DOI 10.20544/HORIZONS.A.25.2.20.P04
UDC 005.94:[334.72:004.4

CRITICAL SUCCESS FACTORS IN IMPLEMENTING A KNOWLEDGE MANAGEMENT PROJECT IN A MICRO SOFTWARE COMPANY

Zeljko Stojanov

University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia, zeljko.stojanov@uns.ac.rs

Dalibor Dobrilovic

University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia, dalibor.dobrilovic@uns.ac.rs

ABSTRACT

Software companies are recognized as knowledge-based organizations because their employees solve creative and innovative tasks by using recent technologies. The main challenge for these companies is how to manage knowledge as the main asset in their business. This becomes even more important for micro software companies due to their recognized constraints in budget, human resources, workspace and working resources, and timelines. Critical success factors, as an indicator of management planning to achieve effective business performance, have been widely used to analyze projects' performances in software engineering. This paper presents an analysis of the critical success factors identified in implementing a knowledge identification and systematization project in a local micro software company in Serbia. After presenting a lightweight inductive method for knowledge identification and systematization that was implemented in a selected micro company, critical success factors were determined and discussed. Based on the discussion of critical success factors, lessons for further knowledge management projects are drawn. In addition, benefits for the selected company, as well as implications for the software industry and academic researchers are discussed.

KEYWORDS

critical success factor, knowledge management, micro software company, software industry

1. INTRODUCTION

Knowledge has become the main resource the companies use for their business success in the contemporary and changing market, which is especially true for software companies (Schneider, 2009). In order to be competitive, the companies should develop specific capabilities and recognizable way of doing things, which is based on capabilities of people working in the company (Andreu and Sieber, 2010). This fact strongly emphasizes the importance of people skills and knowledge. Since knowledge resides in people heads, and it can

be lost if people leave a software organization, there is a need to implement knowledge management (KM) initiatives in software companies (Rus and Lindvall, 2002). New knowledge is usually created through development of innovative concepts and creative approaches to new situations and problem solving (Grimsdottir and Edvardsson, 2018). According to Schneider (2009) KM includes acquisition of new knowledge, transformation from implicit to explicit knowledge and back again, storage and dissemination, and applying knowledge. Hansen and Kautz (2004) suggested that the key element in KM is to evolve the current industrial practices by carefully studying it and extracting information that will help in adjusting and improving future practice.

Software engineering practice has been recognized as knowledge based practice, which requires dedication to personal experiences and skills in order to capture them and organize for future reuse (Rosqvist et al., 2003). Based on an empirical study with nineteen software experts from industry, Steen (2007) pointed out the importance of experience-based, practical knowledge for successful software engineering practice. In addition, a contemporary trend with geographically distributed software teams introduces several challenges in managing knowledge in software development, such as distribution of shared knowledge of the application domain, knowledge of who knows what in the team, durable knowledge of the software development process itself, and fleeting knowledge of whether other team members are adhering to the process (Espinosa et al., 2007). Refinement and reuse of existing knowledge in software organizations lead to practice improvement and increase the quality of products and services (Ivarsson and Gorschek, 2012). Due to the recognized constraint of small software companies (resources, team, budget, etc.), KM was implemented informally (O'Connor and Basri, 2014). Since there are usually no formal training for employees in micro and small software companies, learning occurs as self-learning and acquiring knowledge and skills while working on projects.

Knowledge management occurs in specific organizational context that influence its adoption and implementation. Success of KM initiatives and projects depends on organizational characteristics and factors that provide the context for knowledge flow among

individuals (Conley and Zheng, 2009). Critical success factors (CSFs) were introduced by Rockart (1979) as an effective approach used by executives to define their needs. Critical success factors relate to managerial areas, also called minimum key factors, the organization should give special attention to successfully achieve proposed objectives and mission with high performance (Oakland, 2003). Knowledge management has been mostly adopted by large companies that have enough resources to implement KM initiatives. This causes that critical success factors (CSFs) for implementing knowledge management (KM) practice in small enterprises have been mostly derived from the studies related to larger companies and practically they do not match their real needs (Wong , 2005). A thorough understanding of CSFs is essential for the success of KM practice in organizations, but the adoption of not suitable factors can lead to not desired performances.

