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KM SYSTEM IN THE CONSTRUCTION FIELD: INVESTIGATING NEW KNOWLEDGE RESOURCES

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ABSTRACT

Managing knowledge in the construction field is an ongoing research topic. Although many methods have been proposed for managing knowledge in the construction field, the following issues remain unclear: what knowledge resources are, what the optimal knowledge representation is, and what knowledge sharing means. In this paper, a novel approach for managing knowledge in the construction field is proposed. Our contributions in this paper include the definition of new knowledge resources by acquiring and representing immature knowledge, and acquiring and representing external knowledge (i.e., knowledge not related to the company or the engineer himself). Our proposed approach has been validated through an online system, which is currently used by one of the largest construction companies in Libya.

Keywords: *KM System, Knowledge Objects, Construction Industries, Knowledge Resources*

1. INTRODUCTION

In the construction field, engineers acquire cumulative experiences on a daily basis by resolving the problems they encounter. This knowledge differs from one engineer to another, and from one company to another. The type of projects implemented in a company determines the identity of its knowledge. Any project comprising a set of problems and challenges that are usual or unusual is of significant importance. The handling of unusual problems is considered as knowledge to the company. The term "knowledge of the company" necessarily means the actors in this company, namely, the engineers in the case of construction companies. Thus, the knowledge value of company engineers determines the knowledge value of the company. In this study, knowledge value pertains to the cognitive value that is highly subjective. This subjectivity shows the importance of using a computerized system for knowledge acquisition, knowledge presentation, and knowledge sharing, which comprise the three pillars of knowledge management (KM). The KM system is the required system that plays a key role in company success because it saves cumulative knowledge gained for the company without relying on individuals.

Kamara et al. (2002) defined the main KM question in construction companies as follows: "How the flow of information in the company should be controlled?" To answer this question in pursuit of the best solution, we have developed a portal for this issue.

Lin et al. (2006) named knowledge resources in construction as problem-solution descriptions, construction operation process, virtual communication, and collaboration, and all these resources are classified under projects. Chong and Uden (2007) suggested the portal solution as a KM tool for construction, and defined the main knowledge objects for their solution as project, problem, and solution. Project is the secret word in the construction field (Kamara & Augenbroe, 2002). According to Anumba et al. (2005), Zin and Egbu (2010), and Tserng and Lin (2004), all knowledge objects in the construction field are related to projects in one way or another. Moreover, in the literature, the main source of knowledge in the construction field is the engineer; hence this provided knowledge is limited to its knowledge only.

In sum, knowledge in the construction field has been defined in the literature in terms of three objects: project, problem, and solution. Each problem has one or more solutions, and each problem is related to one or more projects. Therefore, knowledge can be represented as a project and its problems and solutions. From our observations, interviews, and discussions with construction domain experts, we have concluded that some experts have knowledge that is unrelated to any project.

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Those experts obtain this type of knowledge through conversations with other experts. Dahl and Pedersen (2003) concluded that the "informal contact between employees in different firms is argued to be one of the main carriers of knowledge between firms in a cluster." We believe that informal knowledge is also acquired through observation, reading, and imaging. The problem is how to involve this type of knowledge in the representation schema.

Moreover, in the related studies, a ranking mechanism allows other experts to rank and re-rank solutions. The ranking mechanism helps choose the most correct solution among a group of solutions related to one problem. Some experts may have many comments regarding any solution. These comments may have not up re-ranking the solution. These comments are also considered as knowledge, and the challenge is how to retain this knowledge.

In this paper, we introduce our KM solution in the construction field. In contrast to other solutions, we focus on the problem independently from the engineer's knowledge or from a project-based perspective. Our assumption is based on this premise, and the problem is not necessarily related to the engineer's expertise. The problem could be fictional, that is, it is unrelated to either the project or the engineer's expertise.

Our solution is a web-based application. Web-based applications have been proven as a successful KM tool in the construction field (Lin et al., 2006). In our solution, we have satisfied the knowledge objects in the construction field (i.e., project, problem, and solution). The problem has three categories in our system: (1) a normal problem that lies under specific project; (2) an auxiliary problem that is unrelated to any project; and (3) the discussion problem. Each category will be subsequently discussed in detail.

