Adoption of Knowledge Management Practices in Software Engineering Organizations

A Survey of Software Engineers' Perceptions

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Abstract— **Most businesses rely on the fact that their employees possess relevant knowledge and that they can apply it to the task at hand. But a serious problem exists; this knowledge is not owned by the organisation as such. Rather the knowledge is owned and controlled by its employees. The success or failure of the KM systems and the various KM practices claimed to be adopted by software engineering organisations can be best judged from software engineers' point of view as they are the ones who are the first-hand users of the KM systems and technologies. The paper is an attempt to study the perceptions of software engineers as users of the KM systems and discusses the results of the survey.**

Keywords-Knowledge management; Software engineering; KM practices

I. INTRODUCTION

An employee is one of the valuable assets of the organisation and perhaps the most important of all that contributes maximum in the efficiency and productivity of that organisation. In fact, satisfied employees make for satisfied customers. Unmistakably, employee satisfaction is utmost important and demands greater attention if client satisfaction is to be yielded and reinforced. This means that significant efforts must be devoted to hire the right type of personnel, nurturing and developing them, providing them with needed support, compensating them adequately and inventing ways of retaining the best among them for as long as possible.

Most businesses rely on the fact that their employees possess relevant knowledge and that they can apply it to the task at hand. But a serious problem exists; this knowledge is not owned by the organisation as such. Rather the knowledge is owned and controlled by its employees. The following statements illustrate this situation:

"Our knowledge has legs - it walks home everyday"[1]

"Not only do you have experience walking out the door, you have inexperience walking in the door"[2]

"An organisation's knowledge walks out of the door every night and it might never come back"[3]

The success or failure of the knowledge management (KM) systems and the various KM practices claimed to be adopted by software engineering (SE) organisations can be best judged from software engineers' point of view as they are the ones who are the first-hand users of the KM systems and technologies. The software engineers are the face of the SE organisations and can reflect the true picture of the state of affairs in the area of KM in software industry. These are the people who are actually engaged in the sharing and managing of their knowledge through KM systems on a day to day basis. Therefore, their perspective is very important for understanding the actual extent of KM in Indian software industry.

The perceptual world of a software manager is different from the perceptual world of software engineers. Therefore, it is equally important to know about the software engineers' perception for the development of an organisation. This paper justifies the need of the research and analyses the software engineers' perception regarding KM system whether they have adapted happily or is there any problem to be solved for further improvement.

II. OBJECTIVE OF THE STUDY

The objective of this paper is to analyse the perceptions of software engineers working in software organizations about knowledge management practices adopted by them. The study also tests the following natural or alternative hypotheses: Software engineers are acquainted with the concepts and tools of knowledge management (H_{A1}); and Software organisations have knowledge repository or a KM software system in their organizations (H_{A2}).

[1] Leif Edvinsson, Brain of the year '98, Director of Intellectual Capital, Skandia Insurance Co.

[2] Scott Eliot, Director Knowledge Management Product Groups, Lotus (KMWorld 2001)

[3] Kevin Abley (Capgemini) in OR Society Conference on Knowledge Management, London, 1998

III. RESEARCH METHODOLOGY

For the purpose of this study, a questionnaire was prepared and administered to the software engineers to get their views on various dimensions of KM practices used in the industry. The process of developing the questionnaires for this study was based on generally accepted psychometric principles of instrument design. The pilot testing of the survey was carried out on 20 software engineers taken from two different software companies before execution of the questionnaire. Internal consistency analysis using Cronbach's coefficient alpha and detailed item analysis based on Nunnally's method were conducted on the inputs from the pilot testing of the questionnaire. Data collected through questionnaire has been efficiently and suitably tabulated. The data has been analyzed and interpreted using suitable statistical tools such as averages, standard deviation, chi-square test, and t-test. Before applying statistical tools, normalcy of the data was ensured through appropriate measures. Ranking method is also used for various conclusions where ranking is made on the basis of average and total score. The NASSCOM members list formed the database of the software companies for the study. The software companies were classified into three categories on the basis of employee strength - Companies having employees up to 500 were designated as Small companies; companies having employees between 501 and 5,000 were classified as Medium companies; and companies with more than 5,000 employees were recognized as Large companies. Accordingly, all the software engineering organisations, both in public and private sector, developing software and/or providing consultancy, form the universe of the study. As it was not possible to cover the whole universe of the study, it was considered appropriate to go by the sampling technique. A sample of 302 software engineers was taken, drawing 100 each from three types of software companies on the basis of stratified random sampling technique. Table I highlights the socio-economic background of the software engineers, interviewed with the help of a questionnaire.

