Resilient Structures and Sustainable Construction
Edited by Pellicer, E., Adam, J. M., Yepes, V., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-4-8

KNOWLEDGE-BASED PORTFOLIO MANAGEMENT: A TAXONOMY FOR LESSONS LEARNED

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Portfolio management comprises of identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work to achieve specific strategic business objectives. Utilizing a knowledge-based portfolio management approach can be a critical success factor for construction companies. This research aims to present a taxonomy to facilitate the learning process within a knowledge-based project portfolio management system. The taxonomy is capable of codification and classification of lessons revealed during life cycle of projects to enhance their retrieval. Within this context, following a detailed literature review process, the taxonomy is structured under four main categories as "project", "process", "actor", and "resource". Categories provided in the taxonomy enable tagging of the lessons learned according to the intended level of detail, facilitate retrieval and reuse of the lessons learned in forthcoming projects. In this paper, we will present the structure of the proposed taxonomy and discuss how it can be used to improve portfolio management in construction.

Keywords: Construction project portfolio, Knowledge management, Learning, Tacit knowledge.

1 INTRODUCTION

As the construction industry is a project-based industry, competitiveness of firms in this industry can only be sustained by bidding for the right projects, achieving competitive advantage over the rivals using the right bidding strategy, effective project management to complete projects in accordance to client's expectations, utilizing the project-based experiences to carry out the forthcoming projects in a better way and building a positive company image based on project success. Management of the portfolio of on-going projects, learning from previous projects and selection of the right projects to bid are critical success factors for construction companies. Selection of the projects according to only their short-term profitability and by ignoring other factors such as long-term strategic objectives and how they fit to the current portfolio of projects may result in rejection of the projects that would be suitable for the company in the long run (Masoumi and Touran 2016). It is believed that project portfolio management, which focuses on holistic management of projects, can be a solution for the industry. Project Management Institute (PMI) (2008) defines portfolio management as "the centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work to achieve specific strategic business objectives". Using this perspective, companies can effectively utilize their limited resources by concentrating on the long-term strategic objectives and handling projects together rather than focusing on single project objectives. Effective portfolio management can be a major source of competitive advantage in project-based industries (Blismas *et al*. 2004, Wu *et al.* 2013).

The study, depicted in this paper, is a part of an on-going research project on portfolio management in construction industry funded by the Scientific and Technological Research Council of Turkey (TUBITAK). The project aims development of a portfolio management tool for construction projects that would act as a decision support system for portfolio selection and management. With the developed system, evaluation of the projects considering their risks and strategic fit will be possible. Within this context, it is believed that using past project knowledge to select and manage projects in the portfolio will be a major asset. Learning from previous projects can be facilitated by developing an effective "lessons learned" database, implementing an efficient retrieval mechanism and successful codification of knowledge. Within the context of this study, a knowledge-based portfolio management system is proposed and a taxonomy that would facilitate the identification and retrieval of the lessons learned has been generated. In this paper, we present the developed taxonomy that would be used for learning from previous projects as a part of knowledge-based portfolio management system.

2 LESSONS LEARNED IN THE CONSTRUCTION INDUSTRY

Lesson learned is simply defined as knowledge gained by experience; more specifically by a positive action as good work practice, innovative approach, and successful mission; or by a negative action as adverse work practice, mishap, failure (Caldas *et al*. 2009). Investigation by post project appraisals is an effective and widely adopted method to capture lessons learned (Kartam 1996, Shokri-Ghasabeh and Chileshe 2014). By a post project evaluation, advances in sharing of limited resources can be obtained (Akatsuka 1994); however, intended benefits may not always be achieved because of relocation of the project participants at the time of appraisal and the time lag that encounters between the events and their evaluation (Carrillo 2005, Fong and Kwok 2009, Kartam 1996). Considering these disadvantages, capture of individual lessons learned during execution of projects and providing categorization for libraries of lessons learned through corporate intranets provides better handling of the issue (Chinowsky *et al*. 2007). There are formal and informal methods to handle lessons learned (Kartam 1996). Formal methods focus on continuous collection of lessons learned by use of electronic means during course of a project, whereas informal methods seek analyses to be carried out at the end of projects generally by meetings. Performance measurement is difficult for lessons learned due to commonality of variables to measure; however, some reported benefits of lessons learned are cost savings, increased profits, improved execution, increased application of best practices, reduced rework, facilitation in knowledge dissemination, and more satisfied employees (Caldas *et al*. 2009).

Lessons learned studies in the construction management literature vary from identification of lessons learned in a specific project to systems that aim holistic capture of lessons learned during life cycle of construction projects. Construction management literature specifically focuses on capture of lessons learned with the fundamental aim of building learning organizations. The procedures presented differ as informal and formal methods with disadvantages in either codification or dissemination of knowledge. Between all, the system provided by Arditi *et al*. (2010) includes a solution to categorization problem of lessons learned through identification of main categories of construction management practices and their related subcategories. By this system, when a user selects a category, he/she is directed to related sub-categories for selection of categories for the case in hand. Differently from this work, this research aims presentation of a taxonomy including categories for practices of both management and construction processes. Rather than related categories, user is motivated to identify the lessons according to the intended level of detail by selection of tags using a hierarchy having four main categories. Upper level categories are automatically selected to enable retrieval by different levels of detail. Finally, the knowledge-based portfolio management system is established in web-based environment to enable easy capture and dissemination of the lessons learned.