Our system also satisfies the three pillars of the KM system. Our web-based system provides room for knowledge acquisition by providing different pages to fill problems and solutions. From the knowledge representation perspective, we have represented all the knowledge objects in the construction field. In the discussion part of our system, the third KM pillar has been satisfied.

This paper is organized as follows. Related studies are discussed and analyzed in Section 2. Our web-based KM system is described in Section 3. The knowledge objects used in our approach are highlighted in Section 4. Our contributions are presented in Section 5. The conclusions are provided in Section 6.

2. RELATED STUDIES

This section discusses the related studies. It focuses only on those that have dealt with KM in the construction field.

Kamara and Augenbroe (2002) argued that KM in the construction field consists of project knowledge and the knowledge of project teams, and disregarded company knowledge in their definition. They also failed to provide any description of how to represent this knowledge.

Dahl and Pedersen (2003) cited informal contact between employees in different firms as one of the main carriers of knowledge between firms in a cluster. Our approach has considered this premise. Tserng and Lin (2004) proved the usefulness of web-based solutions in the construction field as a knowledge-sharing tool. Although they conducted an experiment, their representation of the knowledge object was unclear. Pathirage et al. (2005) stressed the importance of knowledge workers and tacit knowledge in the construction field, and examined their contribution toward company performance. Our proposed contribution has also considered this assertion.

Chong and Uden (2007) developed a KM model based on knowledge entities. The main differences between our proposed approach and their work are discussed in Section 4.3.

Kivrak et al. (2008) developed a conceptual framework to formalize the knowledge-capturing process in construction companies. They demonstrated how the conceptual framework can be implemented in practice through a web-based system called Knowledge Platform for Contractors. Moreover, they conducted a survey to define the knowledge sources for the knowledge acquisition process, and then developed a portal between these knowledge sources for the knowledge-sharing process. Knowledge is acquired without any emendation, which renders the future analysis of this knowledge almost impossible.

Udeaja et al. (2008) developed web-based prototype to facilitate the live capture and reuse of project knowledge. They found that knowledge entities had not been defined, thereby making the knowledge acquisition merely a documentation

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process without any organization. In contrast to their work, our proposed approach highlights the organized documentation of the acquired knowledge, thus facilitating the follow-up and analysis of this knowledge.

Ahmad and An (2008) developed a KM model, in which the factors and the main problems affecting the project in the construction field were completely defined. In our proposed approach, we have defined a general template for the knowledge objects in the construction field.

Tupenaite et al. (2008) developed a computerized knowledge-based decision support system, which is capable of weighing each decision and prioritizing the alternatives. They provided an auto rating mechanism that is based on current readable factors. The rating mechanism in our approach is manual to prevent the impact of hidden or unknown factors. Awareness or expectation of all factors, including future ones, is impossible to achieve.

Mohd Zin and Egbu (2010) conducted an industrial survey to evaluate the readiness of organizations in the construction industry in implementing a KM strategy. Their study proved the influence of many factors in the KM system for the construction industry. In our proposed approach, all these factors fall under the main pillar of the KM system.

Kanapeckiene et al. (2010) developed a knowledge-based decision support system for construction project management. This system generates automated recommendations and provides alternatives with rankings. Our proposed approach behaves similarly to this system; however, our approach accepts manual ratings.

3. WEB-BASED KM APPLICATION

Our web-based KM application has been posted at the following address: http://www.construction-kmanagement.com. Registration is the first step to start working with the web-based KM application. Registration is important because all actions are documented. All users registered as engineers. Figure 1 illustrates the main page of our web-based KM application. Our web-based KM application also works like any traditional company website, in which the full details about the company (i.e., mission, vision, and contact information) are provided.

Figure 1: main page of our web-based knowledge management application

As mentioned in the Introduction section, “problem” is the secret term in our approach, and a problem is classified into three categories. The first category is the problem related directly to company expertise. This type of problem occurs during the implementation of one of the company projects. The second category is the problem related to the engineer’s expertise, but is unrelated to company expertise. This type of problem represents the accumulated experience and maximizes the usage of company staff. The second type of problem is labeled as “auxiliary problem” in our system. The third type of problem is related to neither company expertise nor the engineer’s expertise; it is unrelated to any project that the engineer is involved in. The engineer indirectly acquires the expertise. The engineer may be briefed on the issue through a friend or through the media, or may even imagine the problem. In our approach, we call this type of problem as a “suggestion.” Our approach has classified problems into different categories. This classification assists the follow-up process and provides a general description of the suggested problem, as well as helps the other engineers to understand and analyze the problem. Table 1 presents the definition of problem in our approach.

