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Recommended Citation
Stirna, J.; Persson, Anne; and Aggestam, Lena, "Building knowledge repositories with enterprise modelling and patterns – from theory to practice" (2006). *ECIS 2006 Proceedings*. 179.
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BUILDING KNOWLEDGE REPOSITORIES WITH ENTERPRISE MODELLING AND PATTERNS – FROM THEORY TO PRACTICE

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Abstract

An approach to building knowledge repositories, Enterprise Knowledge Patterns (EKP), has been developed and applied throughout a number of research projects, most recently in the ELEKTRA, HyperKnowledge[1] and EKLär projects. The EKP approach combines Enterprise Modelling with organisational patterns. Systematic evaluations of applying the approach have been carried out in two of the projects, while the third project is currently running. The aim of this paper is to provide an overview of the evaluation results and to share practical experiences from building knowledge repositories with Enterprise Modelling and organisational patterns. We discuss issues concerning the knowledge content of pattern based knowledge repositories, the language used to express knowledge in organisational patterns and technology support for storing and retrieving knowledge components. .

Keywords: knowledge management, enterprise modelling, organisational patterns

1 INTRODUCTION

Modern organisations need to maintain a high level of innovation in their business and products, which requires them to flexibly adapt to rapid change in their environments. Among the main driving forces in this change process are people and their knowledge. Organisations need to utilise this knowledge in the most efficient way since, in essence, it is part of their competitive advantage. It is therefore that managing experience, competence, knowledge about business processes and best business practices are so important. This knowledge is part of the organisational memory.

The Knowledge Management (KM) process as described in (Figure 1) covers the whole lifecycle of knowledge in an organisation. The cycle is adopted from O'Dell et al (1998) and is similar to the spiral of organisational knowledge creation as presented by Nonaka and Takeuchi (1995).

Creating knowledge can be done in many different ways – running day-to-day business operations, improving existing work routines, restructuring the organisation, planning organisational strategies for the future, etc. Often the creators of knowledge are not aware of this and valuable knowledge may therefore be lost. To prevent this, the knowledge needs to be captured in one way or another. This might require thinking in abstract terms, building models/mind maps, or simply writing down the

[1] The HyperKnowledge Consortium is not associated of affiliated with Logical Water Limited or any of its products

experiences. Most often this should be done in a participative and collaborative way, which enhances one's individual view.

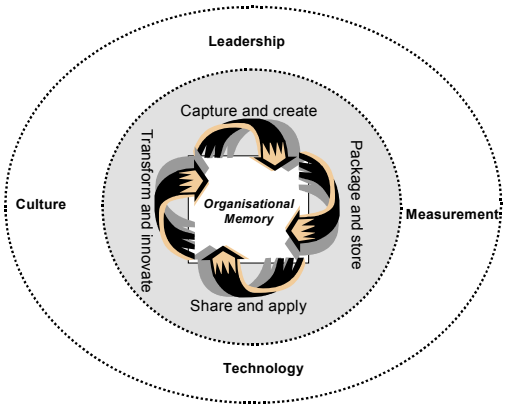


Figure 1: The Knowledge cycle in organisations

Once knowledge is captured, the organisation and its employees are aware of its existence. If the captured knowledge is relevant the next step is to package and store the knowledge so that it is available and can be used by those who need it in the organisation. The key element here is to make the specific knowledge *useful*. This usually requires some degree of generalisation of knowledge. Furthermore it also requires envisioning how each knowledge chunk will be used. The knowledge that is written down in some form usually resides in repositories, manuals, the intranet, etc. However, not everything can be written down. Most often the tacit knowledge is the most important knowledge. In this case we can only write down who knows what, where the knowledge sources are, and how to access it. This also becomes an important part of the organisational/memory knowledge repository. After knowledge is properly documented and stored, it needs to be shared and applied. This is probably the most important task in KM. Knowledge sharing cannot be done mechanistically. It is not enough to install and fill a knowledge repository and expect the organisation to suddenly start sharing knowledge. Therefore, particular attention should be paid to building a knowledge sharing culture in the organisation (supported by e.g. Busch & Richards 2004, Chua & Lam 2005. Davenport & Prusak 1998, Sandelands 1999, Sun & Scott 2005). Technology can only play a supporting role in knowledge sharing and application – it can make knowledge sharing easier and more effective. Successful as well as effective knowledge sharing and application also stimulates innovation - improvement of existing knowledge and creation of new knowledge. This essentially closes the knowledge cycle. In this paper we mainly focus on the two first parts of the knowledge cycle – *capture and create knowledge, as well as package and store knowledge*.

