

An Empirical Study of an Informal Knowledge Repository in a Medium-Sized Software Consulting Company

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Abstract

Numerous studies have been conducted on design and architecture of knowledge repositories. This paper addresses the need for looking at practices where knowledge repositories are actually used in concrete work situations. This insight should be used when developing knowledge repositories in the future.

Through methods inspired by ethnography this paper investigates how an unstructured knowledge repository is used for different purposes by software developers and managers in a medium-sized software consulting company. The repository is a part of the company's knowledge management tool suite on the Intranet. We found five distinct ways of using the tool, from solving specific technical problems to getting an overview of competence in the company. We highlight the importance of informal organization and the social integration of the tool in the daily work practices of the company.

1. Introduction

Knowledge Management has attracted a lot of attention in various business domains in the past years, including software engineering [1]. Reasons for the interest in knowledge management are that:

- Software Engineering is knowledge-intensive work; the main asset in software companies is what has been called the “intellectual capital”.
- In order to improve software development, the management of knowledge has to be improved as well.

Hanssen et. al. [2] divide between two main strategies for knowledge management:

- Codification - to systematize and store information that represents the knowledge of the company, and make this available for the people in the company.
- Personalization - to support the flow of information in a company by storing information about

knowledge sources, like a “yellow pages” of in-house expertise.

Most of the work that has been reported on knowledge management in the software engineering literature (often referred to as work on “experience factory”) are from large organizations, such as Daimler Chrysler [3, 4], The NASA Software Engineering Laboratory [5] and Ericsson [6]. See [7] for an overview.

Such organizations can devote a lot of resources on organizational issues such as knowledge management. Many of the software engineering companies have opted for a strategy involving both codification and personalization.

Codification is the strategy that requires the heaviest investment – both in codifying knowledge that exist tacit in people or teams, and also in having an infrastructure for distributing it in the organization.

It is interesting to see how smaller (in this case: medium-size) organizations cope with a codification strategy on scarce resources. In particular, we will examine how a medium-sized software consulting company is using a knowledge repository. But first, we will describe knowledge management tools more in general in the next section.

2. Knowledge management tools

When we talk of tools for knowledge management, we will mean tools that have several users, and are widely available for employees in an organization. This is usually what we can call Intranet tools, that support knowledge management [8] in “at least three ways: 1) Providing compression of time and space among the users. 2) Offering the flexibility to exchange information, and: 3) Supporting information transfer and organizational networking independent of direct contacts between the users” .

There are many dimensions for describing knowledge management tools. Ruggles [9] mentions tools that “generate knowledge”, where tools for data mining (to

discover new patterns in data) can be an example. Further, we have “knowledge codification tools” to make knowledge available for others, and “knowledge transfer tools” to decrease problems with time and space when communicating in an organization.

Another dimension is whether the tools are “active” [10] or “passive”. By active tools, we mean tools that notify users when it is likely that users require some kind of knowledge. Passive tools require a user to actively seek knowledge without any system support.

We also find another way of categorizing the tools other than the ones mentioned so far, from the book *Information Technology for Knowledge Management* [11]. The authors divide technology for a “corporate memory” into four parts, shown in Figure 1:

- Knowledge repositories and libraries - tools for handling repositories of knowledge in the form of documents.
- Communities of knowledge workers - tools to support communities of practice in work; like organizing workspaces for communities for online discussions and distributed work.
- Knowledge cartography - tools for mapping and categorizing knowledge, from core competence in a company to individual expertise; what we can refer to as “metaknowledge”.
- The flow of knowledge - here we find tools for supporting the interaction between tacit knowledge, explicit knowledge and metaknowledge; that is, that combines the three parts above.

