the construction industry, have limited resources to afford extensive investments on developing KMS.

This research aims to address these challenging issues and develop a web-based construction knowledge management portal (CKMP) system. The proposed system targets SMCs users based on both the codification strategy and personalization strategy. To achieve these objectives, case studies are carried out to identify problems of the current KM, and then, the concepts and component methodologies of the CKMP are developed and they are justified according to the KM process. Finally, the CKMP system is implemented as part of the Web-based Distributed Lean Construction Information System (Lean Construction Research Center, LRC2) Project. In order to validate its applicability, field tests with actual users are conducted, and the outcome is compared with the current systems' performance. Then, it is concluded that CKMP would provide SMCs with a more efficient way to KM at acceptable expenses and provide academia with a means of enhancing the performance of KM in the web 2.0 or web 3.0 era.

2. CONSTSRUCTION KNOWLEDGE MANAGEMENT

KM has been defined as the identification, optimization, and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage [7]. It has also been defined as a systematic and organized attempt to use knowledge within an organization to transform its ability to store and use knowledge to improve performance [8]. Knowledge and expertise existing in organizations generate more value when they are rapidly applied, emphasizing the role of expertise transfer. Indeed, knowledge is of limited value if it is not shared. As a result, companies are beginning to implement information systems designed specifically to facilitate the generation, integration, sharing and dissemination of organizational knowledge [9] [10] [11]. Such systems are referred to as knowledge management system (KMS). KMS support and enhance the organizational processes of KM.

2.1 Knowledge Management in Construction

Although KM is not a new concept, it is still an emerging topic in the construction industry [1]. The construction industry is a knowledge-based industry and managing knowledge is important because its characteristics. The construction industry involves the diverse areas of a project where many stakeholders are interacting with different cognitive experiences and skills. Here, construction companies that heavily rely on human networks, such as experts and skilled worker, find it difficult to manage and preserve mainly knowledge intensive resources. It makes KM particularly attractive in construction industry. The ability to manage the knowledge generated from the projects not only can help to prevent the 'reinvention of the wheel' and the repetition of similar mistakes, but also serves as the basis for innovation, overall improvement, and sustaining competitive advantage [12]. In other words, effective KM can reduce construction project time and cost, improve quality, and provide a major source of competitive advantage for the construction organization [13].

2.2 Requirements for Construction KMS

Despite of potential benefits of KM in construction, construction companies face barriers to implementing KM. These barriers have been addressed by many researchers [14] [15]. According to Carrillo et al. [16], the major barriers to construction KM are the lack of standard processes, insufficient time, organizational culture, insufficient funding, employee resistance, and poor information technology infrastructure.

These barriers are recognized as more serious issues in SMCs. In order to further examine KM barriers in SMCs and identify the causes of barriers, case studies have been conducted. The case studies found barriers to KM implementation as follows. First, insufficient funding is considered as the most important barrier. Financially less capable SMCs have limited resources to afford extensive investment and maintenance. Second, inconvenient interface are also seen as the barrier. The current KMS operates within an organization and runs separately with other information systems such as PMIS (Project Management Information System) and ERP (Enterprise Resource Planning). Third, knowledge workers rarely participate in a KMS voluntarily. Companies promote KM activities by providing incentives, but it's not the fundamental solution for the problem. Fourth, expert master or expert groups are assigned too much works. In the current KMS, experts must evaluate and store knowledge in bulk. Furthermore, SMCs do not have capacity to organize an expert group. Sixth, knowledge workers rarely register knowledge for KMS. Knowledge workers are concerned about losing their intellectual property. Finally, knowledge worker confronts difficulty in creating a search query that includes their knowledge requirements. The characteristics of construction projects and the domain-specific content and context of knowledge are not properly captured and reflected in the knowledge retrieval process. Based on these barriers, requirements for implementing KMS are derived as follows: 1) motivating knowledge worker to use KMS, 2) Solving the problems of intellectual property, 3) Making use of collective intelligence, 4) Delivering the right knowledge to the right person at the right time, 5) Reducing cost of developing and operating KMS; and 6) Linking up existing information system with KMS.