An approach to building knowledge repositories, Enterprise Knowledge Patterns (EKP) (ELEKTRA Consortium 1999, Bubenko et al 2001) has been developed and applied throughout a number of research projects during the last decade. The EKP approach combines Enterprise Modelling (EM) with organisational patterns. It results from the work by collaborating research groups from the Royal Institute of Technology (KTH), Sweden, University of Paris 1, France, and UMIST, UK. The current version of the approach under the name of Enterprise Knowledge Development (EKD) was further developed in projects Electrical Enterprise Knowledge for Transforming Application (ELEKTRA) and Hypermedia and Pattern Based Knowledge Management for Smart Organisations (HyperKnowledge) (HyperKnowledge Consortium 2001). In the ELEKTRA and HyperKnowledge projects the EKP approach was applied to extensive real life cases, which all have been evaluated using more or less the same evaluation approach. The results of the ELEKTRA evaluation have been reported in ELEKTRA Consortium (1999b) and in Rolland et al (2000), the results of the HyperKnowledge project have been reported in (Stirna et al 2002, Persson et al 2003). Currently the EKP approach is further advanced and

applied in the Swedish healthcare sector within the project Efficient Knowledge Management and Learning in Knowledge Intensive Organisations (EKLär) supported by VINNOVA, Sweden.

The aim of this paper is to provide an overview of the evaluation results and to reflect on the accumulated experiences from building knowledge repositories with using EM and organisational patterns. The paper is organised as follows. Section 2 gives an overview of the EKP approach to building knowledge repositories. The application of the approach, carried out in the ELEKTRA, HyperKnowledge, and EKLär projects, are outlined in Section 3. Section 4 provides an overview of the evaluation that was carried out in the Elektra and HyperKnowledge projects. Section 5 presents the more prominent evaluation results, presents a set of principles for building knowledge repositories as well as discusses possible improvements of the EKP approach building on these results. Finally, Section 6 gives some conclusions and discusses future outlook.

2 THE EKP APPROACH TO BUILDING KNOWLEDGE REPOSITORIES

The main components in the EKP approach to building knowledge repositories are as follows:

- An Enterprise Modelling approach supporting a set of structured, goal/problem-driven models to be used for structuring and representing organisational knowledge. This modelling approach is called EKD - Enterprise Knowledge Development (Bubenko et al 2001, Bubenko et al 1997, Loucopoulos et al 1997). Versions of this approach have been successfully applied in a number of European companies. More about the applicability of EM as a stand alone approach and EKD in particular is available in Persson and Stirna (2002).
- Support for reusing existing knowledge, business designs, and enterprise models in the form of *organisational patterns.* Organisational patterns are *generic and abstract organisational design proposals, which can be easily adapted and reused* and that represent solutions to specific problems within an organisation. Each pattern couples a problem with a solution, reflecting the context and the way in which the pattern can be applied (ELEKTRA Consortium 1999, Bubenko et al 2001).
- A set of guidelines for conducting the knowledge acquisition and representation process. The basic assumption is that knowledge acquisition is strongly participatory, i.e. all involved actor and stakeholder types in an organisation are required to contribute actively. Within the ELEKTRA project two web-based tools for guidance of the EKD process were developed – the EKD Road Map (Nurcan & Rolland 1999) and the EKD FAQ (Sneiders 1999).

The most recent version of EKP is described in Bubenko et al (2001). The evaluation results and experiences currently form the basis for further development of the approach in the ongoing EKLär project.

As argued in Coad (1992), "*finding and applying patterns indicates progress in a field of human endeavour"*. The progress lies in the fact that by constructing a pattern, domain practitioners *condense part of their knowledge* on current domain practice and make it available to others. In fact, a pattern indicates *best practice* in a domain, practice that origins from organisational processes and has proved to be sound and efficient, and can therefore be disseminated. When other practitioners subsequently reuse this pattern, they benefit from the experience of the pattern designers. In this way they can create solutions to new problems by combining elements of solutions to previous problems and avoid "re-inventing the wheel" every time a new situation needs to be addressed. In other words, patterns are a medium that helps the *dissemination of best practices* throughout a domain.