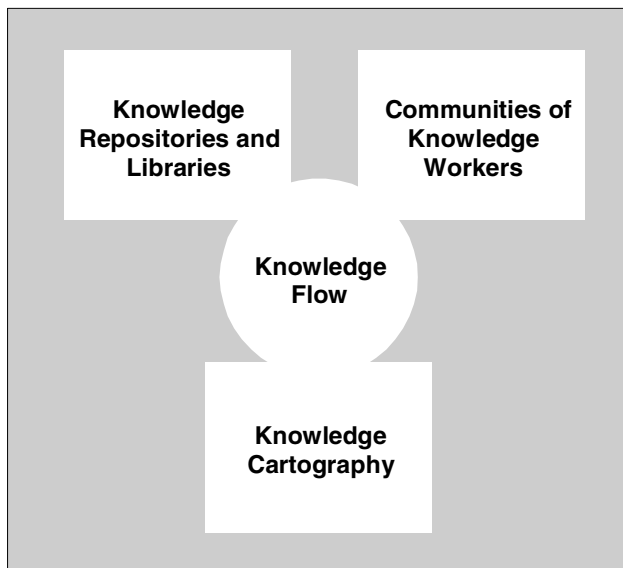


Figure 1. Types of Knowledge Management Tools or Architecture (Borghoff and Pareschi).

Now, we describe knowledge repositories and libraries in more detail.

2.1 Knowledge repositories

Liebowitz and Beckman [12] define knowledge repositories as an “on-line computer-based storehouse of expertise, knowledge, experiences, and documentation about a particular domain of expertise. In creating a knowledge repository, knowledge is collected, summarized, and integrated across sources”.

Such repositories are sometimes referred to as “experience bases” or “corporate memories”.

The repository can either be filled with knowledge by what van Heijst et. al [13] call “passive collection” – where workers themselves recognize what knowledge has sufficient value to be stored in the repository, or “active collection” – where some people in the organization are scanning communication processes to detect knowledge.

Davenport and Prusak [14] divide between three types of knowledge repositories:

1. *External knowledge repositories* (such as competitive intelligence).
2. *Structured internal knowledge repositories* (such as research reports, product-oriented market material).
3. *Informal internal knowledge repositories* (such as “lessons learned”).

There are many examples of informal knowledge repositories from the software engineering literature.

The University of Nebraska-Lincoln has developed a research prototype tool for knowledge management support in software development called BORE [15]: This is a tool which contains information in cases about problem solving experience, and descriptions of resources like tools, projects, people and development methods. These descriptions are used to find relevant solutions when software developers are faced with a new problem.

Another prototype system, is CODE - a general-purpose knowledge management tool which serves as a medium for knowledge capture, transfer and iteration, as well as editing or “packaging” knowledge to make it easily available [16].

The Fraunhofer Institute for Experimental Software Engineering has developed “COIN Experience Factory” – a tool for capturing experience from research projects in software engineering [17].

ICL Finland has developed a knowledge management system, which includes a repository divided in two parts [18]:

- Structured internal knowledge: includes databases for sales and marketing information and employee competence, as well as examples of frequently used

documents, templates, software components, best practice information, and research reports.

- Informal internal knowledge: includes electronic discussion forums, news and “project folders”. The project folders contain overviews of the projects, news and important announcements, technical documents and reusable components (for a complete list, refer to the paper cited above).

What kind of knowledge can we expect to find in these repositories? Robert Taylor [19] who has been working in the “information use” field, divides information into seven groups: *Enlightenment* – to use information for ones own amusement, an example can be company-internal news that are not fully relevant to normal work. *Problem understanding* – using information to increase the comprehension of a problem. *Instrumental* – follow guidelines or procedures. *Factual* – use information to determine facts. *Confirmational* – use information to verify other information. *Projective* – make forecasts or scenarios. *Personal or political* – use information to develop relationships.

There has been little work describing how knowledge repositories are used in practice. That is what we aim to do in this paper, and we will be using the classification developed by Taylor in examining the types of usage later.