TABLE I. DEMOGRAPHIC PROFILE OF THE RESPONDENTS

Group /Sub Group	Number	%age
Type of SE Company		
Small	100	33.11
Medium	100	33.11
Large	102	33.77
Age Group		
Below 25	34	11.26
25-35	121	40.07
36-45	109	36.09
46-55	29	09.60
Above 55	9	2.98
Work Experience		
Below 1 yr	74	24.50
1-3 yrs	50	16.56
3- 5 yrs	28	9.28
Above 5 yrs	150	49.67
Qualification		
Graduate	70	23.18
Post Graduate	79	26.16
Professional	144	47.68
Ph.D.	09	2.98
Total	302	100.00

Table I reveals that out of 302 Software engineers, 40% belongs to age group of 25-35 and 36% are of 36-45 years of age and the remaining are either less than 25 years or above 46 years. The table reveals that maximum software engineers are above 5 years of domain experience. Education-wise 144 software engineers (48%) have some professional qualification, 70 (23%) software engineers are graduates and 79 (26%) software engineers are post-graduates.

IV. LITERATURE SURVEY

Knowledge management in software engineering is somewhat distanced from mainstream KM and the reason cited for this absence of software engineering in the wider KM literature is a tendency for discussion of such topics to take place only at conferences for the software engineering community [1]. Overview of works published on knowledge management in the area of software engineering has been found in the exhaustive survey of literature. An overview of KM in software engineering, focusing on motivations for knowledge management, approaches to knowledge management and factors that are important when implementing KM strategies in software engineering organisations has been given in [2]. A detailed account of types of software tools relevant for knowledge management, ranging from document and content management tools to collaboration tools and tools for competence management has been given in [3]. Further, a description of KMS in companies is found in literature [4]. They also provide a list of key factors of success for implementing KMS in organisations. Another landmark study in the field of KM in SE is given by [5]. They provide an insight into the problems faced by small- to medium-sized organisations in applying KM techniques in SE. They compliment postmortem reviews and experience reports as two approaches suitable for collecting software development knowledge and conclude that lightweight postmortem reviews are more suited to software development, while experience reports fit better to client relationships and interaction. It is stated that KM compliments existing SPI methods and is not a replacement to any of these approaches [6]. They suggest that both formal and informal knowledge sharing between software developers must be supported and facilitated by organisations. Three categories of KM activity in SE are rendered as purpose of outputs, scope of inputs and effort required to process inputs. A number of options for implementing and using KM systems for SE are also advanced, such as expert identification, the creation of KM champions, document management and using predictive modeling to direct decision-making. The literature for studies of knowledge management initiatives in software engineering has been surveyed and found eight lessons learned reports, which are characterized after what actions companies took, what the effects of the actions were, what benefits are reported and what kind of knowledge management strategies were used [7]. The work on KM in SE is divided into two major groups: technical development for effective KM, and research that examines the effect of KM on an organisation. If we look at the work on the actual use of knowledge management in an organisation, we find much less in the literature. Many tools have been designed to support KM in software development. Specifically, EMS [8], Case Based Reasoning (CBR) for retaining and retrieving experience [9],

CBR for building learning software organisations have been thoroughly discussed [10]. Several works have explained the use of KM systems to support software engineering tasks [11] - [12]. Reference [11] demonstrates the use of KM in SE by building an experience repository to document experiences captured during the software process definition. A framework to facilitate the capturing, storing and sharing knowledge at project level as well as at organisation level is given [12]. The major focus of the proposed framework is to support planning, designing and coding phases of the software development process. Studies are found which equate software processes with knowledge processes, i.e. software processes are structured within a KM framework [13]. Literature also relates improvement in software development with appropriate related knowledge content and structure and engaging in planning activity [14]. From the thorough analysis of the available literature, it is found that there is dearth of empirical research on the perceptions of users of KM systems in software engineering organizations. The present study was envisaged with this aim.