Patterns are built by observing practice in a domain or by trial-and-error. This means that patterns are developed by building many EKD models of different situations. Moreover, the patterns will contain part of the experience gained by applying or constructing such models, in the form of guidelines for the application of the pattern.

Name of field	Description
Name	Each pattern should have a name that reflects the problem/solution that it addresses. Names of patterns are also used for indexing purposes.
Problem	Describes the issues that the pattern wishes to address within the given context and forces.
Context	Describes the preconditions under which the problem and the proposed solution seem to occur.
Forces	Describe the relevant forces and constraints and how they interact or conflict with one another and with goals we wish to achieve by implementing the solution.
Solution	Describes how to solve the problem and to achieve the desired result. Solution describes the work needed. It can be expressed in natural language, EKD models, drawings, multimedia sequences, etc. Solution can be backed up with references to other knowledge sources and other patterns.
Rationale	Explains why the solution presented in pattern is appropriate in relation to the forces, context and problem.
Consequences	Describes what the context should be after applying the presented solution, in terms of positive and/or negative effects.
Related information	Relationships to other organisational patterns, related documents, web-resources, or information systems. These knowledge resources can be located either within the organisation or outside.
Known Applications	Describe where the pattern has been applied.
Authors	Creators of pattern and their contact information
Also known as	Presents aliases of pattern
Examples	References to specific application cases of the solution presented in the pattern. This field can include references to specific models, organisational designs, as well as success stories and lessons learned.
Usage Guidelines	Presents a set of usage tips to the potential user of the pattern about how the pattern can be tailored to fit into particular situations or to meet specific needs of an organisation. Guidelines aim to give an idea of how the pattern can be tailored to create a specific business solution.
Type	Describes the type of the pattern (e.g. goal, business process, concept, etc.). This field is used for structuring the knowledge repository and for searching purposes.
Domain	Describes the business or activity domain for which the pattern is applicable to. Examples of domains are customer servicing, performance indictors, restructuring, organisational policies, etc.
Keywords	A few keywords are defined for each pattern in order to facilitate search and retrieval.

Figure 2 The pattern template used in the HyperKnowledge project (Bubenko et al 2001)

In order to facilitate the reuse of the knowledge embedded in patterns we have structured the pattern in two main components – the *knowledge component* and the *usage component* The knowledge component answers questions such as, what problem does the pattern solve, and how this problem can be solved. The solution to the problem can be described through *free natural language*, *diagrammatic description* (e.g. an EKD goals model, process model, concepts model, etc.), *multimedia content* or a combination of all three. The *usage component* answers questions such as, when can the pattern be reused, how can the pattern be reused, what are the consequences of reusing the pattern, where has the pattern been reused, etc. Figure 2 depicts the outline of the pattern template used in the HyperKnowledge project. In the EKLär project this pattern template was further tailored in order to support the KM requirements of the healthcare personnel involved in the project (see figure 4).

The set of constructed patterns makes up a *pattern language*. Different patterns from a pattern language may be combined in different alternative ways to adopt different solution paths to different facets of the overall problem. Therefore, isolated patterns make sense only in solving small trivial problems. For problems beyond this trivial level we need to look at the relationships between the patterns in order to provide a more complete solution. Here the enterprise models give a good support for discovering the knowledge needs as well as for structuring the existing knowledge chunks.

In the EKLär project we used the EKD participative modelling to create a Concepts Model of relevant knowledge. The Concepts Model then served as a reference model for identifying the knowledge needs and structuring the created knowledge chunks. As a result each concept in the model corresponds to at least one pattern in the repository. E.g. Figure 3 shows a fraction of the Concepts Model; concept "Doppler examination" refers to a pattern explaining what are the necessary steps and equipment to perform it (Figure 4). Likewise concepts "vein examination" and "measurement of arterial blood pressure" refer to patterns showing how to perform this (see underlined text in Figure 4).