3. Research method

To obtain the data for the research reported in this article, we used a method inspired by ethnography [20]. For the analysis, we used grounded theory [21]. We observed for 4 weeks at the software consulting company Computas during the autumn 2000. This company was selected because we knew they had been working with knowledge management for a long time and had some interesting tools. We got access to their Intranet systems, and attended all meetings where all the employees were invited as well as meetings in one project. The project was chosen by Computas: a software development project for a public customer. We interviewed eight developers and six managers. Three developers worked in the project we followed, the others had got awards as “knowledge sharers of the month”. We interviewed the project leader in the project we followed, as well as two process owners for knowledge-management related processes. We also interviewed two general managers, and three managers who had got a “knowledge sharer of the month” award.

In addition we conducted a so-called Learning History [22] from the development and implementation process of an informal knowledge repository. This entailed

interviews and process-meetings with six central contributors.

3.1 Data collection

We used the following data sources:

- Interviews - we used semi-structured interviews with open-ended questions. The interviews were transcribed in full, and in total, we got around 120 pages of transcripts for analysis (also on other knowledge management tools than the knowledge repository). We asked questions like “how do you assess the tools for knowledge management that you have available?”, “what knowledge have you found useful from these tools?” and “when do you use the tools?”.
- Screenshots - we gathered screenshots from different areas of the knowledge management system.
- Pictures - we took pictures of people in normal work-situations to get a better understanding of the workplace and work processes.
- Logbook - we wrote down observations from everyday life in the company in a logbook, together with memorandums from conversations we had, meetings and presentations we attended.

3.2 Data analysis

How did we organize the analysis of the data that was collected? First, we constructed a database with information from the interviews, documents, and our own logbook observations (using N5, a tool for analysis of qualitative research data). We tagged the information to show what kind of source it came from, and applied a simple categorization of the people that were interviewed: managers, project managers, developers, and people responsible for knowledge management.

We searched in this database for areas of interest, and got the information from the different sources. For example, searching this database for the keyword “skill” would result in 43 occurrences in 10 documents.

After that, we analyzed (and “coded”) these chunks of information to find interesting categories that would be usable to build theory later. Would there be any special patterns in what the people were saying? We applied triangulation to see if there were differences between groups of people.

4. The Computas software consulting company

We investigated the usage of a knowledge repository at Computas. Computas is a medium-sized consulting

company based in Norway, developing knowledge-based systems for a variety of customers. When it was founded in 1985, it was a spin-off of a larger, more general consulting company, and according to a Norwegian newspaper, "an international staff of specialists will develop expert systems that above all will cover the needs of the demanding oil industry". The newspaper continues: the company shall "offer services in industrial use of knowledge-based expert systems, and software in the field of artificial intelligence".

Since then, the company has grown organically, from just a few employees in the beginning, to around 150 in year 2000. The company has also extended their services and market.

The company's core competence is knowledge management, process-support and implementation of intelligent systems for knowledge-based behavior and knowledge processes.

Important technology for delivering these solutions, are "network and database technology, document management and search, web technology, work process support, coordination technology, artificial intelligence and data mining". The underlying technology for this is Java, Microsoft and SmallTalk technology.

Customers come from three main groups, the public sector, the marine sector and industry. Projects for these customers typically include 3-10 people working for at least half a year, and in some cases for several years. In projects, the participants take on different roles, as "project manager", "technical manager", and "customer contact".

The company is organized around "processes" and "projects". The "process organization" means that they have defined important areas for the company, which has one "process manager", usually with support from a small team. Examples of processes are "Management", "Delivery" and "Support", and also "Knowledge Management". Many employees in the company are responsible for some process issue while working on a project. Most employees have a university degree in Computer Science, and some have a Ph.D. degree, especially in Artificial Intelligence.

The Knowledge Management Process at Computas includes handing out a prize to the "knowledge sharer of the month" in order to promote knowledge management. This prize has been given to people who share their knowledge through Computas's knowledge management tools, or through oral communication.

On first sight, the organization seems very "flat" - with people rotating between different "process manager" positions. But as one employee told us, "of course, there is a hierarchy here as well, it is just not written down any place".

