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A KNOWLEDGE MANAGEMENT SYSTEM FOR INDUSTRIAL DESIGN RESEARCH PROCESSES

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Abstract

Knowledge management can support industrial design research processes. Indeed, these industrial design research processes are situated between a system of operational units, requiring and using design research results, and a system of technological providers and academic laboratories. The knowledge flow between these systems is exposed to certain industrial constraints. The EADS industrial research center needs to optimise internal and external knowledge flows. In this purpose we propose a knowledge management system. Based on a research process model, the knowledge typology and a theoretical knowledge management model we propose a system architecture. This system architecture allows manipulating information and knowledge more flexible in order to assure a certain dynamic for the knowledge management system. This article discusses the introduction of a knowledge management system for industrial design research processes at the EADS Corporate Research Center.

Keywords: design research processes, knowledge management, knowledge representation

1 Introduction

For companies the managing of knowledge constitutes a strategic perspective [1]. This is particularly true if companies are highly involved in new product development processes and industrial design research activities [2]. The EADS industrial research center is in relation with an external information provider system (e.g. technology suppliers, academic laboratories, etc), and an industrial operational system, (operational units like the design office, the assembly factories, etc). It takes existing solutions, coming from the external information provider system, into account for new research result development. It then transfers the new results into the operational units. An information exchange process takes place between the operational system and the external information provider system with the industrial research center in the middle of this process (Figure 1).

Figure 1. Industrial research processes – a macroscopic description

The role of industrial design research is to experiment, illustrate and validate ideas and theoretical models with new technological and methodological solutions, to combine them in order to propose new possibilities for the requirements coming from the operational system. Industrial design researchers have to use actual knowledge concerning new design requirements and possible solutions. As research activities are under constraints like costs, short timeframes, quality management claimed by the operational units, the researchers have to optimise their information resources and knowledge flows. In order to improve the control and management of information and knowledge [3], we propose to introduce specific knowledge management (KM) system for industrial design research processes. In the next chapters we will expose knowledge relevant problems for industrial design research, show how we introduced a KM architectural framework and discuss our technical realisation.

2 First problem description: requirements – a functional analysis

During interviews with industrial design researchers we identified the following knowledge relevant activities causing permanent problems:

- Knowledge acquisition: find external knowledge to integrate in research projects, get access to new internal knowledge, be always informed about the needs of the operational units concerning new design problems, etc.
- Knowledge distribution: reach and contact the right people, exchange new ideas with experts, inform operational units about new design research results, etc.
- Knowledge preservation: preserve knowledge when people are leaving, update rapidly new arrivals and assure knowledge continuity, formalize and keep feedback concerning the application of design research results, etc.
- Knowledge evaluation: use the right and useful knowledge to produce new knowledge, know the maturity of internal knowledge compared to external knowledge, etc.

In order to extend this first analysis we conducted a requirement analysis, based on the functional analysis principles. Therefore, we organized several meetings with a group of researchers and research managers. We tried to identify potential and desired KM functions, which should be provided by a KM system. We determined first the environment interfaces of a potential system: external information suppliers, internal information suppliers, information resources concerning the customer requirements (operational units), and teams of researchers. The potential functions link the different interfaces (Figure 2).