Table 1: Definition of problem in our approach

No	Name	Description
1	Problem	Problem related to the company’s projects
2	Auxiliary Problem	Problem related to the engineer’s knowledge and not related to company’s project
3	Suggestion	Problem related to the knowledge of other people or imagined by the engineer.

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Based on this new definition of the problem in the construction field, we have facilitated the knowledge acquisition of different resources. These resources include company knowledge, engineer's knowledge (i.e., acquired from his previous work; in other words, another company's knowledge), and knowledge related to other people. To the best of our knowledge, these are the only knowledge resources available. Table 2 presents the knowledge resources in our approach. In general, this definition assists the company in maximizing internal knowledge (company, engineer) and external knowledge (other people).

Figure 2 illustrates the main page for registering a problem. The project needs to be approved first by the system administrator, or the user who controls the system. In our system, the administrator is responsible for approving user and project registration and making backups of the database. Figure 3 demonstrates the Registration of the auxiliary problem.

Each type of problem provides room for a solution. One problem may have one or more solutions; each solution has a priority. At the beginning, a solution that is posted takes its priority from its author. For instance, if an engineer with experience level 5 posts any solution, then this solution will be ranked 5. Later, any other engineer can change the rate conditionally by providing the reason. Figure 4 illustrates the registration of a solution. We have provided the facilities for engineers to support their suggested solutions with a video or a document.

A good solution usually needs supporting evidence as proof or videos for explaining the idea. Any solution ranking is subject to change. Projects in the construction field are affected by different factors, such as country laws, international prices of raw materials, and project environment. All these factors are occasionally subject to change; in fact, these factors continuously change. Problem solution is affected by the project (i.e., the problem is initiated due to some challenges in the project). Therefore, the solution ranking might be changed from one project to another. Our web-based KM application is highly flexible in terms of ranking.

Any engineer has an ability to change the ranking of the posted solution. This ability is controlled by providing the reason (i.e., why he changed the ranking and why he gave a new ranking). Hence, the ranking will not be changed until adequate proof is provided. By providing proofing as a condition for changing the ranking, we protect the knowledge in our system and simultaneously satisfy the nature of the knowledge in terms of dynamism.

Conversely, some engineers may have different opinions regarding one solution and wish to change the ranking, but they have insufficient proof to do so. Hence, they can post a comment regarding the targeting solution.

A tab for discussion near the solution tab is presented in Figure 5. Using this discussion tab, engineers may comment and discuss any solution without changing its rank. The facility of commenting without changing the rank assists our system in acquiring immature knowledge. When the engineer checks the solution, he will consider the comments as well. Figure 6 illustrates the registration process of a discussion. Through the discussion mechanism, we have captured both mature and immature knowledge. According to life experiences, immature knowledge can be highly valuable. Capturing and documenting immature knowledge is one of our contributions in this paper.

As mentioned previously, a discussion is used in our system for documenting an indirect problem (i.e., the problem is not directly related to the engineer's experience). By placing a suggestion inside the problem page, we have provided a kind of discipline. The suggestion part in our system is designed to document the free knowledge that the engineer may acquire from different resources, such as friends and the media. Documenting this type of free knowledge without any control could create problems. Therefore, placing a suggestion under the project's problem or auxiliary problem provides boundaries, thus facilitating the follow-up process.

Table 2: knowledge resources in our approach

Resource	How to acquire it in our system
Company's projects	Documenting of the projects and their related problems and solutions
Other companies' projects where the current company's engineer were previously work	Documenting of the Auxiliary Problem which is not related to company's projects.
Media, discussions, social networks, imagination, etc.	Documenting of suggestions

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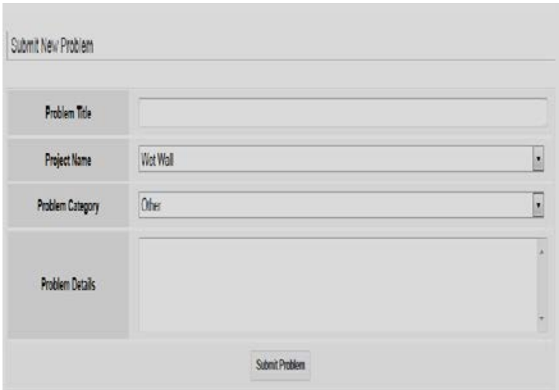