When working in projects, most of the development has traditionally been done "in-house", and not at the customer's site. But it is now getting more frequent that employees work in the customer companies. When we were visiting the company, around 20% of the staff were working somewhere else than in the main company building.

5. The knowledge repository: Well of Experience

Computas has a variety of knowledge management tools available on their Intranet, see [23] for an overview. One of the tools is the unstructured knowledge repository "Well of experience", or WoX. According to Davenport and Prusak's classification it would be an informal internal knowledge repository. It is a small tool for capturing knowledge that would normally be written on yellow stickers, what the company calls "collective yellow stickers". The yellow sticker analogy was in fact a major midwife aid in the initial understanding and practice for getting the system to be used. "Rather than using the post-it note, write your private yellow sticker in the WoX system so others can make use of them". That way the employees always know that there will be some information of use in the system. This way of contributing to the repository is what Heijst et al. describes as a passive collection process.

WoX contains everything from the phone-number to the pizza restaurant on the corner to "how you set up SmallTalk on a special platform". You find information by searching an unstructured database, and can give "credits" to notes that you find useful. Notes with more accumulated credits about an issue show up before notes with less. The tool contains a mechanism to give feedback to the person who wrote the note, and there has been a kind of competition in the company to get the most credits. One developer described this repository as "quite useful - it is simple enough to be used in practice". Another said "you can use WoX as a personal notice board where you can put the same information as you would on a yellow sticker. It's fast to insert notes, and you do not have to worry about where to put it".

When we visited the company, it contained around 600 "experience notes". In 2003, WoX contained around 990 notes and have had about 15,000 searches by 260 users (some customers are also allowed to use the tool in addition to Computas employees). There are 2,300 keywords in the repository.

Employees can search the knowledge repository using a simple search interface available on the company Intranet, see Figure 2. The functionality is simple keyword search, and you can browse the notes and

comments on other people's notes that you have contributed, the credits your notes have gotten from others, the latest 10 notes that have been added to the repository, popular keywords as well as the notes with the most credits. In the simple search, you can select if you want to search in the text and subject information of the notes or also in the comments on notes.

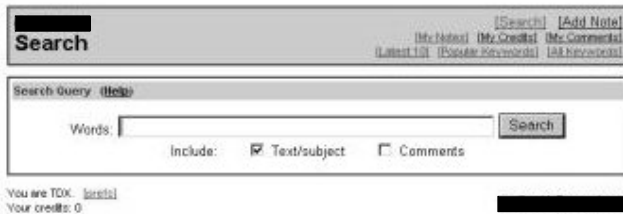


Figure 2. The "Well of experience" (WoX) search interface for the knowledge repository of "experience notes".

Examples of such notes are "how to reduce the size of your profile in Windows NT", "How to remove garbage from an image in SmallTalk", "Technical problems with cookies" and "An implementation of the soundex algorithm in Java". See Figure 3 for a complete example of a note.

Each note contains a subject, a descriptive text, as well as keywords (the one submitting the note defines the keyword, there is no predefined list of keywords), author information and the date it was submitted. When viewing a note, everyone can add a comment to the note, give the note a credit or mail the note as a tip to someone else.

According to one developer "people are very good at submitting notes when they think that something can be useful for others". A manager described it as "a behavioral arena that people use in different ways, that is creating a culture of knowledge sharing, and even creates expectations and lets people experience that others make use of their knowledge". The tool is promoted by posters which can be found on places that people visit a lot, like the one in Figure 4 which was located just outside the staff restaurant.

When we asked people to describe what kind of tools they were using in their work, almost all of the developers mentioned that they were using WoX. All developers but one (seven out of eight) say that they have written experience notes, and all of them have tried to search for experience notes. Among the managers, much fewer were using it actively. Three out of six did not mention WoX when we asked about knowledge management tools in the company.