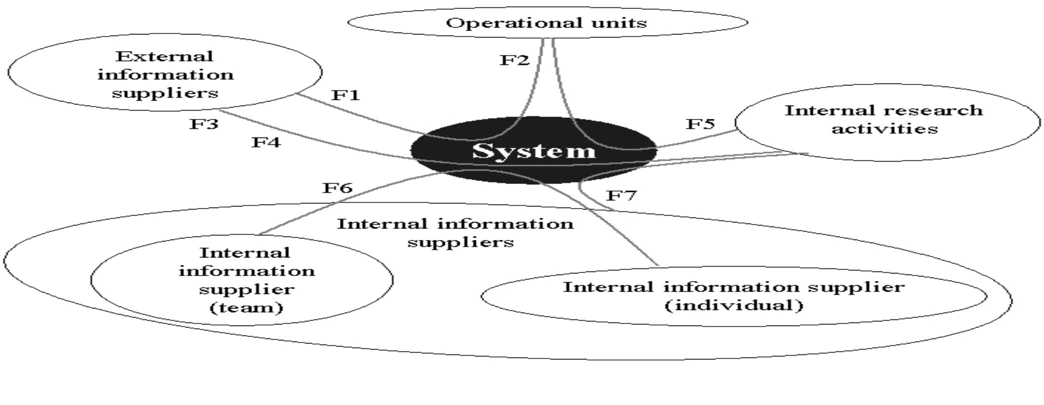

Figure 2. The environment interfaces of a potential KM system and its potential functions

- *F1*: The system should help to identify external industrial design problems comparable with the design problems of the research customers (identifying similarities).
- *F2*: The system should help to identify external design solution proposals (methods and technologies) for the research customer requirements.
- *F3*: The system displays the gap between the design research activities conducted by external research organizations and the internal design research activities (evaluation of internal research activities against external research activities to identify progresses).
- *F4*: The system helps to identify external elements (concepts, methods, technologies, tools, and competencies) in order to carry out internal design research activities.
- *F5*: The system should show in which way the design research activities cover the design customer requirements (visualize the difference between the non-covered and covered customer research requirements with internal research activities to indicate possible future research activities).
- *F6*: The system should support a sense of sharing among internal researchers working in the same research area.
- *F7*: The system should help to identify internal elements (concepts, methods, technologies, tools, and competencies) that help to carry out internal design research activities.

In order to be able to realize and introduce these functions in the design research environment, we had to analyse the design research process and activity, and the knowledge organisation.

3 Industrial design research processes – activity, organization and knowledge analysis

This section proposes a more detailed analysis of the organizational research structure, the design research processes, the information and knowledge flows and the knowledge structure used by industrial design researchers to create new design research solutions.

3.1 The official information management oriented organizational structure

Design research processes are embedded in official information management oriented organizational structures. In our case this structure concerns a quality certification, a stable intranet structure with its document organization, a regularly reporting about the project advancements and regular project meetings and reviews. The quality certification implied to introduce procedures describing and defining certain work processes and defining the production of certain documents. Documents have to be produced at the beginning of a research project (research programs) after every meeting concerning this project (minutes of meetings), at milestones and at the end of the projects (reports). The documents are structured according to the research project structure. This concerns also external relevant documents important for certain research projects. Regularly project reporting and review meetings are another mean to assure the distribution of the information concerning new research project results.

This structure with its existing and defined information flow and document creation gives an opportunity to build KM solution on existing practices and frameworks and to take them into account for new solution development.

3.2 The activity view and the knowledge flows of design research processes

A design research process can be initiated by a need to improve processes and/or products of the operational system or by the discovery of the importance of new innovative concepts [4]. According to the maturity degree of the researcher's knowledge, the research process can be decomposed into three phases: *investigate, focus, and transfer*.

The activities concerning the investigate phase characterize the identification of new research domains, the observation of new technological possibilities and activities and aims to constitute state-of-the-arts about new design technologies and methods. Therefore, the industrial researcher transfers and transforms external information or external knowledge into internal knowledge: a knowledge flow from the external environment to the internal environment. Before transferring external knowledge into internal knowledge, the researcher evaluates the utility of the external knowledge for his future research activities.

The objective of the next phase is to focus on new design technologies and methods and to acquire new knowledge and competencies. The objective is to experiment and illustrate new prototypes by using new design technologies and methods. The activity allows combining internal and external knowledge with given problems. This combination is characterized by learning processes for researchers and knowledge exchanges among researchers.