3 LESSONS LEARNED TAXONOMY

Following literature review, taxonomy is generated as a mechanism for identification of lessons learned while entering them and also facilitating the retrieval process by fostering the search of the related lessons. By this way, construction project portfolio management tool is made capable of reviewing past project lessons to support decision making by learning from projects.

3.1 Structure of the Taxonomy

The taxonomy is based on literature survey. For identification of project types “EuroStat” (1997), for management sub-categories “Project Management Institute” (2003), and for construction sub-categories “MasterFormat” (CSI 2015) are the primarily used sources. The structure of the taxonomy is based on four main categories as "Project", "Process", "Actor", and "Resource" as it is proposed in study of El-Diraby *et al*. (2005). "Project" enables project type specific tags, whereas "Process" is identified as processes during life-cycle of a project as feasibility, design, contract formation, management, and construction. "Actor" is required to address the problematic/useful parties as organizations or individuals, "Resource" is required to indicate details as personnel, manpower, machinery and equipment, material, subcontractor, and software. The taxonomy contains tagging of task related factors as well as management level factors. The sub-categories are identified up to a reasonable level that would enable the retrieval of the available and related/expected lessons learned, and also prevent excessive information that would restrict the usability of the taxonomy. The initial aim is to present the user a default taxonomy that would be sufficient for any company for tagging of the lessons learned, however the taxonomy would be editable in the tool for specific use of companies. The taxonomy is structured within five-level categorization with more than 2000 concepts; however, two-level categorization is presented in the Table 1.

Table 1. Two-level hierarchy of the taxonomy.

Project	**Process**	**Actor**	**Resource**
Buildings	Feasibility	Client	Sub-Contractor
Civil Engineering Works	Design	Constructors	Manpower
	Contract Formation	Dispute Resolvers	Machinery and Equipment
	Management	Regulators	Material
	Construction	Staff	Personnel

3.2 Use of the Taxonomy in the Portfolio Management Tool

3.2.1 *The knowledge management system*

The knowledge-based portfolio management tool provides capture of explicit knowledge through a post-project appraisal section to provide some statistical information to generate estimates for the specific project in hand. Whereas, implicit knowledge is aimed to be captured in terms of live information obtained through execution of the projects. The tool is structured on a web-based environment open to use of different levels of users that would be identified within the tool with their own usernames and passwords. This property enables advances of internet as a communication system, providing timely documentation and retrieval of knowledge, anytime, anywhere. Authorization of these users can be identified and limited by the main-user, enabling the main-user to structure their own knowledge management system according to the intended level of privacy and also security since implicit knowledge creates value for the company (Ferrada *et al*. 2014, Tidd and Bessant 2013). These properties of the tool enable usability and reachability of the live entry of cases that overcome the disadvantages encountered with post-project appraisals. "Edit" and "Delete" options are provided for the main-user to change the description or classification of the lessons entered, thus he/she establishes the quality and currency of the entries and overcomes the knowledge overload problem. Before dissemination of the knowledge acquired, it needs to be organized (Tserng and Chang 2008). This organization and classification process is structured with the tagging of the entries and retrieval is directed through the tags assigned and related attributes provided. Retrieval of the entries can be made through several options by the users directly or by the main user in order to push the related lessons to the responsible parties (Eken *et al*. 2015). Users can be senior level professionals or site manager that provides the link with the workforce and whole system may be under control of a knowledge manager as the main-user. Use of taxonomy within such a knowledge management system may help overcoming the identified barriers of lessons learned process in a construction company. The barriers (together with the overcoming property of the tool) can be listed as "lack of employee time" (codification through web as lessons appear), "lack of management support" (the system has to be already adopted within a culture that it is supported by management team), "lack of clear guidelines" (it can serve as a guideline in codification), "data repository too hard to search" (it provides various search options supported by tags) and "wrong people are involved" (the authorized individuals can be set from the beginning) (Shokri-Ghasabeh and Chileshe 2014).

3.2.2 *Features of the taxonomy*

Due to variety in lessons learned to be documented, Kartam (1996) identifies the ideal framework for documentation of a lesson learned to be simple, comprehensive, and flexible. In light of this remark, the taxonomy is embedded in a system that neither limits the user in identification of the cases nor leaves him/her unguided. The taxonomy is presented with main categories at first to ease its access, as long as the user opens the sub-categories the taxonomy extends. When a sub-category is assigned as a tag for an entry, the ancestor categories are automatically assigned to the entry. With this property, related entries are obtained in case of search with an upper level category. Taxonomy is fully editable; the user can change the level of the detail by adding/deleting concepts, can change the hierarchy of the concepts by drag and drop options, and can re-structure the taxonomy from scratch within the tool. The user is free to search the entries by direct search of an assigned tag. In addition to this, projects can be first eliminated by attribute-based or similarity-based filter options provided in the tool and then search by a tag within the filtered projects is provided (Eken *et al*. 2015). These properties provide flexibility for tagging of a case and also for retrieval of the entries for that case.