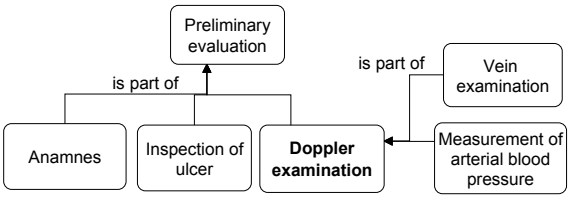


Figure 3 A fraction of the EKD Concepts Model serving as a knowledge map

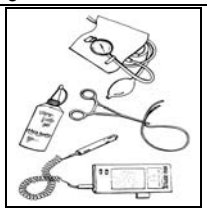
Name	Doppler examination
Problem	What is included in a doppler examination? Which equipment is needed? How is a doppler examination carried out?
Criteria	The ulcer is older than 6 weeks
Goal	The goal is to achieve a correct evaluation of the ulcer and thereby give the patient the right treatment.
Solution	Included in a doppler examination is a measurement of arterial blood pressure including an ancle/arm pressure index and/or a vein examination. The following equipment is needed: ▪ Simple utra-sound doppler for measurement of blood pressure ▪ Ultrasound gel ▪ Ordinary equipment for measuring blood pressure ▪ … ▪ … 
Reference	Doctor NN, 2006-04-04

Figure 4 An example pattern showing the necessary equipment of examination with an ultrasound doppler

3 PRACTICAL APPLICATION OF THE APPROACH

The EKP approach has been applied to a number of domains – electricity distribution, hydro power plant maintenance, risk management and mitigation, human resource management, healthcare, as well as various areas of public administration.

- In the ELEKTRA project we targeted the electricity industry, focusing on electricity distribution and human resource management. The organisations for which the knowledge repositories were built were Vattenfall AB (Sweden) and Public Power Corporation (Greece) (ELEKTRA Consortium 1999).
- In the HyperKnowledge project we continued targeting the electricity industry through Verbundplan GmbH (Austria) and also involved a public organisation, the Riga City Council (Latvia). In Verbundplan the main focus was risk management of project proposals and management of large damages in power plants (Dulle 2002, Persson et al 2003). In the Riga City Council the target domains were school administration, drug abuse prevention, traffic administration, environmental services, and municipal police (Mikelsons et al 2002).
- The Sweden based EKLär project is in the area of public healthcare. Its objective is to build a knowledge repository for learning and sharing of best practices concerning treatment and prevention methods for leg ulcers. The organisations for which the knowledge repository is being built are: a hospital – Kärnsjukhuset Skövde, a local authority – Skövde Kommun, and a healthcare centre – Hentorps Vårdcental.

As can be seen, the three projects cover several different domains, which should give some indication of the general applicability of the approach. However, the differences in experiences from the projects are not related to the issue of application domain. Rather it has to do with 1) existing culture, 2) who were the main drivers of the pattern development process, and 3) what was the tool support used.

In the ELEKTRA project, the main drivers of modelling and pattern development were the researchers, who also developed the approach. They worked as pattern development experts together with the organisations but they did not have any previous knowledge about the domains in question. In

the HyperKnowledge project the modellers and pattern developers were domain experts who had been assigned the task as part of their ordinary work-load. Before the pattern development work started, they were given training in modelling, in pattern development and in using the supporting tool. None of the domain experts had previous experience in modelling or pattern building. They were, however, experts in their respective domains. In the EKLär project the knowledge creators and contributors to the repository are the doctors and nurses of the hospital, assisted by the EKP method experts. Nurses working in the municipality and the healthcare centre are seen as the main target users of the knowledge. Furthermore, in the EKLär project, the target organisations have a culture which supports knowledge sharing. Additionally the knowledge sharing culture benefits from the specifics of the healthcare work processes where open discussions of cases and treatment methods take place.