Transfer driven research is directly related to the operational units requirements. The objective is to experiment illustrators, prototypes and methods with concrete data coming from the operational units. As in the "focus" phase, researchers combine internal and external knowledge to come up with suitable solutions. However, the role of internal knowledge dominates the role of external knowledge. Internal knowledge, coming from the investigate and focus phase has to be adapted to research customer problems. This transfer of knowledge is also accompanied by learning processes for researchers: the feedback of the operational units about implemented research solutions (Figure 3).

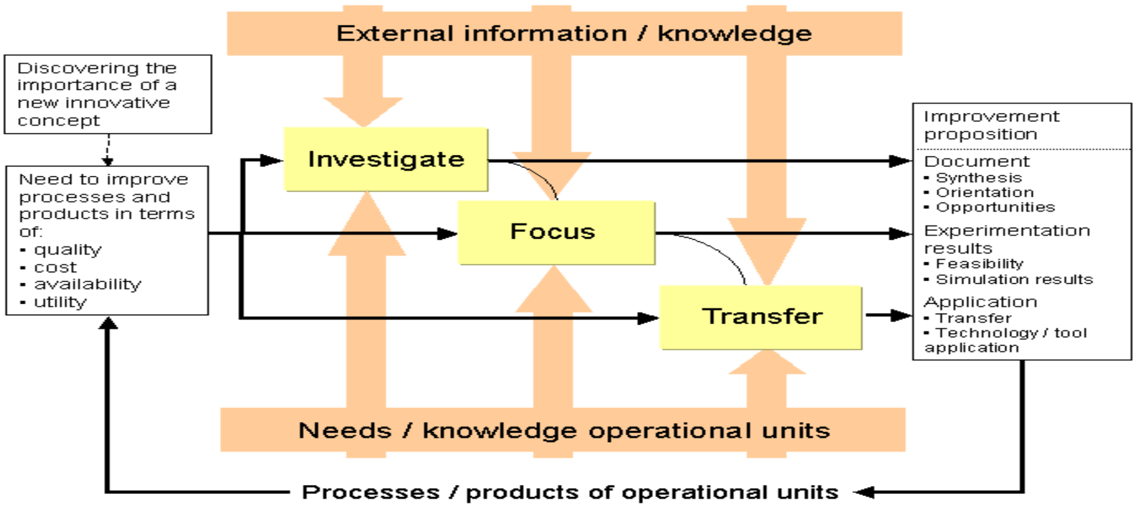

Figure 3. Industrial research process – an activity view

3.3 Second problem description: object oriented problem analysis

The activity, organisation and knowledge flow analysis allowed to precise the problem description from chapter two and to focus the description on a more object oriented problem analysis. This analysis showed, that the knowledge and information relevant problems are very often linked to problems concerning the exploitation and management of document contents. This concerns the exploitation of external and the production of internal documents

During the activity and organization analysis we identified the following additional problems: the industrial design researcher losses the overview of collected documents: what is collected, why are they collected, where are they stored, what are they talking about; he looses track of which document or document section was important to take into account for later research work and what for (too much implicit information concerning one single and all documents); the context / description of the use of documents or document sections stays implicit and risks to be lost after some time; the actual storage structure has limited capacities in order to store and to find documents according to their storage context; he risks to not taking into account (loosing) the argumentation for intermediate information, research results and ideas; the implicit communication (reactions) on documents or document sections are lost after a while and not accessible for other people; the oral reactions on documents or document sections are not transmitted if author and sender of internal documents (ex. case for minutes, reports, presentations) or sender of external documents or document sections is not available during a certain time.

These problems are directly linked to the functions of the functional analysis. The identification of external information (for example functions F1 and F2) or the comparison of information (function F3) is directly linked to the representation of information and knowledge in documents of various formats. This has to be taken into account for the technical solution proposition.

3.4 KM relevant activities in industrial design research processes

The activity and organisation analysis as well as the requirement analysis allowed identifying and characterising the different KM relevant activities for industrial design research activities. For structuring, we decided to represent them with the KM model form Romhardt [5].