3. FUNDAMENTAL MODEL OF CONSTRUCTION KNMOWLEDGE MANAGEMENT PORTAL (CKMP)

Considering to conditions of SMCs, the technology of setting up KMS for them should be different from that

used for large ones. Application Service Provider (ASP) is suitable for SMCs, which does not have enough resources to maintain an in-house IT department and/or a sophisticated networking infrastructure [17]. ASP is provided by professional information technology (IT) solution companies. It requires less technical, financial, and human resources to develop and operate it [18]. Along with ASP, portal provides a more efficient way to manage construction information and support more flexible collaboration, both among company's own units and other project participants. According to Gartner Group [19], portal enables e-business by providing a unified application access, information management and knowledge management both within enterprises, and between enterprises and their trading partners, channel partner and customers. Therefore, KMS that is linked with portal enables construction participants to utilize a higher level of integrated information.

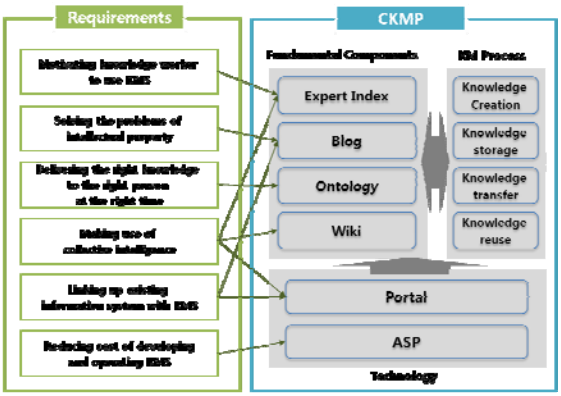

Figure. 1 Fundamental Model of CKMP

Based on the identified construction KM requirements, Construction Knowledge Management Portal (CKMP) for SMCs is proposed as shown in Figure 1. Fundamental components for developing CKMP are Expert Index (EI), blog, ontology and wikiblog. The most important functionality of CKMP is their ability to synchronize and support KM process. Based on the KM processes, knowledge creation, store, transfer, and reuse, the followings sections will present CKMP can functions and support each KM process.

3.1 Knowledge Creation Process

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge [20]. Knowledge creation is an activity enabled by user's willing as well as technology. Under the current KMS, knowledge creation process lies in the lack of user's motivation for KM activities. This is particularly problematic when the individual benefits to employees are not properly communicated or understood. Furthermore, how to filter and accurately evaluate created knowledge are significant challenges. When inappropriate knowledge results in accidents or impacts on productivity negatively, user's motivation eventually can be reduced.

This research adopted Expert Index (EI). EI is the level of specialty that users achieve in a certain field when engaging in a knowledge activity [21]. When users register their knowledge in a specific category, they receive EI point. Every user could receive points according to the knowledge activity performed. This approach is similar to the mileage point of knowledge compensation. However, EI is directly applied to knowledge evaluation and affects over the length and breadth of KMS. The overall model of KM activities using EI is illustrated in Figure 2.

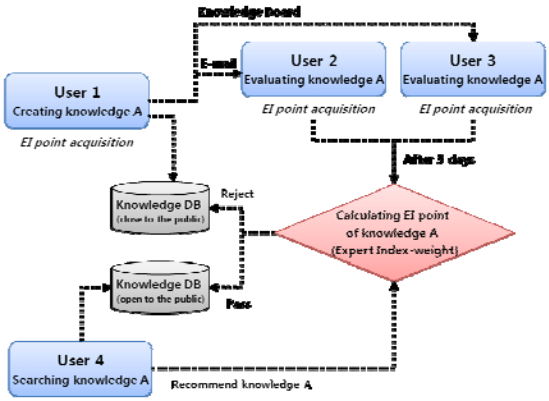

Figure. 2 KM activities using expert index [21]

Introduction of EI enables to decrease evaluation workload because of many experts on each category. Then, this links to reduction in evaluation time and better sincerity of evaluation. Consequently, this leads to enhancement of KMS usability and user's satisfaction on KMS. Besides, there is the other psychological factor influencing motivation. Use of KMS leads to bigger gap of EI between high users and low users, and this brings about psychological competitiveness. This sense of rivalry leads to anticipation for high EI, in the end, this encourages the motivation.