3.2.3 *Case entry with the taxonomy*

Kartam (1996) defines a successful codification of a lesson learned with a set of attributes as description of the lesson itself, information regarding the source of the lesson, and means that provide classification of the lessons for retrieval (Ferrada *et al.* 2014). Additionally, classification system should not be too general to limit the user in narrowing the scope or too specific to make him/her lost in onerous information (Kartam 1996). In light of these, attributes required for lesson entry are provided as indication of "Best Practice" or not, "Title of the Lesson Learned", "Description of the Event", "Recommendation", "Impact on Project Duration", "Impact on Project Cost" (where positive entry indicates "saving" and negative entry indicates "loss") and the "Tags". The description and recommendation sections are used only for description of the lessons learned; whereas remaining attributes are used in classification of the lessons. For example, an entry for "Poor Fire System Design" can be summarized as in Figure 1. In this example; description of the lesson learned is provided with its impacts and the directly assigned tags are only "Office Building" from project main category, "Fire Engineer" from actor main category, "Fire Design" and "Specification" from process main category; whereas the other tags are assigned automatically. For example; when the user assigns the "Office Buildings" tag, the others as "Project", "Buildings", "Permanent Buildings" and "Non-residential Buildings" are automatically assigned for retrieval of the case by searching these tags at different levels.

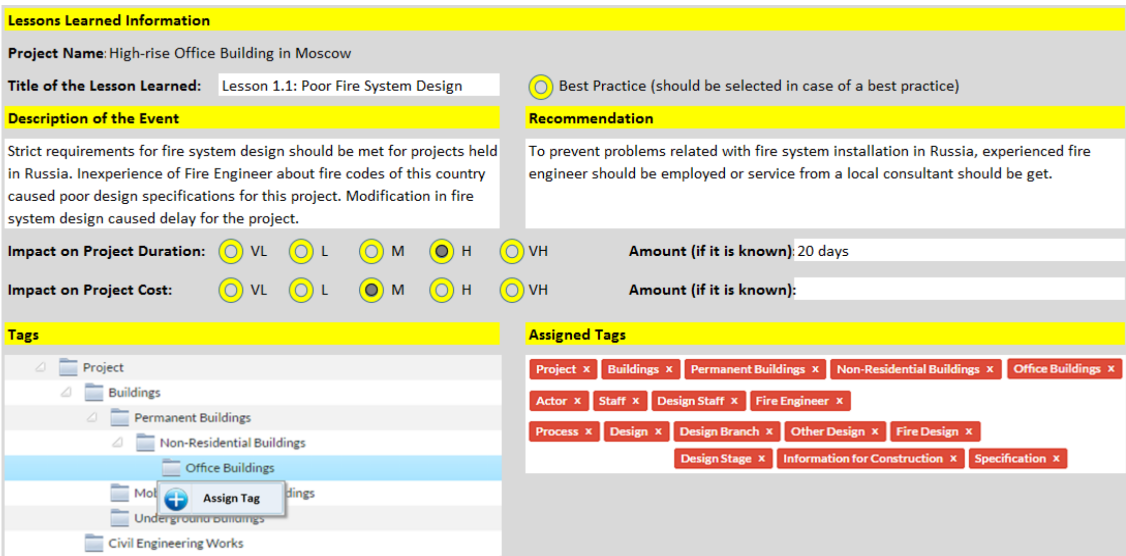

Figure 1. Entry of a lesson learned.

3.3 Validation of the Taxonomy

Current evaluation of the taxonomy is limited with verification tests for its use in the portfolio management tool. Several cases are entered into the tool and successfully retrieved through different search options. The validation of the tool will be made through an expert review process, usability testing process and a case study that consists of actual use of the tool by a construction company with its own portfolio of projects. Within a contemporaneous evaluation study, coverage of the taxonomy and the lesson learned entry process will be tested by a construction company with entry of real lessons learned from projects.

4 CONCLUSIONS

A taxonomy that is capable of tagging lessons learned event histories are provided. The taxonomy is embedded in a knowledge management system that is established with the aim of capturing knowledge within a portfolio management tool. The provided taxonomy is capable of tagging event histories for management and construction related factors. Taxonomy is editable and various search options are structured so that variety in retrieval of the lessons can be ensured. By the authorization options provided in the tool, user is able to establish the knowledge management system according to availability of personnel and intended level of privacy.

Successful use of this knowledge-based portfolio management system may help construction companies to enhance their organizational learning abilities and has a potential to improve the quality of their decisions during selection and management of projects.

Acknowledgments

This research is funded by a grant from the Scientific and Technological Research Council of Turkey (TUBITAK), Grant No. 213M493. TUBITAK's support is gratefully acknowledged.

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