Based on the above discussion, we propose a research objective for this study: "What are the most critical factors in a KM project implementation in a micro software company?" The paper is structured as follows. The next section briefly outlines work on CSFs in knowledge management and their use in software engineering. The third section presents a case study with the focus on a KM project in a micro software company and CSFs for implementing a KM project. Lessons learned during the project implementation are presented in the fourth section. The last section contains concluding remarks and future research directions.

2. CRITICAL SUCCESS FACTORS

Holsapple and Joshi (2000) proposed a descriptive framework for understanding the influences for the success of KM initiatives in organizations, with three main classes of influences: managerial, resources and environmental. Each KM initiative (episode) assumes the recognized knowledge need, requires knowledge resources and knowledge management influences, which after successful implementation results in learning and projection (basis for further innovations and development within the organization). According the Holsapple and Joshi (2000), the most important influence for KM initiative success is managerial influence, with the following four main factors:

- *Leadership*. The primary factor that influences the sharing of organizational knowledge, inspires, fosters mentoring, and engenders trust and respect by instilling a cohesive and creative organizational culture.
- *Coordination*. It relates to managing dependencies among KM activities, marshaling sufficient skills for activities execution, and integrating knowledge processing.
- *Control*. This factor ensures availability of all resources in sufficient quality and quantity for all KM activities.
- *Measurement*. It ensures valuation of knowledge resources and processors in a KM initiative, and provides the basis for evaluation of leadership, coordination and control.

Based on a detailed literature review, Wong (2005) proposed 11 CSFs for implementing KM in small and medium enterprises: management leadership and support, culture, IT, strategy and purpose, measurement, organizational infrastructure, processes and activities, motivational aids, resources, training and education, and HRM. Empirical assessment aimed at evaluating the extent of success of the proposed CSFs clearly supports the findings of the integrative literature review and indicates the appropriateness of the proposed CSFs.

Sedighi and Zand (2012) conducted a literature review on CSFs in KM and identified eight major factor's clusters that are shaped as a conceptual classification model. Clusters of factors are arranged in two basic dimensions: external (environmental) factors, and internal (organizational) factors. The external factors include macro and meso factors. Macro factors encapsulate all global factors such as legal, economic, political, technological, social, educational, and globalization factors. Meso factors relates to the market segment and industry in which the firm operates. The internal factors originate in an organization and can be classified in six categories: culture, structures and procedures, human and financial resources, technology and infrastructure, strategy and leadership, and KM process. Totally 26 internal and 9 external CSFs were identified and included in the conceptual classification model.

CSFs have gained attention from the software engineering and information systems research community, which resulted in using them in many different aspects of the practice since the 1980s (Cooper, 2009). CSFs have been used in the fields such as information systems use (Bergeron and Bégin, 1989), software development projects (Purna Sudhakar, 2012), offshore software development outsourcing (Khan et al., 2009), agile software development (Chow and Cao, 2008; Kaur and Singh, 2016), software process improvement implementation (Niazi et al., 2006), integration in global software development (Ilyas and Khan, 2015), industrial requirements engineering process assessment and improvement (Sommerville and Ransom, 2005), process modeling for enterprise systems (Rosemann et al., 2001), or knowledge based software process improvement (Chugh and Nitin, 2018).

This brief literature review reveals that there is a lack of empirical studies dealing with CSFs for KM use in software engineering, which indicates that there is a need for more research in this domain. This study aims at filling this gap and contributing to the knowledge base in this field.

3. CASE STUDY

A knowledge management project has been implemented in a micro software company as a part of the project ”The development of software tools for business process analysis and improvement”, which is funded by the Ministry of Education, Science and Technological Development, Republic of Serbia. The project was prepared and conducted as a joint endeavor of the company employees and the researches from Technical faculty ”Mihajlo Pupin” in Zrenjanin, Serbia.

The company has seven employees and can be classified as micro software company (European Commission, 2015). It is oriented towards local clients. The majority of daily work in the company is devoted to maintaining software business applications (Stojanov et al., 2018), which clearly suggested the importance of systematizing knowledge about software maintenance practice (Stojanov, 2019).