3.2 Knowledge Storage Process

The organization should classify the filtered knowledge and add it to individual memory and organizational memory. However, in current KMS, both memories are not standardized and do not conform to knowledge registration standards regarding storing at a knowledge map depository. Furthermore, as stated above, users are unwilling to register and store knowledge because they feel concern about losing their intellectual property.

This research adopts blogs based at the personal, project and corporate level as knowledge repositories as illustrated in figure 3. Adopting blogs to construction KM has already been addressed conceptually by Mills [22]. A blog is a knowledge warehouse as well as a communication and collaboration tool for project members. From an individual perspective, blog plays a role of managing personal content. Employees can maintain their own topic of blog that allows adding commentaries to the contents. A repository of knowledge blog can link project members with documents and knowledge needed to read about best practices and

important parts of specification. Furthermore, construction companies heavily rely on knowledge and skills acquired and developed through project processes. It is important to maintain knowledge storage and human-network, to be aware of where knowledge is and who retains knowledge.

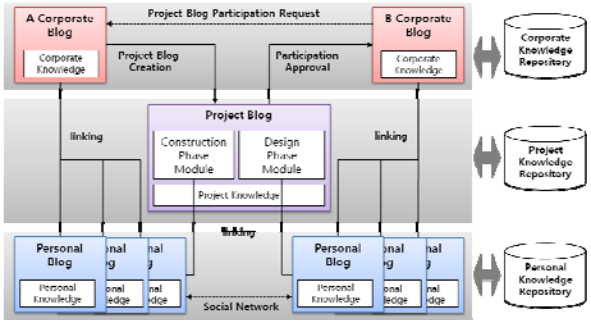

Figure. 3 Relationships among blogs as knowledge repository

3.3 Knowledge Transfer Process

Knowledge needs to be transferred and shared throughout the organization, before it can be exploited at the organizational level [24]. Knowledge retrieval is a way of transferring knowledge to where it is needed. Knowledge retrieval serves a role in transferring the captured and validated knowledge to an applicable situation or problem. However, current knowledge retrieval practice in construction projects occur due to that the characteristic of construction projects and the domain-specific content and context of knowledge are not properly captured and reflected in the knowledge retrieval process.

To enhance the knowledge retrieval in construction project by delivering the right knowledge to the right person at the right time, this research applies construction ontology to the retrieval process. Among many different definitions of ontology, the most prevalent and frequently cited is perhaps the definition, an explicit specification of a shared conceptualization. As ontology is specification of common vocabulary in which shared knowledge may be represented, it is used as the link between knowledge from previous projects and the requirements made in the current project. The link is formed in the aspect of context and context of knowledge.

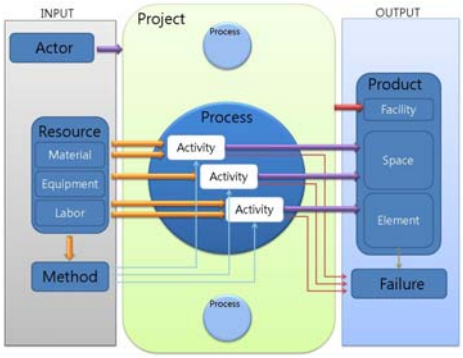

Figure. 4 Main Concepts of Construction Ontology [25]

The seven main concepts proposed by Lee [25] that compose the top-level of the construction ontology are ‘project’, ‘actor’, ‘process’, ‘resource’, ‘product’, ‘method’, and ‘failure’. As illustrated in Figure 4, the content of knowledge can be represented by the concepts of ‘process’, ‘resource’, ‘product’, ‘method’, and ‘failure’ and the context can be represented by the concepts of ‘project’ and ‘actor’.