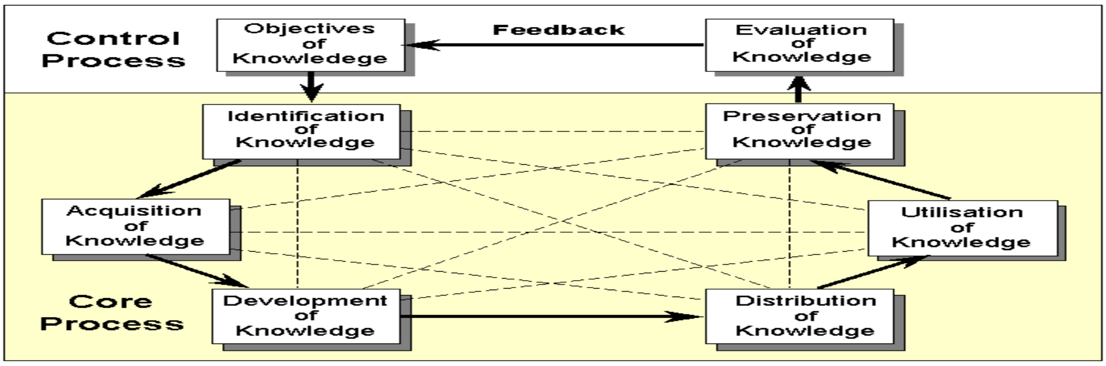

Figure 4. KM relevant activities according KM model from Romhardt [5]

This representation illustrates that the different KM relevant activities are always connected to each other. This is also true for the industrial design research activity environment. The different activities, or the KM model, emerge for every research process phase: investigate, focus, and transfer. This will constitute an important building block for our later KM architectural framework proposition.

3.5 The eleven knowledge types of industrial design researchers

Managing knowledge in industrial design research processes requires knowing which knowledge needs to be managed. It is also important to know which knowledge is necessary to conduct design research activities and to come up with research results. These two aspects encouraged us to create and formalize a *knowledge typology* of industrial researchers. In order to identify the different knowledge types, we analysed documents and held interviews with researchers, using the systemic analyse framework: which are the people concerned in a project, which decisions are made, what are the different activities, where are information shared.

The typology tries to describe 11 knowledge types as objects. *K1* describes the researcher's knowledge concerning his own research developments and products. *K2* describes the researcher's knowledge concerning his process to reach research results and products. *K3* describes the researcher's knowledge he has about existing external experts, being a part of the external information provider system (e.g. technology suppliers academic and industrial laboratories, etc.). They provide the researcher with new information and knowledge, characterized with *K4.* K4 is the concrete information a researcher has to know and to take into account for new research results. We distinguished three main categories in K4: the researcher has knowledge about academic / industrial laboratories, technology suppliers, and external users (competitors / partners). For each main category we found sub-categories describing knowledge objects. As an example, the knowledge objects for technology suppliers are *orientations, innovative concepts, methods, tools, means, and experimentations*. For the other knowledge types we defined similar categories. *K5* describes the researcher's knowledge he needs to get in touch with external information and resources. K3, K4 and K5 describe the entire knowledge of an industrial researcher concerning his knowledge about the external information provider system.

K6 describes the researcher's knowledge concerning the internal research unit experts. These internal experts provide him with knowledge or information (*K7*) which he includes in his research results. *K8* describes the researcher's knowledge which enables him to access K6 and K7. K6, K7 and K8 are the counterpart of K3, K4 and K5 and describe the entire knowledge of an industrial researcher about the internal industrial research system. *K9* describes the researcher's knowledge about operational unit experts. Their problems and needs are characterized with *K10.* With his knowledge *K11* the industrial research knows how and where to access to the operational unit information and research needs.

The typology describes the overall knowledge an industrial design researcher needs to conduct his research activities. As we can see, we have two sorts of knowledge types: process oriented knowledge types and content oriented knowledge types. The content oriented knowledge types will play an important role for our solution proposition.