Storing and retrieving patterns can be done in a number of ways. So far, two approaches have been tested. In the ELEKTRA project the patterns were stored in HTML documents and made available through the web. Pattern users would search and retrieve patterns through a "map" of related patterns within a specific domain. In the HyperKnowledge project the RETH tool (Kaindl 1997, Kaindl et al 1999) developed by Siemens AG Österreich, Austria was used. The tool represents textual objects and their relationships. It makes use of hypertext functionality and multimedia objects. RETH supports the RETH user in relating concepts that are defined using natural language, through semi-automatic generation of hyperlinks. Another useful feature of the tool is that the knowledge repository contents can be automatically exported into a Web representation and thus be made available for a larger knowledge networking community. After the export, the complete repository, including all multimedia files attached, is available in the Web representation. This means that users who only want to access the knowledge repository can do so by using their web browser. In the EKLär project the knowledge repository will have to support various kinds of data formats such as video, photo images, drawings, as well as text. For this a content management system will be built that is accessible from the Internet.

4 EVALUATION METHOD

The knowledge repositories developed in the ELEKTRA and the HyperKnowledge projects were evaluated according to the ELEKTRA evaluation approach (ELEKTRA Consortium 1999, Rolland et al 2000). Table 1 gives an overview of the evaluated aspects of the repositories and the EKP approach as addressed in this paper. In the ELEKTRA project the tool support was not emphasised, while in the HyperKnowledge project it was. Therefore, this aspect was incorporated in the evaluation. In the HyperKnowledge project the pattern development process was also observed by the involved researchers and the experiences of the pattern developers were collected as the work progressed.

In the ELEKTRA project the evaluators were experienced professionals with an extensive amount of knowledge in their respective areas of expertise. The main focus of the evaluation was on the knowledge content and on the pattern language.

Evaluated aspect	**ELEKTRA**	**HyperKnowledge**
The *knowledge* embedded in patterns with regard to its potential usefulness for solving relevant problems within the domain in question (usefulness, relevance, usability, adaptability, adoptability, completeness, coherence, consistency with the domain, prescriptiveness, granularity)	Questionnaire	Questionnaire
The pattern *language* used to express the knowledge with regard to its effectiveness for capturing and transferring knowledge (usefulness, comprehensiveness, richness, ease of use, relevance)	Questionnaire	Questionnaire
The *technology* used for making patterns available The use of RETH to store patterns (ease of use, usefulness of menu structures, usefulness of instructions, guide and on-line help) The use of the RETH web export to retrieve patterns (ease of use, usefulness of search engine and usefulness of indexing facilities)	Not evaluated in the project	Questionnaire

Table 1: Evaluated aspects

In the HyperKnowledge project the knowledge repositories and patterns in particular were evaluated by a set of domain experts who had substantial competence in the respective knowledge domain. For some of the cases evaluation was also made by a number of domain experts from another organisation. The evaluators all used the web based knowledge repository created by the RETH tool in order to locate and retrieve patterns that were assigned to them for evaluation. No particular training in the EKP approach was carried out prior to the evaluation.

The HyperKnowledge team observed that in some cases evaluators who had no prior experience with knowledge repositories of this kind appreciated the knowledge repository more than those that had some experience. One possible explanation for this could be that they did not have a reference point to compare the HyperKnowledge patterns with. They also had very limited experience with working the Web export of the RETH tool.

The EKLär project is ongoing and has not yet reached the evaluation stage. There are as always different levels to evaluate. In an initial stage it is important to evaluate activity level, e.g. how many are using the repository, is there less telephone calls to the hospital, On the contrary, if you try to evaluate results on a higher level, e.g. how many patients come to hospital for treatment for leg ulcers, there will at this stage not be any results and there is a great risk that people then think that the project does not work.

5 PRINCIPLES FOR BUILDING KNOWLEDGE REPOSITORIES WITH PATTERNS

This section presents the main evaluation results as well as suggests principles for building pattern-based knowledge repositories. We have divided the discussion in four parts: the three aspects depicted in Table 1 and the pattern development process. The full evaluation results can be found in ELEKTRA Consortium (1999b) for the ELEKTRA project and in Stirna et al (2002) for the HyperKnowledge project. In this paper we concentrate on the general ideas conveyed by the evaluators, which provide valuable input to further development of knowledge repositories, the EKP approach and pattern approaches in general. No references will therefore be made to specifics in the knowledge repositories.

5.1 The Knowledge Embedded in Patterns

The ELEKTRA and HyperKnowledge pattern evaluation results are comparable when it comes to the overall usefulness of the developed patterns. The evaluation process showed that potential users regard such pattern repositories as useful. A large number of specific comments were made by the evaluators. The comments are valuable sources for drawing important conclusions about organisational patterns.