Applying ontology in the retrieval process can increase precision rate by preventing retrieval of irrelevant knowledge in cases when same term is used in different meaning. Also, the precision rate can be increased by retrieving relevant knowledge that uses different vocabulary but has similar meaning with search word. Moreover, establishing a synonym relationship between concepts (terms) neglecting of relevant knowledge can be reduced and increase the recall rate.

3.4 Knowledge Reuse Process

An important aspect of the KMS is that the source of competitive advantage resides in the reuse of the knowledge rather than in the knowledge itself [9]. The organization’s knowledge worker should use the retrieved knowledge in performance tasks such as solving problems, making decisions, researching ideas, and learning. The reuse of knowledge is the most essential task of KM. IT can enhance knowledge reuse by facilitating the capture, updating, and accessibility of organizational directives. However, as increasing the speed of knowledge changes, organizations have difficulties in accessing and evaluating of their knowledge by only expert group. Furthermore, by increasing the size of individuals’ social networks and by increasing the amount of organizational memory available, IT is required for the speed of knowledge integration and application by codifying and automating organizational routines. Coping with knowledge growth, this research applies wiki concepts to blog, known as wikiblog.

Wikiblog model is combination of the two internet concept of a blog and wiki. As with blogs, posts or articles appear in reverse chronological order on the front page, with the most recent one at the top. But editing is done in wiki style, with a version history for each page and special markup tag. Wikblog makes it possible to synthesize and synchronize knowledge as illustrated in figure 5.

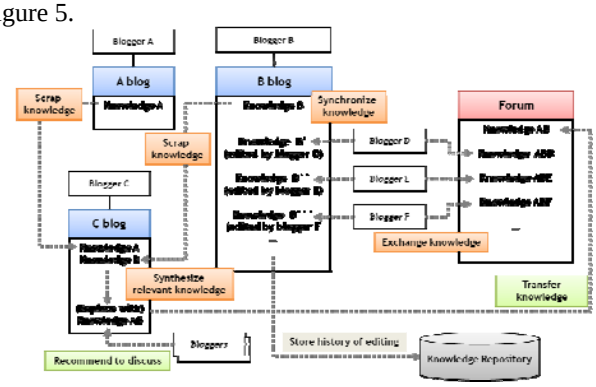

Figure. 5 Knowledge reuse model

Wikiblog improves the effectiveness of knowledge and knowledge sharing since the process of archiving allows knowledge to evolve through the wisdom of crowds, which repeatedly advance and retreat until a consensual advance is attained. Wikiblog supports KM in a simple user friendly people-centric manner, consistent with the opportunity to capture, share, reuse, and maintain knowledge as proposed by Tan, et al. [12], in their focus on 'live' construction KM and that of Chinowsky and Molenaar [26] in their work on "learning communities."

4. DEVELOPMENT OF CONSTRUCTION KNOWLEDGE MANAGEMENT PORTAL

In this section, based on the fundamental model, a proposed system called CKMP has been briefly explained. The primary aim of developing CKPM is to facilitate the knowledge creation, storage, transfer and reuse in SMCs. It is developed for all construction knowledge workers involved SMCs. CKMP will be a platform for sharing and identifying knowledge through the real-time participation of these users.

4.1 System Development

This system is built using ASP.net, HTML, and java scrip, and the data including knowledge on blogs is transferred in real time to project blogs in XML format. The entire web-based application is built based on IIS (Internet Information Services) and MS-SQL.