Figure 2: Main Page for Registering A Problem

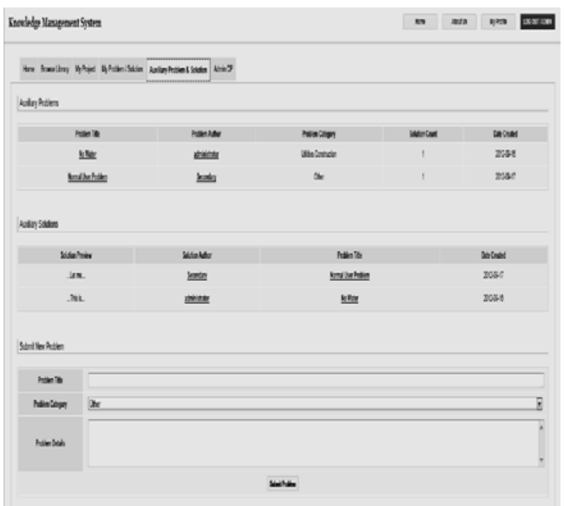

Figure 3: Registration of the Auxiliary Problem

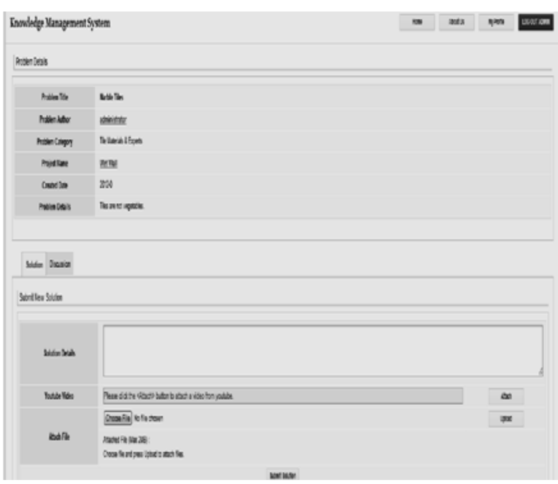

Figure 4: The Registration of a Solution

Figure 5: Registration of a Discussion

4. KNOWLEDGE OBJECTS

This section discusses the knowledge objects of our system. We use the standard knowledge object of the construction field.

Project: The project is the first knowledge object. We describe the project information as follows:

Project no: Represents the project number; it is the primary key

Project title: Title that describes the project

Project location: Location of the project; this information is useful for statistics

Details: Description of the project work, and the members and their positions; these details could be useful in future

Project leader: Name of the engineer who leads the project; this information is useful for statistics

Date created: Project starting date; this information is useful for statistics

Problem: This is the second knowledge object that describes any difficulties, challenges, or main issues that need to be resolved. We describe the problem information as follows:

Problem no: Represents the problem number; it is the primary key

Problem title: Title that describes the problem

Problem category: This field assists in categorizing the problem, which is useful for statistics and provides a better understanding of the solution and the problem itself.

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Problem author: Information on the individual who posts the problem. The author's background provides a better understanding of the solution and the problem itself.

Project no: Each problem should be related to one project.

Date created: The date of posting the problem

Details: Provide an open space in which to write the problem

Auxiliary Problem: This knowledge object is one of our research contributions. The problem is unrelated to any project; it is simply related to its author. It includes the following sub-objects: problem no., problem title, problem category, problem author, date created, and details.

Solution: This knowledge object describes the solution details of one of the registered problems. Each problem is related to the project; hence, any solution is related to the project as well. The solution comprises the following sub-objects: solution no., problem no., author, date created, details, and rate.