- *Patterns should describe concrete solutions instead of guidelines and suggestions on how to tackle the problem in general*. The evaluators frequently expressed an opinion that the abstraction level is inappropriate for the kind of problem that is solved. Often it is too high in that the patterns contained too few concrete proposals. To address this issue many evaluators suggested decomposing patterns into a number of smaller (and more concrete) sub-patterns, each addressing a part of a larger problem. A concrete example of this from the EKLär project is when a nurse in healthcare centre is about to do an anamnesis and wants some guidance for it. There is then no time to read anything except concrete instructions of how to do this. At the same time the nurses should not be forced to make too many “clicks” in order to get relevant information. This will be a trade-off. Another contribution towards achieving more complete solutions would be to add specific “best practices” and references to examples of known cases where similar solutions have been applied. Such best practices and cases would then serve as proposals for organisational designs.
- *Patterns in clusters are easier to understand and are therefore they are more appreciated than isolated patterns.* The pattern clusters present broader and more complete solutions. Thus the pattern users can grasp the proposed solution faster.

- *Patterns describing alternative solutions should have guidelines for choosing an appropriate solution.* This should consider various situational and organisational contexts.
- *EKD models and schemas were generally appreciated as explanations and clarifications of the proposed solutions.*
- *Links among patterns and to other knowledge sources should be more explicit*. In some cases links to external knowledge and information sources, such as databases could also be beneficial. However, "linking everything to everything" tends to distract the attention from the problem at hand. Therefore careful selection of really useful links should be made.
- *The structure of patterns was sometimes regarded as too complex or too difficult to grasp.* Users should be provided with a good overview of the repository contents.
- *Some patterns used words and terms that had different meaning to the evaluators, which created unnecessary confusion.* Such words and terms need to be identified and avoided in the future. Language and cultural differences should also be taken into account. User organisations should aim to establish a common glossary of terms used in their business.
- *Some users have difficulties to grasp the purpose and usefulness of knowledge repositories and organisational patterns*. Therefore their purpose and the benefits of the pattern approach should be made explicit and easy to locate in the repository.

Some items above indicate that developing a pattern repository is not a trivial task and therefore the amount of training needed for this task should not be underestimated. See further Section 5.4.

In the current EKLär project the knowledge repositories will mainly contain methods for treating leg ulcers. Looking back on the previous projects, we can see that the patterns in EKLär will have to be a great deal more concrete than before, since a patient's health is dependent on the treatment being correct at all times. This also emphasises the need for quality criteria and the need to develop a consistent terminology throughout the repository.

5.2 The language used to express the knowledge

Most evaluators considered the pattern language to be useful for conveying reusable knowledge, although the concrete comments indicate that some improvements are needed. Some of the more important comments are as follows:

- *The richness of the template is reflected by the fairly large number of fields.* Some evaluators found this richness confusing in that several fields seemed overlapping to them. They commented that the same information appears in several fields in the template. This could either mean that the semantics of the fields is somewhat overlapping or that the semantics of each field has not been properly understood by the pattern developers. For the knowledge bases this meant that the knowledge in the template was placed incorrectly. I.e. after the evaluation we found out that in some patterns Context, Forces, and Solution was mixed together. This requires two types of measures, a reduction of the template and a clarification as to the semantics of the remaining fields. Also, in reducing the template particular attention should be paid to avoiding overlapping fields in order to make the pattern clearer. In the ELEKTRA and HyperKnowledge projects the pattern developers paid the main attention to describing the proposed solution. In the EKLär project the context and the affecting forces are equally important since treatment methods for leg ulcers are dependent on the context, e.g. the medical history, contradictions, etc.
- *Some fields were considered more relevant than others, such as Problem, Context, Solution and Forces.* In essence these fields constitute the core of the pattern template. This is indicated by the fact that they are in general reasonably well elaborated in the patterns.
- *On a few occasions the structure of the patterns or their relationships were not logically sound.* These cases suggest that an approach to building knowledge repositories should provide a clear set of guidelines for pattern development and quality assessment.
- *Several evaluators suggested that the pattern template is too complex for their understanding*. For such application cases guidelines for *reducing the pattern template* should be elaborated. E.g. such

a template would only contain the following fields: Problem, Context, Forces, and Solution. In the future this could be supported by the knowledge repository, in a way that the user first sees only the most important fields of the pattern, that are supported by the rest of the template available on demand. A number of evaluators also suggested having the possibility of renaming some of the fields in the template, motivating this by the underlying assumptions related to a particular word. E.g. some Latvian evaluators associated the word "problem" with something negative and unsolvable, because the word problem has negative connotation in Latvian. In general, the appropriate wording of the fields in the template needs to be carefully reviewed.