V. FINDINGS AND DISCUSSIONS

A. *Familiarity with KM concepts and tools*

In small organisations, 39% respondents know to some extent about KM concepts (cf. Table II). Similarly, in medium and large organizations, 54% and 42% respectively know somewhat about knowledge management. On the basis of age-profile of the respondents, less than 50% respondents are somewhat familiar with the concepts and tools for managing knowledge. On the other hand, less than 60% respondents know KM to some extent on the basis of their work experience. Qualification-wise, below 35% respondents are familiar to a large extent about KM. Overall, 63.67% respondents have know-how about KM concepts and tools and techniques for managing knowledge. Statistically, co-efficient of variation reveals that there is more variability in the opinion of large company respondents and more consistency in small and medium organisation respondents (cf. Table III). Overall, WAS of three organisation groups is insignificant because it is less than 1. The chi-square test shows that the differences in the opinions of organisation-group respondents is significant at 1% LOS, thus leading to the rejection of null hypothesis (H01: The software engineers are not acquainted with the concepts and tools of knowledge management) and hence the result that the software engineers are familiar with KM concepts and tools. The t-test expresses the significant difference in small and medium organisations at 1% LOS.

TABLE II. FAMILIARITY WITH KM CONCEPTS AND TOOLS

Group /Sub Group	Very Little	Little	Cant say	Some what	Very Much	$\chi 2$	WAS	Mean	S.D.	CV
Type										
Small	4.00	19.00	19.00	39.00	19.00	52.62**	0.50	3.50	1.12	32.00
Medium	6.00	19.00	6.00	54.00	15.00		0.53	3.53	1.14	32.29
Large	7.00	20.00	9.00	42.00	22.00		0.52	3.52	1.23	34.94
Age										
Below 25	6.76	18.92	8.11	39.19	27.03		0.61	3.61	1.25	34.63
25-35	2.52	19.33	11.76	47.90	18.49		0.61	3.61	1.07	29.64
36-45	5.45	21.82	16.36	49.09	7.27	79.04**	0.31	3.31	1.06	32.02
46-55	11.90	16.67	9.52	47.62	14.29		0.36	3.36	1.25	37.20
Above 55	10.00	20.00	10.00	20.00	40.00		0.60	3.60	1.43	39.72
Experience										
Below 1 yr	5.26	23.16	15.79	37.89	17.89		0.40	3.40	1.17	34.41
1-3 yrs	3.95	14.47	15.79	40.79	25.00	116.44**	0.68	3.68	1.11	30.16
3-5 yrs	8.82	14.71	2.94	57.35	16.18		0.57	3.57	1.18	33.05
Above 5 yrs		25.00	50.00	25.00			0.00	3.00	0.71	23.67
Qualification										
Ph. D.	13.79	17.24	3.45	31.03	34.48		0.55	3.55	1.45	40.85
Graduate	0.98	19.61	13.73	42.16	23.53	107.32**	0.68	3.68	1.07	29.08
Post Grad.	9.01	18.02	14.41	45.05	13.51		0.36	3.36	1.18	35.12
Professional	3.45	22.41	5.17	56.90	12.07		0.52	3.52	1.07	30.40
Industry Average	5.67	19.33	11.33	45.00	18.67		0.52	3.52	1.16	32.95

** significant at 1%

TABLE III. SIGNIFICANCE OF DIFFERENCE OF PROPORTIONS

Comparison	p1	p2	t-values
1 Vs. 2	0.58	0.69	3.23**
1 Vs. 3	0.58	0.64	1.74
2 Vs. 3	0.69	0.64	1.50