Are there areas where the tool has been found not to be effective? At least it is not a space devoted to routines

and reflection: "WoX is not suitable as an arena for routinized knowledge and long strings of reasoning." Another critical factor is that "if a tool like WoX shall be useful, the total amount of available information must reach above a critical mass." Hence, the analogy with the yellow stickers. It was vital to get the consultants themselves to put information into the system.



Figure 3. An example experience note.

Summarizing some of the potentials in WoX, one employee said: "New functionality and technical tips are suitable to be mediated by WoX. Also, it is usable for putting bits of programs and reusable components. Put another way, WoX-notes should be little patterns of applied knowledge engineering".

Based on the material from Computas we found five different types of usage of the knowledge repository:

- Solve a specific technical problem.
- Getting an overview of problem areas.
- Avoiding redundancy in having to explain the same solution to several people.
- Improve individual work situation by adjusting technical tools.
- Finding who has a specific competence in the company.

We describe each of these types of usage in more depth:

5.1 Solve a specific technical problem

The most prominent use of this tool seemed to be in "problem solving". As one developer put it "if you run into a problem, then you can use WoX to see if anyone else in the company has had a similar problem", or "when you sit with a problem that you can't solve, or a strange bug, or if you do not understand why the computer does not behave the way it should".

Another developer says: "It happens that I have been searching and have found things in WoX. Then you do not have to search in other places, and maybe spend two or three days".

It is also a good tool for sharing pieces of code, patterns, and reusable components with others.

A problem with the notes that one developer mentioned, is that "the person that writes something has a certain background, and with that background they presume that when they write 'first you do this, then that...' - that the others also know what to do". Which is not always the case for complicated matters.

5.2 Getting an overview of problem areas

One said: "if I am stuck and wonder about something, usually I remember that it was written somewhere in WoX in fact, and then I go back and find it". An example is some notes about project-startup that this developer will usually go back to when being in that phase, which happens every 6 months or so. Another developer and another manager also said that they would see almost every day what was new "so I know what is in there, and do not have to search for things".

But people do not write about all types of problems as experience notes. Issues that are more "unofficial knowledge" - as one developer put it: "not things that are unethical, but things that you do that could easily be interpreted wrongly by customers, even though I mean we can stand for it" - that kind of issues you do not find any notes about, and that knowledge is transferred through informal oral communication.



Figure 4. "I've been WoX'ing today, have you?". One of several posters promoting the use of the WoX knowledge repository at Computas.

5.3 Avoiding redundancy

Some would use the WoX system to avoid redundancy in the sense of having to explain the same solution to several people. One developer said: "when the third person comes and asks about the same thing - then you realize that it is about time to document it". He would then later tell people who were asking about the new topic to look it up in WoX. WoX notes can be mailed easily by clicking on "Mail Tip to Someone" when looking at the note.

5.4 Improve individual work situation

Others would improve their individual work situation by adjusting technical tools based on information found in WoX. They would find information on how to improve the tools that they use in their daily work, like Outlook, to make them more easy to use. Another example would be to get to know "how to reduce your profile in Windows NT" - which reduces the booting-time of your operating system quite a bit. A third example of a small improvement is a note on how to burn CDs for customers; which explained how to design covers for the CDs so that they look more professional when delivering a final software product.

5.5 Finding competence

The last major category of types of WoX usage we found in Computas was finding who has a specific competence in the company: "Newbies get a shortcut to discover things that I have spent some time to build up. If they browse WoX a bit, they can find that 'this person knows a lot about low-level Windows-patching' and that

‘this person is good at Apache webserver set up’”, one developer said. This function of finding and linking “who knows what” is often an underestimated function of knowledge management systems, and in the case of Computas it overlaps with their “Skills-management” system [24]. The WoX notes gives clues to where to search for further knowledge, and may in this way be said to broaden the opportunity structures for knowledge sharing in Computas [25].

6. Discussion

From our interviews with developers and managers at Computas, it seems that the WoX is a tool that is actively used, and is helpful for several purposes, although the knowledge that it contains is unstructured, and the tool was easy to develop.