- *The evaluators were in favour of natural language descriptions and models as part of patterns.* This means that the combination of natural language and models as proposed by the EKP method seems to be fruitful. This increased understandability and comprehensiveness of the knowledge,
- *The amount of occurrences of hyperlinks to one and the same knowledge entry should be restricted.* E.g. as this evaluator of the transport licensing repository points out – *"The fact that the picture of the taxi licence card appears so often disturbs me. Since I want to learn more about the problem I click on the word "licence" and then always one and the same picture appears".* More explicit guidelines how to organise hyperlinks in the repository should be provided.
- *Evaluators of the ELEKTRA project suggested extending patterns with multimedia content.* In some of the knowledge repositories of the HyperKnowledge project (transport licensing (Mikelsons et al 2002), hydro power plant maintenance (Dulle 2002, Persson et al 2003)) incorporated multimedia content. The knowledge repositories of the EKLär project will be multimedia intensive containing training films, presentations, and images of cases.

Although the pattern template has been revised between the two projects, the transfer of the responsibility to develop patterns from researchers to domain experts has demonstrated the need for still more refinements. In the EKLär project a significantly simpler version of the template was developed. This is mainly due previous experiences and the following two circumstances. Firstly, the target users of the knowledge repository are in general not used to this way of presenting knowledge. They are mainly accustomed to learning from colleagues through a trainee and mentoring system. Computer based learning tools have so far not been used, although it has been discussed. Secondly, the delicate nature of the usage of the knowledge involving a patient's safety emphasises the need to reduce the complexity of the pattern and to improve usability.

5.3 Tool support for storing and retrieving patterns

The pattern repositories of the ELEKTRA project were presented as HTML documents. In the HyperKnowledge project the RETH tool was used to organise and store patterns. The web export of the tool was used for searching and retrieving patterns. Some conclusions can be drawn from using the RETH tool and its web export:

- *The automatic link suggestions of the RETH tool provided useful support for efficiently creating a hypertext*. Without this feature, it would have been necessary to explicitly think about which links to install. The maintenance of the links would also have to be done manually.
- *Attaching multimedia files to the hypertext documents proved to be useful.*
- *The creation of HTML pages from the RETH tool is fully automatic*. While the original strategy was to imitate the GUI of the RETH tool as much as possible, the choice was make it look more like the MS Windows Explorer. This was appreciated by the users.
- *The RETH tool requires the pattern developer to understand some principles from object-orientation in order to properly organise the knowledge*. This challenge sometimes overshadowed the bigger challenge of construction high quality patterns. For the normal pattern user this is not a problem.

Compared to the purely Html-based solution used in ELEKTRA, the use of the RETH tool was a considerable advance, particularly when it comes to including different models and multi-media files in the patterns and also for updating the knowledge repository and linking to other patterns or sources.

The repository of the EKLär project will contain an extensive amount of knowledge embedded in multimedia files. Therefore we are currently building a knowledge repository on the basis of an off the shelf content management system. We have assessed about 30 content management tools according to a set of functional and non-functional requirements (Persson et al 2004). Functional requirements can be comparable to requirements for employee KM portals given in Iske (2002). As non-functional requirements we addressed compatibility, robustness, availability, performance, security, and usability. In terms of interoperability requirements we envision that the EKLär knowledge repository will have to be integrated with other systems (e.g. ERP systems) in the hospital. More about the contribution of ERP systems to KM is available in Galandere-Zile (2004).