4 The KM architectural framework

The KM architectural framework we propose is based on three models: the industrial research process model (chapter 3.2), the KM relevant activity model (chapter 3.4) and the knowledge typology model (chapter 3.5). This gives us a three layer architectural framework. As a basic layer we will use the industrial research model which helps to categorize the different research activities in three phases: investigate, focus, transfer. The activities in the phases can be supported by KM activities as described in the KM relevant activity model (Figure 4). In order to support the different KM activities in the different research phases we propose a toolbox for each activity of the KM relevant activity model. This toolbox should enable the execution of the different activities from the KM relevant activity model.

Each toolbox contains an information input field, a specific toolbox area according to the activity of the knowledge management model and an information output field. The information input and output field are structured according to the knowledge typology model. As the typology model represents the necessary content knowledge for research activities this structure assures the availability of critical knowledge. This three layer architecture allows to coordinate the different knowledge management activities and to integrate a process view, an activity view and a knowledge management view (Figure 5).

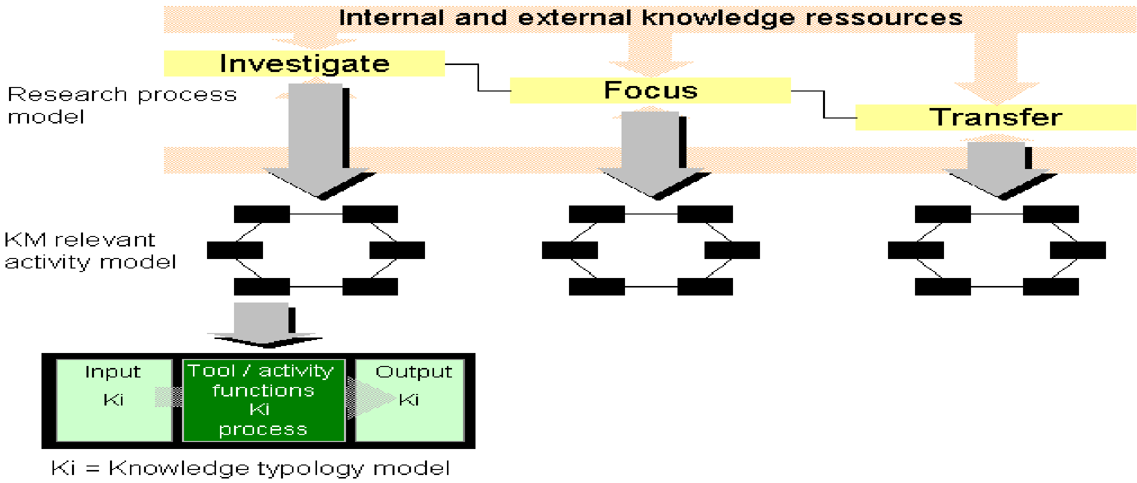

Figure 5. Knowledge management architectural framework

For each research process phase we define the different KM relevant activities with their different inputs, outputs and tool functions. As an example we will describe the investigation phase of the research process and illustrate some inputs, outputs and tool functions for the identification and acquisition activity of the KM relevant activity model.

As we have seen in chapter 3.2 during the investigation phase, the industrial researcher looks for new concepts, new information in general and new needs in the operational units. According to the knowledge typology model the industrial researchers take into account the external, internal and operational unit environment. According to the KM relevant activity model, he first undertakes identification activities. This means using intelligent Internet research machines, consulting internal expert indexes (ex. yellow pages), internal information retrievals systems (document management system), etc. As an output of this activity he has a structured list of potential contacts with internal and external experts, a list of interesting internal and external documents, a list of potential interesting conferences to visit, etc.

After the identification of these information sources the industrial researcher needs to transform the information into internal knowledge. This happens during the acquisition activity of the KM relevant activity model. The output of the identification activity is the input of the acquisition activity. The tools for this activity are a mixture between organizational tools and technical tools: in order to make use of the potential contacts the industrial researcher has to meet people, hold presentations to get feedback, assist to conference and read the collected information, and give context to identified information.