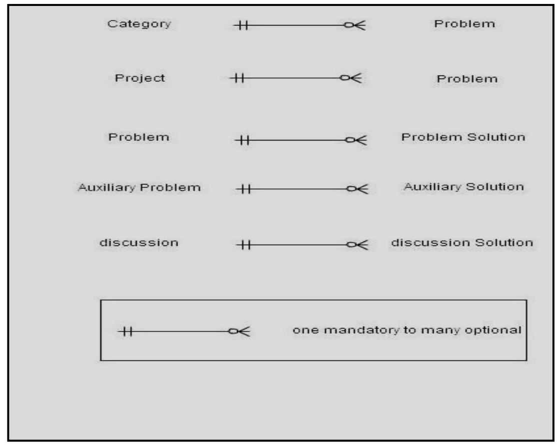
Auxiliary Solution: This knowledge object describes the solution details of one of the problems that is unrelated to any project. It has the following sub-objects: solution no., problem no., author, date created, details, and rate.

Discussion: This knowledge object describes the free discussion that shows the flexibility of our approach. It has the following sub-objects: discussion no., author, date created, and details.

Discussion solution: This knowledge object describes the proposed solution for the problem that is described as a discussion. Discussion and the discussion solution together represent the form in our approach. Discussion solution has the following sub-objects: Dis _Sol_no., author, date created, and details.

Table 3 presents the Entity Relationship Diagram of our proposed approach. Figure 6 illustrates the flowchart of problem registration, whereas Figure 7 demonstrates the flowchart of solution registration.

Table 3: Entity Relationship Diagram (ERD) of our proposed approach



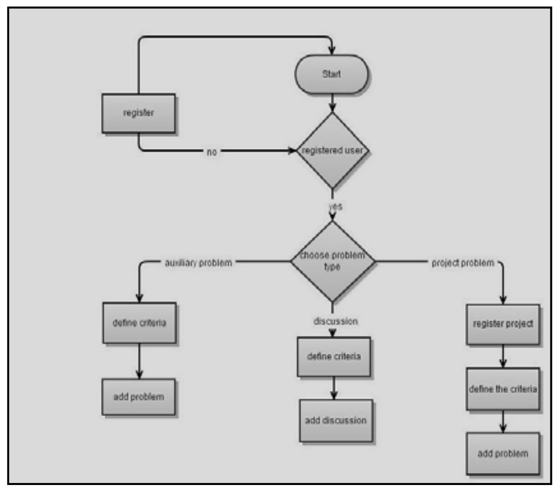


Figure 6: The flow char of problem registration

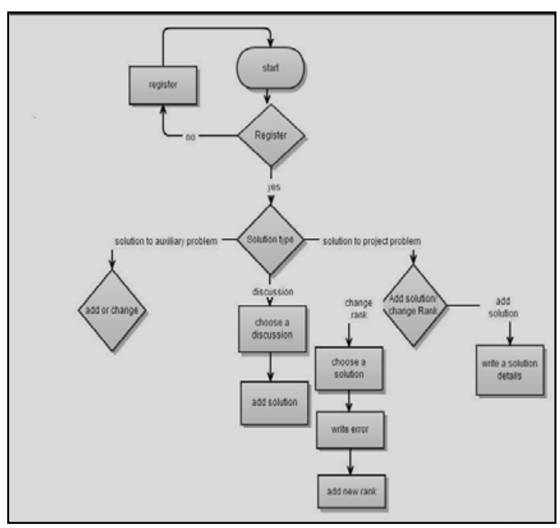


Figure 7: The flow char of solution registration.

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4.1. EXAMPLE

Project name: Developing a highway in the Qara Bolli area

Problem: How to implement the road required in accordance with the topography and geographical location of the area

Solution: Rating 4

First, choose the appropriate path to avoid obstacles and reduce the cost to the executive.

Second, conduct a field visit and palpate the pathway to determine the soil quality.

Third, carry out a cadastral survey.

Fourth, study the number of cars that pass through the road to design the layer thickness of the road.

Fifth, carry out the design.

Sixth, make an inventory of items for implementation.

Seventh, implement the infrastructure that carries out the settlement, and prepare the way for the foundation brushes particleboard.

Eighth, supply the foundation particleboard and carry out experiments for the brushes asphalt.

Finally, supply the asphalt concrete by palpate type to determine the type of framework.

Change Rating: On 2012-11-22 05:12:04, user *Y312h* changed the rate by giving it -1. The current rate becomes 3. Reason: These steps are inadequate.