3.1. Knowledge management project

The aim of the knowledge management project was to identify and systematize knowledge on software maintenance practice in the company. The project implementation should not disturb everyday practice, which assumes the lightweight design of the project. For that purpose a ***Lightweight Inductive Method for Knowledge Identification and Systematization (LIM4KIS)*** was created and implemented in the company. The KM project was implemented as a part of software process improvement (SPI) project (Stojanov et al., 2017), which was focused on software maintenance practice. The main characteristics of the LIM4KIS method are (Stojanov, 2019):

- *It is inductive*. It starts from the real working context in the company, which ensures that the most relevant knowledge is identified.
- *It is participative*. It is based on active participation of the company employees in all project activities.
- *It is based on frequent feedback*. During the whole project, feedback to the company management and employees maintains the focus of the project activities.
- *It is based on triangulation of data*. The method uses various data sources and types of data, which ensures more comprehensive findings and the validity of the research study.

The LIM4KIS method tries to identify and systematize the knowledge possessed by the company staffs, which have the best insight into how daily tasks are performed. Since the organization staff has the best insight into the everyday practice, the method uses their knowledge and experience for the identification and systematization of the most relevant knowledge. The method requires the full commitment of the organization's management. LIM4KIS method is quite flexible, but in general it proposes the following phases in the KM project implementation:

- *Project planning*. This is the first and the most critical phase for the project success. It includes defining the clear project objective, determining the roles of the company employees and the researchers, defining data sources and methods to be used. CSFs are determined in this phase

- *Project implementation*. This phase includes several activities that can be cyclically repeated until the most relevant knowledge is not identified and systematized. These activities relate to collecting data from various sources, analyzing data, identifying knowledge and systematizing knowledge in a thematic knowledge framework.
- *Project reporting*. This phase relates to preparing the report and validating the knowledge framework.

The project implementation phase is a cycle with several activities and feedback loops aimed at identifying and systematizing knowledge on software maintenance practice, as it is presented in Figure 1. The project plans contain details about the project team, data sources, methods for collecting and analyzing data, and the project objective that drives the implementation phase.

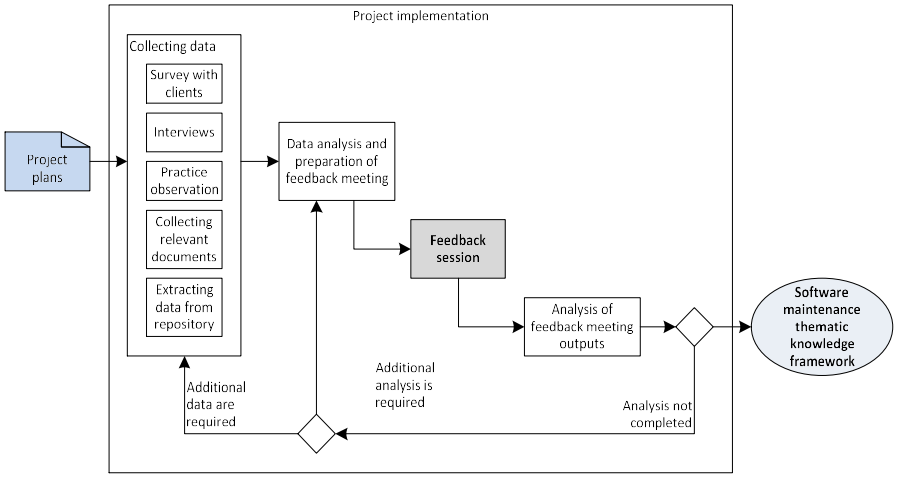

Figure 1. Implementation of the knowledge management project

The central activities in the project implementation are feedback sessions that are working meetings organized in the company. These meetings are organized for analyzing the current state of the project implementation and the issues related to data analysis. The main aim of these meetings is to provide feedback to the software company about the project implementation, which directs the next activities.

Based on the analysis of the feedback session outputs, the new cycle of data collecting or data analysis activities can be initiated.

Data sources for knowledge identification include interviews with the company employees, a survey of the company clients, the notes from the everyday practice observation, the company documents, and the data extracted from the company internal repository of tasks. In addition, the transcripts from the feedback sessions were used as the data source. Due to the variety of data types, different data analysis techniques were used, both quantitative (descriptive statistics, regression analysis, and fuzzy screening) and qualitative (inductive thematic analysis).