** significant at 1%

B. *Knowledge Repository/ KM Software System in Organisations*

It was attempted to judge how far the SE organisations which have invested hugely in technology provide platforms for acquisition and sharing of knowledge through KM software systems or do SE companies have knowledge repositories of some sort where accumulated organisational knowledge is stored for future reuse. Organisation group-wise, in small

companies, 92% of the respondents say their organisations do not provide any formal knowledge repository and KM software systems (cf. Table IV). Of medium and large companies, 93% and 90% of the respondents respectively state that SE companies do not have any repository for storing knowledge. Age group-wise, majority of the respondents say that companies do not have any knowledge repository or KM software system in place. 86.49% respondents of below 25 years and 90% respondents of more than 55 years of age also gave the same answer. Work experience-wise also, majority of the respondents state that their organisations do not have any formal knowledge repository or KM software systems. The same is the view given by the majority of the respondents on the basis of qualification. Overall, almost 92% respondents confirm the absence of any organisational knowledge repository system and any KM software in the SE environment. The chi-square test reveals that the results are statistically insignificant both at 1% and 5% LOS. Thus, the null hypothesis (H02: SE organisations do not have any knowledge repository or a KM software system) is accepted.

TABLE IV. AVAILABILITY OF KNOWLEDGE REPOSITORY/ KM SOFTWARE SYSTEM IN ORGANISATIONS

Group /Sub Group	Yes	No	$\chi 2$
Organisation Group			
Small	8.00	92.00	
Medium	7.00	93.00	2.44
Large	10.00	90.00	
Age Group			
Below 25	13.51	86.49	
25-35	5.88	94.12	
36-45	7.27	92.73	12..82
46-55	7.14	92.86	
Above 55	10.00	90.00	
Work Experience			
Below 1 yr	8.42	91.58	
1-3 yrs	13.16	86.84	14.27
3-5 yrs	7.35	92.65	
Above 5 yrs	3.77	96.23	
Qualification			
Ph. D.	6.90	93.10	
Graduate	12.75	87.25	10.32
Post Grad.	6.31	93.69	
Professional	5.17	94.83	
Industry Average	8.33	91.67	

C. Preference for Source of Information

Table V reflects the fact that majority of the respondents prefer the most the sources outside their organisational knowledge sources like Internet to look for the problem-solving information. Contacting a fellow worker or colleague is at the second rank followed by the corporate knowledge repository. The main reason behind the least average score to the knowledge repository could be the absence of any such source or the repository could be ill-managed or not regularly updated.

TABLE V. PREFERENCE FOR SOURCE OF INFORMATION

Source of information	Average Rank	Average Score	Ranks
Corporate knowledge repository	2.17	44.19	3
Outside sources, e.g., Internet	1.88	54.04	1
Co-worker	1.95	51.77	2

D. Benefits of Documenting SE Knowledge

The software engineers were asked to rank the benefits they perceive the well documented SE knowledge could provide to their projects. In response to this, the shorter activity time appeared to be the most important benefit of documenting the SE project knowledge. This is followed by the re-usability advantage at second rank though the average score is much poor (65.69) than shorter activity time (83.55). But re-usability is the core motivation behind knowledge management in software engineering. From the average score in Table VI, it is evident that better product quality is another benefit of documenting the SE projects knowledge, according to the Software engineers, though reduced budget and other product cost factors do not get that much importance in Software engineers viewpoint.

TABLE VI. BENEFITS OF WELL DOCUMENTED SE KNOWLEDGE

Benefits of well documented SE knowledge	Average Rank	Average Score	Ranks
Shorter activity time	1.65	83.55	1
Cheaper product	4.86	37.66	4
Better product quality	4.86	37.77	3
Reduced activity budget	4.94	36.58	5
Re-usability	2.90	65.69	2

E. Reasons behind not re-using experience

In order to know the reasons for the lack of knowledge re-use in software engineering organisations, the respondents were asked to rank the importance they attach to the reasons behind their not re-using experience in their working. Table VII reflects that Software engineers cite the lack of mutual trust among Software engineers as they rank the option “others don’t share experience” as the first reason followed by the lack of documentation of knowledge at the second rank. The next reason for not re-using experience with average score of almost 50 is that project members do not discuss things in a well organized and formal manner so that there is a proper flow of experience sharing among team members. Lack of monetary compensation or other benefits and incentives for re-using experience has also been cited as a reason behind not re-using experience.