Another solution: User Rating 4

Must correct the initial planning for each project and work as surveyors integrated team to set the border on the ground and site inspection and correct mistakes by giving initial incorrect views

Change Rating: On 2012-11-30 05:11:21, user *Y315h* changed the rate by giving it +1. The current rate becomes 4. Reason: Good spatial information

Discussion: Author Fathi; date posted 2012-12-02 08:08:39

As an engineer surveyor, I see that this is more correct and is planning primary for each project which is to work as a team surveyors to set limits to any site on the ground and is site inspection eyes and dialogue with the project owner to identify the type of project and to express an opinion and correct errors before they occur prospectively and desired to see the GPS data.

Auxiliary Problem: Fragility of concrete bricks

Author: Administrator.

Problem Category: Contractor equipment and supplies

Problem details: How to manufacture concrete bricks of stiff consistency to remove the fragile quality of the existing concrete bricks for construction purpose

Auxiliary Solution: User Alex. Initial rating 3

I see to be sure of raw materials for Mixed and type of cement used and the type of coarse aggregate user RFM 0.8 cm and use fine aggregate and from the area of "Zliten" and must be sent to the laboratory for testing, and also testing plain water.

5. RESEARCH CONTRIBUTIONS AND THEIR COMPARISON WITH RELATED STUDIES

The following points describe the contributions of our study. Later, this section presents a comparison of our research contributions with those of related studies.

5.1. New Definition for the Problem: As mentioned previously, the three pillars of the KM system in the construction field are the project, problem, and solution. In this research, we have redefined the meaning of the problem. Previous studies, such as those of Chong and Uden (2007), Kivrak et al. (2008), and Zin and Egbu (2010), described the problem as an existing problem that has actually occurred. In our research, we have redefined the problem to be independent from the project. This definition helps extend knowledge resources to involve the problem related to the expertise of other people, or even the imagination of the engineer.

5.2. Capturing, Representing, and Sharing Mature and Immature Knowledge: Knowledge could be categorized into mature and immature knowledge (known in the literature as tacit knowledge). Following is a description of how our

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approach could be used to capture, represent, and share each type of knowledge.

Mature knowledge: In our approach, mature knowledge is described as knowledge that is directly related to the company or to the engineer. The company builds and develops this type of knowledge through company projects. Engineers also develop this type of expertise by working on real projects. Our contribution in this type of knowledge is by providing a mechanism for ranking the solution. As a life fact, the best solution for a specific problem could not be the best one in a different situation or in a different time. Therefore, by adding the mechanism, we are satisfying this life fact. To the best of our knowledge, this study is the first work that introduces a flexible ranking mechanism.

Immature knowledge: Immature knowledge is defined in this study as knowledge that is obtained indirectly. Engineers gain such knowledge through discussions with friends and colleagues, and by noticing the knowledge in the media or even imagining it. In this research, we have defined a clear procedure for representing and sharing immature knowledge.

Kivrak et al. (2008) represented knowledge as a portal, but there is clear mentioned for the knowledge pillars. Knowledge is represented as project-related, which is narrow and limits the scope of the represented knowledge. Moreover, ranking is lacking. The main advantage of this work is that it clearly presents the knowledge auditing step, which is undertaken by the knowledge manager. In our approach, knowledge is added based on the responsibility of its owner. The idea is to make our approach more flexible (i.e., give the engineers more freedom). At the same time, we depend on self-monitoring given that any addition is a documented process.

Chong and Uden (2007) provided a clear representation for the knowledge pillars in the construction field (project, problem, and solution). Although the authors defined a mechanism for rating the best solution, our work is different in terms of the re-rating aspect. Through re-rating or re-ranking, our approach satisfies the dynamic nature of knowledge; the best solution could not be the best solution in a different situation or in a different time. In the same work, the knowledge source is defined as the user, designer, employer, builder, and decision maker. In our approach, the knowledge source is the engineer who functions as the knowledge auditor.

5. CONCLUSION

The KM system aims to maintain the knowledge creation, usage, and sharing in the organization (Alavi & Leidner, 2001). Regarding this definition, our approach is a complete KM system. In this paper, we have introduced new definitions of the knowledge objects in the construction field. Our approach has been implemented in this website, http://www.construction-kmanagement.com. In addition, more than 10 experts from one of the largest construction companies in Libya have used the system for over six months to validate our approach. The final results have proved the applicability and usability of our proposed approach.

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