The dominant data analysis method was inductive thematic analysis (Braun & Clarke, 2006), which was used for developing the main project output - the thematic knowledge framework on software maintenance practice. Inductive thematic analysis was performed by using different tools. The sources of qualitative data were the interviews' transcripts, the notes from the practice observation, and the transcripts from the feedback sessions. These data were prepared as MS Word documents and imported in MAXQDA software for qualitative data analysis, in which initial coding was performed. Created code system and memos were exported in rich text format, printed and analyzed in feedback session. The final stage of data analysis was conducted by using printed code schema by using pens in different colors.

The resulting thematic framework contains themes classified in three thematic areas: maintenance request process, human factor, and company business policy and organizational issues. In each thematic area, themes were hierarchically organized as the main themes, sub-themes and sub-theme topics. This thematic framework presents the current state of the practice, and it could be expected to evolve as the practice changes.

3.2. Identification of critical success factors for project implementation

Critical success factors for the project implementation were examined during the planning phase of the KM project. In the analysis of potential critical factors participated the company manager and

leading researcher (the first author of this paper). This ensures that CSFs reflect the management and organization of the company and specificities of the KM project. In addition to determining CSFs, project planning also included determining how these factors can be managed and assessed after finishing the project, and who will assess how CSFs were treated. The following CSFs were determined during the project planning:

- *Full support of the company management*. The project was designed based on the company needs, as a sub-project of the software process improvement project. The company management was included in the project preparation, which ensures that the project is aligned with the company business strategy and objectives. In addition, company management was included in the whole research process, especially when they should arrange access to the employees or other resources in the company.
- *Availability of the company employees based on the project needs*. Since the knowledge is personalized, it assumes active participation of the company employees in the different phases of the project implementation. The employees were used as the sourcea of data through the interviews or the practice observations, or assisted in collecting documents or electronic data. In addition, they were included in the data validation and data analysis where appropriate.
- *Motivating the employees to actively participate in the project*. The projects objective is to identify and systematize the knowledge possessed by the company employees, and to make it available to all employees, which is very important for young and novice programmers.
- *Access to all resources in the company*. Knowledge identification assumes triangulation of various data sources, which assumes access to these sources. The company employees should assist in accessing the relevant documents, data in the repository and access to the clients.
- *Access to the company clients*. The clients participated in the survey aimed at identifying the characteristics of the company services, which was primarily used in process improvement

project, but some data and findings were used in the KM project. The company management and the employees prepared clients' contact data, which helped in organizing the survey.

- *Implementing the project in a way that does not disrupt everyday activities*. The employees are dedicated to everyday tasks, which in many cases includes tight cooperation with the clients. The company employees participated in the project activities when they were free from usual tasks, and the project activities were tailored to the specific working schedule in the company.
- *Inclusion of the company employees in the data analysis*. The company employees, as the main sources of the knowledge, were also included in the data analysis, which should ensure that the identified knowledge really reflects the existing knowledge. The company employees participated in feedback sessions (working meetings), in which all project relevant issues were jointly examined. This includes data analysis activities.
- *Validation of the project findings*. The project findings should present the real knowledge about the practice. Therefore, the company management and two leading programmers validate the findings.
- *Including external researchers based on the project needs*. The complexity of the practice was reflected in the complexity of the collected data and used data analysis methods. Variety of qualitative and quantitative data analysis methods requires the researchers with different skills. These researchers were accessed at the university, and included for the specific data analysis tasks.

This short elaboration of the CSFs also includes the notes on how they were handled within the KM project. After the project implementation, the leading researcher and the company management analyzed how these factors influenced the project realization and the project findings. The analysis was performed in the company and included in the project report.

The company management full dedication and support to the project implementation was identified as the main CSF for the project success, because it influences other CSFs. Without this support the project cannot be implemented with the proposed objective and this will influence the quality of the findings. The influence of other CSFs can be more easily controlled.

Further analysis of the CSFs for the KM project implementation relates to the alignment of the identified CSFs with the CSFs reported in the literature. A brief analysis confirms a high degree of the conformance to the relevant literature, but it is important to note that each project and organizational context have own specificities, which assumes identification of very specific CSFs.