TABLE VII. REASONS FOR NOT USING EXPERIENCE

Reasons for not using experience	Average Rank	Average Score	Ranks
Lack of incentives/ compensation for reuse	3.60	48.36	4
I would rather be seen as an innovative software professional	4.10	40.03	6
Others don’t share experience	2.26	70.71	1
Nothing is documented well enough	3.27	53.79	2
Project teams don’t discuss things	3.53	49.49	3
Inadequate IT/ software support	3.65	47.47	5

F. KM Technologies

The software engineers were asked about the technology support tools existing in their organisations for knowledge management. The respondents were asked to rate the various KM technologies in terms of their frequency of use as well as their effectiveness in helping them manage their knowledge. As it is clear from Table VIII, the majority of the respondents (83%) reported the Internet Browsers and Search Engines as the most frequently used KM tools in their organisations, followed by Email and Groupware systems (76.5%). Corporate Intranet/ Extranet and Communities of Practice are the other frequently used IT tools for managing the knowledge by employees in software organisations. 74% of the respondents stated Multimedia Repositories to be the least frequently used tool, followed by Teleconferencing/ Videoconferencing reported by 69% respondents to be either used with very low frequency or not used at all by them in managing their knowledge. Also half the respondents reported that they never use Agents/ Filters for KM in their organisations. External Server Services also find very low usage (8.7%). Workflow Management Systems and Data mining and knowledge discovery tools are other technology components which find deplorable use by software engineers in their routine knowledge management activity.

Majority of the respondents (78.8%) feel that Best Practices Repositories are the most effective technology support tool for knowledge management (cf. Table IX). E-mail and Groupware Systems are the next technology perceived to be very effective in managing knowledge by 77.8% of the respondents. 74% of the software engineers surveyed stated Communities of Practice to be another effective KM technology support tool. On the other hand, majority of the respondents (79.4%) feel that External Server Services are less effective in managing knowledge in organisations, followed by WWW Server/ Communication Software which is perceived to be less effective KM tool by 67.7% respondents.

TABLE VIII. FREQUENCY DISTRIBUTION OF TECHNOLOGY SUPPORT TOOLS USED FOR KM

Technology Support Tools for KM	Very High	Fairly High	Moderate	Fairly Low	Very Low	Not At All	Can't Say
Corporate Intranet/ Extranet	97 (31.3)	90 (29.0)	47 (15.2)	23 (7.4)	10 (3.2)	28 (9.0)	15 (4.8)
Browsers/ Search engines	190 (61.3)	67 (21.6)	20 (6.5)	15 (4.8)	3 (1.0)	0	15 (4.8)
Search and retrieval tools	93 (30.0)	3 (1.0)	75 (24.2)	15 (4.8)	2 (0.7)	115 (37.1)	7 (2.3)
Agents/ Filters	53 (17.1)	20 (6.5)	50 (16.1)	10 (3.2)	10 (3.2)	155 (50.0)	12 (3.9)
E-mail and groupware systems	186 (60.0)	51 (16.5)	10 (3.2)	30 (9.7)	3 (1.0)	0	30 (9.7)
WWW server/ Communication software	20 (6.5)	47 (15.2)	27 (8.7)	29 (9.4)	47 (15.2)	128 (41.3)	12 (3.9)
Data repositories	112 (36.1)	8 (2.6)	77 (24.8)	20 (6.5)	2 (0.7)	85 (27.4)	6 (1.9)
Multimedia repositories	13 (4.2)	10 (3.2)	23 (7.4)	8 (2.6)	215 (69.4)	15 (4.8)	26 (8.4)
Best practices repositories	30 (9.7)	25 (8.1)	38 (12.3)	30 (9.7)	165 (53.2)	12 (3.9)	10 (3.2)
Data mining and knowledge discovery tools	32 (10.3)	67 (21.6)	47 (15.2)	27 (8.7)	32 (10.3)	95 (30.6)	10 (3.2)
External server services	17 (5.5)	10 (3.2)	47 (15.2)	27 (8.7)	62 (20.0)	132 (42.6)	15 (4.8)
Document management systems	8 (2.6)	110 (35.5)	62 (20.0)	20 (6.5)	8 (2.6)	100 (32.3)	2 (0.7)
Workflow management systems	8 (2.6)	7 (2.3)	12 (3.9)	128 (41.3)	82 (26.5)	67 (21.6)	6 (1.9)
Teleconferencing/ Videoconferencing	15 (4.8)	15 (4.8)	43 (13.9)	12 (3.9)	9 (2.9)	205 (66.1)	11 (3.5)
Communities of Practice (CoP)	105 (33.9)	60 (19.4)	56 (18.1)	15 (4.8)	15 (4.8)	52 (16.8)	7 (2.3)