5 Technical realization of KM architectural framework and argumentation

Our technical realization is based on a portal solution. This solution includes document management and sharing, collaborative workspaces, shared agendas, shared contact database and a user profile management. On this portal solution we implement specific modules according to the requirements and the industrial design research environment (Figure 6).

In recent chapters we explained the necessity to introduce more context to information and knowledge stored in external but also self-produced documents. For this purpose we propose a module which allows attributing different viewpoints to documents or document sections, and a second module dealing with the representation according to specific viewpoints of documents, document sections or self-produced additional information to documents.

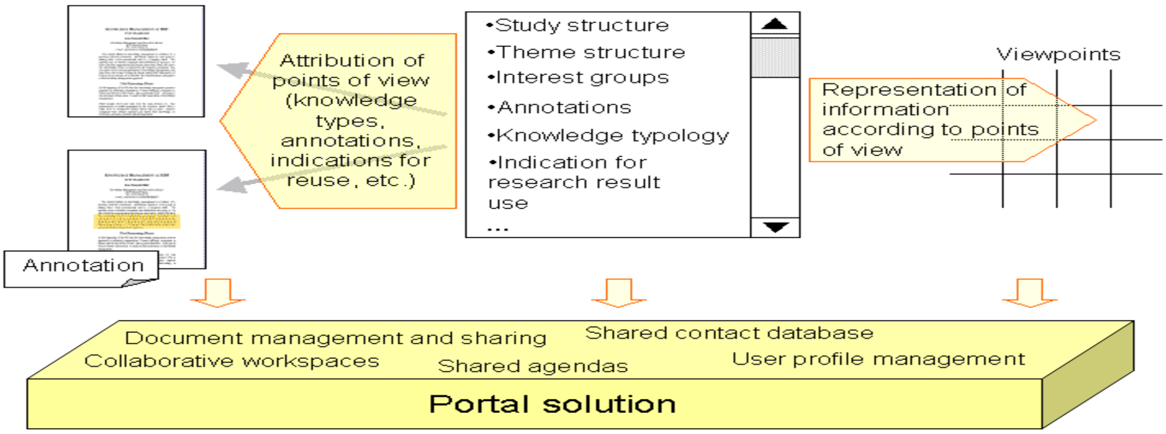

Figure 6. Technical realisation of KM framework

Once the user of the system identified an interesting document, he has the possibility to add context by choosing in a list different viewpoints and attributing them to this document or sections (paragraphs). The viewpoints list contains official (shared) and personal items. The user can for example attribute a theme to a document, indicating that the document is relevant for a special design research theme. He also has the possibility to attribute viewpoints according the knowledge typology (ex. a document or document section is talking about a new interesting tool, coming from a supplier). This means, he structures the information according to his research objectives and according to certain knowledge types. The next figure shows an example for external identified information (knowledge type K4) (Figure 7).

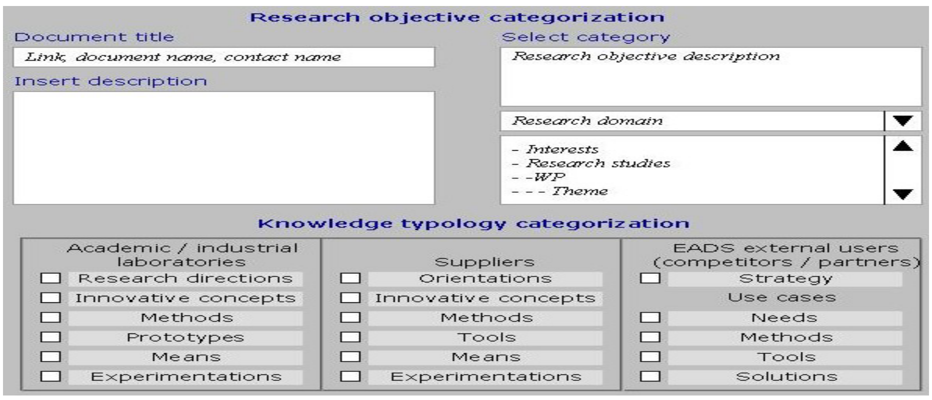

Figure 7. Giving viewpoints to identified document according research objective and knowledge typology

He also has the possibility to attribute annotations on documents or document sections. These annotations are comments he can make and which helps him to transform his implicit thoughts or comments on the document into explicit information, accessible for other users. Annotations can be linked to other annotations, documents, or document sections. It is also possible to indicate if the document or document section might be interesting for users. This gives the possibility to share information and favour information exchange.