We note that managers contribute less frequently to the repository than developers. This might be because the kind of knowledge that is useful for developers is easier to codify than knowledge, say on estimation of software projects, or project management.

If we compare the types of usage we found in our interviews with the categories developed by Taylor, we see that “solving a technical problem” and “improving individual work situation” are types of knowledge that we can classify as “instrumental” – something you would look up and follow. “Avoiding redundancy” is also in this category. “Getting an overview of problem areas” is similar to Taylor’s “problem understanding”. “Finding competence” can be seen as using knowledge as “personal or political”.

Why is it that WoX is a popular tool to use at Computas? There were many other tools in the company that were not used as much. WoX had many users and many different types of usage. One reason can be that this tool serves a purpose that other tools in the company do not. It is like a newsgroup on the Internet in one sense, but contains mostly knowledge that is local to the company. Employees have also been encouraged to contribute with experience notes in the tool – through advertisements in the company as in Figure 4, and also through “commercial banners” at the company Intranet. The tool is also easily accessible from the Intranet that most people at Computas use daily. Another reason can be the use of “credits” – that people get feedback on what they have contributed – and are thus motivated to contribute more. A final reason can be the company emphasis on sharing knowledge, that employees who have written many experience notes get a small prize as the “knowledge sharer of the month”.

One of the topics discussed in Computas is the organization of the WoX system. Should it be structured

or not? For example we found the opinion that too much structure hinders the growth of notes: “We must not construct too many links in WoX. It must not be too formalized. The strength of WoX is that it is organically growing. We have a hierarchy several other places, for example on the [internal] web.” On the other hand, utility of the system to some degree means fast access: “WoX is a bit slow, and I miss the opportunity to browse”.

“When WoX is so unstructured it is difficult to reuse information. I can see a danger that WoX becomes a kind of Internet (in the negative sense). A huge archive where it is difficult to maneuver and find useful information”.

Another discussion in Computas was the explicit integration of WoX with other knowledge management tools, as for instance the Skills Manager. “We have competing mechanisms for knowledge sharing. We have to work more on developing distinct roles for the different electronic mediums we use for sharing knowledge”. As an integrated part of dialogues with customers, for example concerning change requests, WoX could also play a part: “WoX could be used as a channel for change request from customers. WoX should be an integral part of development projects with customers and a central part of communication with them. In this way we could have built a pool of experience concerning the establishment of a system for the customer, a pool that both of us could have utilized”. WoX would then have stored tips for other users and tips for revisions of the system.

7. Conclusion and further work

We have examined how an informal knowledge repository is used in a medium-sized software consulting company. We found that the well of experience, WoX, is especially appreciated amongst developers and used to a wide degree compared to other similar tools in other companies, even though the company is quite small for a codification strategy. We also found that:

- The Knowledge repository is used for different types of instrumental knowledge, as well as knowledge to increase problem understanding, and to strengthen personal and political ties.

The company plans to develop the tool further.

What can we learn from the usage of the knowledge repository at Computas when developing similar tools in other companies? First of all, we think the emphasis on combining an easy to use technical tool, which does not require rigor in contributing with knowledge (the unstructured nature) and the social incentives for use in the company were fruitful.

We think the emphasis on formal structures, techniques and procedures are generally overrated in the software engineering field, while the power of social aspects are underestimated.

Some main discussion points in the company on how to develop the repository further are:

- There has been a discussion in the company on whether to make the knowledge in the tool more structured. Many have opposed as structure can be found in other tools, and would make the tool harder to use.
- The company has raised a discussion on if it should combine the tool with other tools.

Acknowledgement

We are deeply grateful to all employees we have talked to at Computas for sharing their opinions on experience sharing, and especially Hans Karim Djarraya who has been our main contact person. We would further like to thank Gavin Gaudet and the anonymous reviewers for helpful comments.

We are further grateful to the Research Council of Norway for supporting this work through the projects PROFIT and KUNNE.

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