TABLE IX. FREQUENCY DISTRIBUTION OF EFFECTIVENESS OF KM TECHNOLOGY TOOLS

Technology Support Tools for KM	Highly Effective	Fairly Effective	Moderately Effective	Less Effective	Very Less Effective	Not At All Effective	Can't Say
Corporate Intranet/ Extranet	136 (43.9)	84 (27.1)	34 (11.0)	29 (9.4)	27 (8.7)	0	0
Browsers/ Search engines	162 (52.3)	60 (19.4)	35 (11.3)	5 (1.6)	15 (4.8)	0	33 (10.6)
Search and retrieval tools	100 (32.3)	13 (4.2)	52 (16.8)	11 (3.5)	4 (1.3)	113 (36.5)	17 (5.5)
Agents/ Filters	46 (14.8)	38 (12.3)	41 (13.2)	61 (19.7)	16 (5.2)	102 (32.9)	6 (1.9)
E-mail and groupware systems	201 (64.8)	40 (13.0)	12 (3.9)	8 (2.6)	8 (2.6)	30 (9.7)	11 (3.5)
WWW server/ Communication software	32 (10.3)	40 (12.9)	16 (5.2)	45 (14.5)	65 (20.9)	100 (32.3)	12 (3.9)
Data repositories	140 (45.2)	86 (27.7)	27 (8.7)	30 (9.7)	6 (1.9)	15 (4.8)	6 (1.9)
Multimedia repositories	31 (10.0)	74 (23.9)	109 (35.2)	58 (18.7)	18 (5.8)	10 (3.2)	10 (3.2)
Best practices repositories	131 (42.3)	113 (36.5)	46 (14.8)	16 (5.2)	4 (1.3)	0	0
Data mining and knowledge discovery tools	6 (1.9)	99 (31.9)	67 (21.6)	36 (11.6)	76 (24.5)	16 (5.2)	10 (3.2)
External server services	11 (3.5)	15 (4.8)	20 (6.5)	74 (23.9)	81 (26.1)	91 (29.4)	18 (5.8)
Document management systems	146 (47.1)	14 (4.5)	48 (15.5)	17 (5.5)	30 (9.7)	38 (12.3)	17 (5.5)
Workflow management systems	104 (33.5)	16 (5.2)	62 (20.0)	18 (5.8)	15 (4.8)	60 (19.4)	35 (11.3)
Teleconferencing/ Videoconferencing	23 (7.4)	69 (22.3)	90 (29.0)	68 (21.9)	39 (12.6)	6 (1.9)	15 (4.8)
Communities of Practice (CoP)	119 (38.4)	110 (35.5)	33 (10.6)	23 (7.4)	17 (5.5)	0	8 (2.6)