The different information objects can be rated in order to determine their importance for taking them into account for the constitution of final research results: after reading documents or annotations, the researcher indicates if he wishes to reuse this information for constituting the final research results. If this is the case, the researcher indicates for which part (if he has an rough idea of the research results) of the research results and in which context he counts to reuse the information.

The representation module allows representing information according to specific user profiles. Research managers can have a different representation of information than industrial researchers. The representation is done in a specific two-dimensional format, allowing crossing different viewpoints with each other.

The overall technical realisation takes into account the developed KM architectural framework and the requirements expressed by the industrial design researchers. One of the major advantages of our solution is the possibility to add context to information such as documents and even document sections by attributing viewpoints. This makes explicit, why and for what information could be useful and gives a better understanding of complex information. Beyond, the attribution of viewpoints supports significantly the information retrieval process and therefore saves time.

The possibility to make annotations supports the idea creation process for new design solutions and is a mean for decision traceability concerning the choice of new solutions. The fact that annotations can be exchanged among different users, and other annotations can follow initial annotations or be linked together, creates a space to exchange new ideas and therefore a strong support for common knowledge creation and common problem understanding avoiding time-consuming misunderstanding.

The indication and rating of information for further research activity reuse can be considered as an indication for preservation of important information. The fact that the information is reused gives it a certain importance for research production. The indication of preservation and the evaluation helps to create a certain reference which shows on which bases the production of new design research results has been done. Important information is not lost in the mass of information overflow. Furthermore, indicating information for reuse for design research results accelerates the solution production process.

The representation module supports the reuse by indicating the available information according to certain viewpoints. The two dimensional representation allows to have a multi view on available information. This is a direct support for decision-making processes for industrial design researchers and research managers to define new research orientations.

6 Conclusion and perspectives

In order to realize a knowledge management solution for industrial design research processes we first described the different research activities in a research process model and illustrated the knowledge of industrial researchers in a knowledge typology model. With a functional analysis we tried to describe, in a "systematic way", the demanded functions of a potential knowledge management system. Based on these models and the existing organization environment (ex. quality certification) and with a KM relevant activity model we constructed a knowledge management solution for industrial design research processes. For the different research activities we proposed different knowledge management solutions. All these solutions are integrated in a portal. The knowledge management architecture takes into account most of the requirements. There is a better structure of information and there exists a better overview of the different external and internal environments where the different information come from. The structure of information according to the knowledge typology of the industrial researchers allows manipulating information without manipulating whole documents. This facilitates comparing external information like information coming from technical suppliers with information coming from operational units (function F2 of the functional analysis). The developed modules are flexible and can be plugged to different exiting technologies. Therefore they can create added value to existing design tools connected with information exchange mechanisms.

As a perspective, we will now start working on knowledge evaluation. A knowledge evaluation process could constitute a basic framework for the functions included in a knowledge management system for industrial design research processes [6]. The evaluation process is important for innovative processes: considering external knowledge as important can lead to new research activities in order to obtain the same knowledge. The knowledge evaluation in specific research context and for given problems can initiate new research projects which can lead to the development of new knowledge and gives a dynamic framework to knowledge management.

Beyond this, we will use our KM solution as framework to elaborate Best Practice propositions for design activities. Best Practices for design activities are a useful mean to avoid repeating errors and teach young arrivals common practices [7]. Our KM system could help to develop and capitalize Best Practices and to make them available in their specific use context.

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