4. DISCUSSION

Identification of CSFs helped the company management to more thoroughly prepare the KM project, and to identify possible obstacles in the project implementation. More comprehensive understanding of potential problems and obstacles in the project realization increases chances for successful project implementation. This understanding helps in preparing strategies to overcome problems and obstacles

The experience gained in this project can be used in preparing the next projects, which could ensures better project planning, more structured implementation, and more accurate validation of the project outcomes in the company.

Other micro software companies can use this set of identified CSFs as a starting point when considering the implementation of KM projects, and adapt them according to their specific needs. In addition, micro software companies can use the proposed approach for organizing a KM project and for considering CSFs specific to their internal organization and needs.

Researchers from academia can find lessons how to include examination of CSFs when preparing projects with micro software companies because their specific business model requires more intensive cooperation with the company management and employees in all phases of the projects.

5. CONCLUSIONS

The main contribution of this study is the identified set of CSFs that were managed in order to ensure the success of the KM project implementation in a selected micro company. The authors are aware that this set of CSFs is context-specific, but some common characteristics of micro software companies enable considering these CSFs when planning other projects in other companies. Due to the lack of studies reporting the use of CSFs in KM projects in micro software companies, this study contributes to the base of knowledge in this field of research.

Based on the experience gained in this study the following further research directions can be identified. The first research direction is the identification of the metrics for measuring the impacts of proposed CSFs in this study, which will lead to the refinement of these factors and measuring their importance. The next research direction relates to implementing the approach for identifying CSFs in other similar software companies and getting insight into similarities and differences. Several implementations of this approach can be used for proposing the framework with common CSFs for implementing KM projects in micro software companies.

ACKNOWLEDGMENT

Ministry of Education, Science and Technological Development, Republic of Serbia, supports this research under the project "The development of software tools for business process analysis and improvement", project number TR32044.

REFERENCES

1. Andreu, R., & Sieber, S. (2010). External and Internal Knowledge in Organizations, In David G. Schwartz and Dov Te'eni (editors) *Encyclopedia of Knowledge Management, Volume I, Second Edition*, pp. 298-307. Hershey, PA, USA: Information Science Reference.

2. Bergeron, F., & Bégin, C. (1989). The Use of Critical Success Factors in Evaluation of Information Systems: A Case Study. *Journal of Management Information Systems*, 5(4), pp. 111-124.

3. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), pp. 77-101.

4. Chow, T., & Cao, D-B. (2008). A survey study of critical success factors in agile software projects. *Journal of Systems and Software*, 81(6), pp. 961-971.

5. Chugh, M., & Nitin, N. (2018) Critical Success Factors and Critical Barriers for Application of Information Technology to Knowledge Management/Experience Management for Software Process Improvement – Findings from Literary Studies. In: Bhattacharyya P., Sastry H., Marriboyina V., Sharma R. (editors) *Smart and Innovative Trends in Next Generation Computing Technologies. NGCT 2017*. Communications in Computer and Information Science, vol 827. Springer, Singapore.

6. Conley, C.A., & Zheng, W. (2009). Factors Critical to Knowledge Management Success. Advances in Developing Human Resources, 11(3), pp. 334-348.

7. Cooper, V.A. (2009). A Review Of The Critical Success Factor Method Using Insights From An Interpretive Case Study, *Journal of Information Technology Case and Application Research*, 11(3), pp. 9-42.

8. Espinosa, J.A., Slaughter, S.A., Kraut, R.E., & Herbsleb, J.D. (2007). Team knowledge and coordination in geographically distributed software development. *Journal of Management Information Systems*, 24(1), pp. 135-169.

9. European Commission. (2015). *User guide to the SME definition*. Luxembourg: Publications Office of the European Union.

10. Grimsdottir, E., & Edvardsson, I.R. (2018). Knowledge Management, Knowledge Creation, and Open Innovation in Icelandic SMEs. *SAGE Open*, 8(4), pp. 1-13.

11. Hansen, B.H., & Kautz, K. (2004). Knowledge Mapping: A Technique for Identifying Knowledge Flows in Software Organisations. In *Proceedings of the 11th European*

Conference on Software Process Improvement (EuroSPI 2004), pp 126-137. Trondheim, Norway.