VI. CONCLUSIONS

Overall, a large majority of the software engineers have know-how about KM concepts and tools and techniques for managing knowledge. As per the employees' survey, there is no KM software system or knowledge repository available in SE organisations. Overall, almost 92% software engineers confirm the absence of any organisational knowledge repository system and any KM software in the SE environment. In the absence of any knowledge repository within their organisations, majority of the employees prefer the most the sources outside their organisational knowledge sources like Internet to look for the problem-solving information. Contacting a fellow worker or colleague is at the second rank. It is believed that re-usability of knowledge is the core motivation behind knowledge management practices in software engineering. But from the employees' point of view, shorter activity time appeared to be the most important benefit of documenting the SE project knowledge, followed by the re-usability advantage. Also, reduced budget and other product cost factors do not get that much importance in software engineers' viewpoint. Software engineers cite the lack of mutual trust among themselves and the lack of documentation of knowledge as the most important reasons behind their not reusing experience within their work environment. Though lack of monetary compensation or other benefits and incentives for re-using experience have also been cited as a reason behind not re-using experience but this does not find merit among majority of the employees.

REFERENCES

[1] J. S. Edwards, "Managing software engineers and their knowledge," In Managing software engineering knowledge, A. Aurum, R. Jeffrey, C. Wohlin and M. Handzic, Eds. Springer-Verlag, 2003, pp. 5-27.

[2] I. Rus, M. Lindvall and S. S. Sinha, Knowledge Management in Software Engineering - A DACS State-of-the-Art Report. Fraunhofer Center for Experimental Software Engineering and the University of Maryland, Maryland, 2001.

[3] M. Lindvall, I. Rus, R. Jammalamadaka and R. Thakker, Software Tools for Knowledge Management. Technical report. DoD Data Analysis Center for Software. N. Y.: Rome, 2001.

[4] R. Conradi and T. Dingsoyr, Software experience bases: a consolidated evaluation and status report. Proceedings of the 2nd International Conference on Product Focused Software Process Improvement (PROFES, 2000), pp. 391-406, 2000.

[5] T. Dingsoyr, N. Brede Moe and O. Nytro, Augmenting Experience reports with Lightweight Postmortem Reviews. LNCS, vol. 2188, pp. 167-181. Berlin Heidelberg: Springer-Verlag, 2001.

[6] I. Rus and M. Lindvall, "Knowledge management in software engineering," IEEE Software, vol. 19(3), pp. 26–38, 2002.

[7] T. Dingsoyr and R. Conradi, "A survey of case studies of the use of knowledge management in software engineering," International Journal of Software Engineering and Knowledge Engineering, vol. 12(4), pp. 391-414, 2002.

[8] C. Seaman, M. Mendonca, V. R. Basili and Y.-M. Kim, An experience management system for a software consulting organisation. In Proceedings of the 24th Annual NASA Software Engineering Workshop, 1999.

[9] K.-D. Althoff, A. Birk, C. G. V. Wangenheim and C. Tautz, CBR for experimental software engineering. In Proceedings of the Case-Based Reasoning Technology - From Foundations to Application. Chapter 9, pp. 235-254. Heidelberg: Springer, 1998.

[10] K.-D. Althoff, F. Bomarius and C. Tautz, Using case-based reasoning technology to build learning software organizations. In Proceedings of the Interdisciplinary Workshop on Building, Maintaining and Using Organisational Memories, 1998.

[11] L. M. S. Borges and R. A. Falbo, Managing Software Process Knowledge. In Proceeding of the CSITeA'2002, 2002.

[12] M. Markkula, Knowledge Management in Software Engineering Projects. In Proceedings of the 11th International Conference on Software Engineering and Knowledge Engineering. Germany: Kaiserslautern, 1999.

[13] P. Kess and H. Haapasalo, "Knowledge creation through a project review process in software production," International Journal of Production Economics, vol. 80(1), pp. 49-55, 2002.

[14] A. Aurum, R. Jeffery, C. Wohlin and M. Handzic, Managing software engineering knowledge. Heidelberg, Germany: Springer, 2003.