The implication of CKMP is that the design of an interactive and collaborative information system should not reflect the needs of individual users but the social structure of the emerging network. It is required a relational and rich information systems design with innovative and collaborative approaches. A blog-based KMS can be more powerful if it is connected with web-based communication technology. This research adopts email, forum and webhard as web-based communication technology. The knowledge management functions of each communication technology are illustrated in Figure 7.

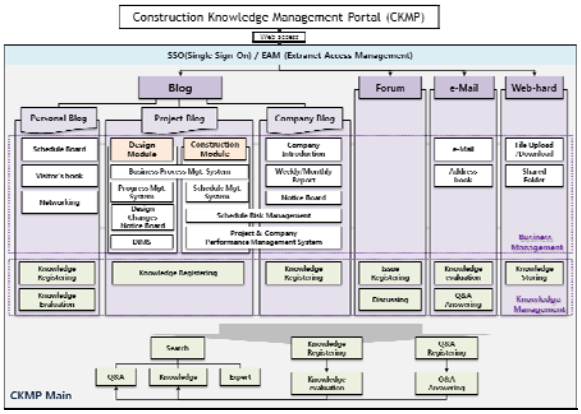

Figure. 6 CKMP framework

4.2 Applicability

As discussed before, CKMP is designed to reflect user's requirements for implementing KMS. In this respect, the applicability validation is designed by methodology of usability evaluation. The conventional KMS of firm A was selected as a comparable current system due to its relatively high usage. Twenty participants were recruited and they was chosen to be as close as possible in age, computer experiences, and experience in construction project in order to eliminate the effect of external elements on the results of the test. The participants were asked to complete two questionnaires, one for CKMP and one for a conventional KMS. And then, short and informal interviews were conducted with the participants.

The main problems indicated by case studies were inconvenient interface, employee resistance and insufficient time. To overcome these problems, CKMP is developed based on EI, blog, ontology and wikiblog. As a result, CKMP received higher score in questions about confidence of use, ease to use, extent of motivation and the effectiveness of reusing found knowledge. It would be identified that in forms of portal improves ease to use by providing a unified application access. As a matter of fact, most participants revealed satisfaction with using collective intelligence such as EI and wiki. It can be inferred that Expert Index and wiki activate participants to do KM activities by the philosophy of web 2.0. Therefore, it is considered that these factors influence on enhancement of usability and make participants to use CKMP confidently hereafter. On the other hands, the question about the probability to find need knowledge shows still low score. Some participants indicated that maintenance of ontology considering the application is important. They were also concerned that no ontology can include every concepts of a domain. Therefore, further understanding of the nature of ontology is needed and the technical problems of the system should be solved.

5. CONCLUSIONS

In today's knowledge-based economy, effective KM in construction industry is critical to the survival and advancement of company. The importance of this issue is increasingly being recognized in this industry, and companies have adopted the information systems in order to support and enhance the organizational processes of KM. However, despite of efforts, construction companies face barriers to implement KMS. This research identified requirements throughout conducting case study. To deal with requirements, component methodologies which are Expert Index, blog, ontology, wikiblog, ASP and Portal are suggested. This research presents how these component methodologies can support the KM process and developed the CKMS connected with email, forum and webhard. Thereafter, a field test with actual users is conducted to validate applicability.

A significant contribution of this research is to present a web-based Construction Knowledge Management Portal (CKMP) for SMCs which have limited resources to

afford extensive investments on developing KMS, even with high demands of the system. CKMP can provide to an organization a great contribution of the potential improvement in social network between people, but reduction of the cost of information technology. As user-oriented KM methodologies were adopted by carrying out case study, CKMS is straightforward and the interface is user-friendly. Furthermore, this research presents a possibility of commercializing web 2.0 or web 3.0 technologies and would be fundamental model of process or methodology building for KMS development. The suggested CKMP makes the KM process more systemized that enhances the usability to arrive all participants jointly at practical and efficient solution for the KM activities. Consequently, the system can offer greater support for motivating KM activities than conventional system.

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