5.4 The pattern development process

Since the users of the EKP approach were the domain experts in the HyperKnowledge project, observing the work and its results provided useful input for the future evolution of the approach and also for developing enhanced training facilities. The following list shows the reflections made by the pattern developers in HyperKnowledge:

- *Modelling seems to be inherently difficult.* One aspect of this has to do with the quality of constructed models — not in terms of adherence to the notation in the models but rather with regard to their usefulness and understandability. In the participative approach to modelling it is the responsibility of the domain experts that the knowledge content is correct. The facilitator, on the other hand, is responsible for the modelling process and for ensuring that the purpose of the modelling session is fulfilled. One important purpose here is that the resulting models are useful. This means that in order for a person to be able to so take on the responsibility of running a participative modelling activity, much more training and experience than what can be obtained within a project like HyperKnowledge is needed.
- *While up till now relatively simple models have been built, more elaborated models would be desirable from a theoretical point of view.* In practice, however, learning modelling takes more time, as discussed in the previous point.
- *Although a few people were suspicious at the outset of participative modelling sessions, most became convinced of the advantages of the approach, and some were even exited about the result.* They viewed the constructed models as an explicit representation of previously "tacit" process knowledge. However, the results would have been even better, had more preparation been made. In this particular case, the modelling session was carried out mainly for the purpose of demonstration to stakeholders in the organisation. This involves negotiating the purpose of the modelling session and interviewing each participant prior to the modelling session (Bubenko et al 2001).
- *Participative modelling sessions are costly with regard to time and financial resources.* However, previous approaches of one person writing something down and having it reviewed by others are time-consuming as well. The difference is only that in participative modelling the time spent by each participant is visible because it is scheduled. A visible cost for using the participative approach is a facilitator if he/she is brought in as a consultant to support the project. In any case, the constructed models need to serve their purpose, which means that a balance between cost and utility needs to be found.
- *Participative modelling sessions are effective for large and complex problems that require collaboration between different stakeholders, but should not be applied to each and every problem.* The ability of judging whether or not to apply the participative approach requires a large amount of experience.
- *Structuring patterns in RETH is another facet of modelling and this is, again, inherently difficult.* In fact, a series of model transformations have been necessary. E.g. putting EKD models (goal models, process models, concepts models) into EKP patterns; organising single patterns into a useful, coherent and comprehensive structure – in the pattern language ("pattern" of patterns).

Again we conclude that the importance of training in the EKP approach and its computerised support tools should not be underestimated. A mentoring programme should follow the first training course,

where the quality of the developed models and patterns are assessed and discussed, and where additional training can be introduced if needed.

6 CONCLUSIONS AND FUTURE OUTLOOK

On the basis of the results of the three projects we conclude that the EKP approach has proven to be useful. It has been received well by the stakeholders involved. We have experienced some challenges concerning teaching, methodology guidance, and tool support. The evaluation results let us think, however, that no major changes in the approach are needed. Two more urgent needs for improvement that we are currently working on are as follows:

- A clear set of guidelines for pattern development and quality assessment should be incorporated in the EKP approach. A qualitative inquiry of quality criteria for enterprise models applied in practice is a step towards such guidelines (Larsson and Segerberg 2004).
- Mechanisms and guidelines for flexible adaptation of the pattern template to specific organisational settings should be developed. This includes guidelines for reducing the pattern template, hiding elements of the template and possibilities for renaming some of the fields in the template.

With regard to tool support for packaging, storing and making patterns available to their users, more research is needed. Although the RETH tool showed some promising results, we find that it is not targeted for the type of users that were involved in the HyperKnowledge pattern development. Taking into account the target user group in the EKLär project, we find that the RETH tool is even less suited here. The search for tool support that caters more for the needs of this type of user is ongoing. We are currently testing the possibility to use web-based content management systems.

The evaluation results also show that the efforts needed to develop a pattern repository should not be underestimated. In particular, attention should be paid to developing patterns that provide concrete and tangible solutions to relevant and important problems. If the potential users of the repositories find that the solutions are too general or that they solve only "toy problems", the patterns will not contribute to their problem-solving and hence the repositories will not be used. In a situation where a new repository is to be developed, the effort should be concentrated towards creating a reasonably small number of patterns with high quality contents rather than producing a large number of very general patterns. However, it should be noted that to make a pattern repository useful in practice it must contain a "critical mass" of useful knowledge content. What this critical mass is should be defined according to the domain in question and on the project objectives.

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