12. Holsapple, C.W., & Joshi, K.D. (2000). An investigation of factors that influence the management of knowledge in organizations, *The Journal of Strategic Information Systems*, 9(2–3), pp. 235-261.
13. Ilyas, M., & Khan, S.U. (2015). Software integration in global software development: Success factors for GSD vendors. In *2015 IEEE/ACIS 16th International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)*, pp. 1-6. Takamatsu, Japan.
14. Ivarsson, M., & Gorschek, T. (2012). Tool support for disseminating and improving development practices. *Software Quality Journal*, 20(1), pp 173–199.
15. Kaur, N., & Singh, G. (2016). Critical Success Factors in Agile Software Development Projects: A Review. *International Journal on Emerging Technologies*, 7(1), pp. 1-4.
16. Khan, S.U., Niazi, M., & Ahmad, R. (2009). Critical Success Factors for Offshore Software Development Outsourcing Vendors: A Systematic Literature Review. In *Proceedings of the 4th IEEE International Conference on Global Software Engineering*, pp. 207-216. Limerick, Ireland.
17. Niazi, M., Wilson, D. & Zowghi, D. (2006). Critical success factors for software process improvement implementation: an empirical study. *Software Process: Improvement and Practice*, 11(2), pp. 193-211.
18. Oakland, J.S. (2003). *Total quality management: text with cases, 3rd edition*. Oxford; Burlington, MA: Butterworth-Heinemann.
19. O'Connor, R., & Basri, S. (2014). Understanding the role of knowledge management in software development: a case study in very small companies. *International Journal of Systems and Service-Oriented Engineering*, 4(1). pp. 39-52.

20. Purna Sudhakar, G. (2012), A model of critical success factors for software projects. Journal of Enterprise Information Management, 25(6), pp. 537-558.

21. Rockart, J.F. (1979) Chief executives define their own data needs. *Harvard Business Review*, 57(2), pp. 81-93.

22. Rosemann, M., Sedera, W., & Gable, G. (2001). Critical Success Factors of Process Modeling for Enterprise Systems. In *Proceedings of the 7th Americas Conference on Information Systems*. pp. 1128-1130. Boston, MA, USA. http://aisel.aisnet.org/amcis2001/218.

23. Rosqvist, T., Koskela, M., & Harju, H. (2003). Software quality evaluation based on expert judgement. *Software Quality Journal*, 11(1), pp. 39–55.

24. Rus, I., & Lindvall, M. (2002). Knowledge management in software engineering. *IEEE Software*, 19(3), pp. 26-38.

25. Schneider, K. (2009). *Experience and Knowledge Management in Software Engineering*. Springer-Verlag Berlin Heidelberg.

26. Sedighi, M., & Zand, F. (2012). Knowledge management: Review of the Critical Success Factors and development of a conceptual classification model. In *Proceedings of the 2012 Tenth International Conference on ICT and Knowledge Engineering*, pp. 1-9. Bangkok, Thailand.

27. Sommerville, I., & Ransom, J. (2005). An empirical study of industrial requirements engineering process assessment and improvement. *ACM Transactions on Software Engineering and Methodology*, 14(1), pp. 85-117.

28. Steen, O. (2007). Practical knowledge and its importance for software product quality. *Information and Software Technology*, 49(6), pp. 625-636.

29. Stojanov Z., Stojanov, J., & Dobrilovic, D. (2017). Knowledge discovery and systematization through thematic analysis in software process assessment project. In *Proceedings of the IEEE 13th International symposium on intelligent systems and informatics (SISY 2015)*, pp. 25-30.

30. Stojanov, Z., Stojanov, J., & Dobrilovic, D. (2018). Domain complexity in corrective maintenance tasks' complexity: An empirical study in a micro software company. *Theory and Applications of Mathematics & Computer Science*, 8(1), pp. 24-38.

31. Stojanov, Z. (2019). Thematic knowledge framework on human factor in software maintenance practice: A study in a micro software company. *Journal of Software Engineering & Intelligent Systems*, 4(1), pp. 41-57.

32. Wong, Y.K. (2005), Critical success factors for implementing knowledge management in small and medium enterprises, *Industrial Management & Data Systems*, *105*(3), pp. 261-279.