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INTERFACE QUALIFICATION BETWEEN THE RESEARCH CENTRAL TEAM AND DESIGN OFFICES IN ORDER TO EVALUATE THE KNOWLEDGE SHARING

Marie Fraslin, Eric Blanco and Valérie Chanal

ABSTRACT

This article presents a case study which was led in an international company dealing with hydraulic power plant machine design. It exposes a diagnosis of the interface set up between the Research central team (R) and Development local team (D). The diagnosis shows how the information and knowledge are shared among R&D communities. It shows that the explicit knowledge formalized by the Research central team, is known and applied by the local development team, thanks to two types of networking; (1) The networking with experts in charge of communicating and explaining technical instructions applied on project, (2) and the networking between local colleagues. These practices reveal local logic that are not aligned with the company globalisation objectives. As a consequence, it is proposed that new collaborative tools resulting from Web 2.0 (wiki, bogs, collaborative platforms, etc…) can be exploited to effectively support the design activity through social networking with colleagues spread geographically. Today, no actual solution is developed and evaluated.

Keywords: R&D communities, Information and Knowledge exchange, Interface , Intermediary object, Social networking.

1 INTRODUCTION

The study was carried out within a French unit of an international organization. The studied organization builds and provides various ranges of Turbines/Generator on the international market in order to produce electrical power from water. The characteristics of the business market lead to a huge variety of products since each sold turbine/generator is specific and must answer to new customer expectations and constraints. By constraints, we mean the whole environmental, geological, hydraulic or economic situation (for example: the water head, the flow, type of fluids…). These data will influence systematically the profile of the product and its design. Therefore, the design knowledge is a key to address the large business market and to offer relevant solution to customers.

The organization is geographically divided in different entities. Each entity comes from acquisition or creation and used to have its own way of working and, *in fine*, its own way of designing. Each entity used to work with a portfolio of activities, and had to generate profits on its own business market.

Since 2000, the business globalization has implied new working methods and tools standardization. One of the stakes is to enable the setup of an integrated industrial scheme, to smooth the workload and to optimize costs by mutualizing costs.
This new organization lead to drastic changes in the R&D paradigm, with a disjunction of Research and Design functions and a centralization of the Research function [1]. This evolution is consistent with the observations of Hatchuel and Lemasson [2]. This new organization reveals new boundaries between design activities, new roles and new work division between R&D actors. Basically, some actors are in charge of producing and formalizing the technical knowledge that has to be shared with the local design teams. They are localized in a central research team, called «design back-office». The other actors are localized in different local design offices called «design front office» and are supposed to use this technical knowledge to design products.

Concretely, the Research central teams have to ensure the standardization of the way products are designed through the setup of a common knowledge framework.

However, because design offices make specific design for each client, the harmonization and standardization of their practices should not go with a reduction of their knowledge. The Research central teams have to guarantee a high level of knowledge among designers in order to enable them to autonomously respond to the specific requirements of customized designs. It is all about imagining a new way of communicating and of sharing information within the new boundaries of this international context.

In this paper, we explore the current interface requirements that relate to support the exchange of information within these new boundaries. Our observations are aimed to understand how members of the research central team and design office work and what type of information designers generally require to progress during the design activities. We explore through a case study how the existing interface is supporting or not the needs of this new organization. Our interest focuses on intermediary objects (IO) that vehicle formalized knowledge.

We will first discuss the status and definition of knowledge in the literature. Then, we will present the interface concept as well as a part of an auditing tool developed by Surbier[3] in order to characterize this interface. This auditing tool allows us to highlight that the intermediary objects which are supposed to transfer explicit knowledge are to rigid to be understand by designers without the support of a third party. That is why the formal know-how formalized through processes, and the explicit know-why formalized through manuals, are applied on projects thanks to experts and local social networks of Product designers.
Finally, we will conclude with a discussion about the knowledge sharing among R&D and how it could be enhanced with new collaborative technologies with the help of Web 2.0 (wiki blogs, collaborative platforms, etc…).

2 TWO VISIONS OF KNOWLEDGE SHARING

2.1 Instrumental Approach

According to Markus [4], three major roles appear when companies carry out knowledge management actions. There is the (1) knowledge producer—who records explicit knowledge or makes tacit knowledge explicit, (2) knowledge intermediary—who prepares knowledge for reuse by eliciting it, indexing it, summarizing it, sanitizing it, packaging it, and performs various roles in dissemination and facilitation, and (3) knowledge consumer—the knowledge re-user, who retrieves the knowledge content and applies it in some way.

The knowledge producer has first to determine the key knowledge that has to be formalized. The following question must then be addressed: What is the fundamental expertise that needs to be capitalized and transferred?[4]. This question is difficult to answer because of the perpetual generation of knowledge by the company.

Once this exercise of identification is done, the process of “encodability” allows the company to «retrieve» the knowledge from the individual and to place it on a support that can be transferred in order to enrich the overall organization. However, the field of “encodability” is strongly linked with the characteristics of the knowledge. Only “explicit” knowledge could be easily encodable. All the other part of knowledge seen as tacit is hard to transformed into information or even for a part of it just impossible. In order to illustrate this point, Herbert Simon [5]takes the example of a doctor. A doctor has done long studies that allowed him to acquire a theoretical knowledge of the human’s body, the symptoms of disease, etc. During a medical diagnosis, the doctor connects symptoms. He then associates the possible treatments to be given . His internal expertise is difficult to access for the organization (E.g. hospital). His knowledge could disappear with his departure.

Perrin [6] raises up 3 main ways to capture and to formalize the knowledge.
a) **The engineering of writing.** There are many methods (Merex, Rex, Information Mapping, etc.) to allow organization to formalize its explicit knowledge. Also, the ISO 9000 standards are tools to formalize explicit knowledge through a quality documentation system [7]

b) **The engineering of memory**. If an individual is not able to encode his knowledge, a third person can conduct an interview to help him formalizing his expertise. The method MKSM described by Jean-Louis Ermine [8] has for example been used to preserve the knowledge of researchers who are about to retire.
c) **The legal engineering.** The legal protection of technical knowledge in the form of patents is another mechanism that enable the formalization, preservation and protection of knowledge.

These practices of identification, formalization and retention - thanks to digitalization- refer to an instrumental approach of knowledge management[9]. The instrumental approach also called “possession approach”, shows a vision of the organization where everything must be objectified, formalized in processes that are stored in databases. It is a "rational myth" of the organization where an activity can be carry out by an employee thanks to the application of a process. The knowledge related to the activity can be shared thanks to the process. This vision of the knowledge seen as something malleable and that can be codified and more globally this vision of Knowledge sharing is challenged by researchers such as Wenger, Robillard [10]. These authors have another conception of knowledge and knowledge sharing, a conception embedded in “practices and focuses on the social character of knowledge and learning phenomena» [11].

2.2 Pragmatic approach

In this second approach, the knowledge cannot be reduced to the status of a codified and transferable object. In this approach, Knowledge is created and mediated through action - by the practice of individuals- and through the interaction of people. The interaction could be between individuals or between individuals and objects. Regarding interaction between individuals, the creation of practice communities [12], as well as storytelling methods will be encouraged by companies using this “practice or pragmatic approach”. Regarding interaction between individuals and objects, all methods that will lead employees to build dynamically the meaning of information, and show how that they are going to have to grasp[13] will be encouraged. For instance, a lot of efforts will be done to qualify the information manipulated by employee. Qualifying information consists in giving a status to a posted information in a database or elsewhere in order to facilitate the interaction between the receiver and the object. The qualification of the document has to enable the receiver to identify at a glance what type of information he is reading. For example, it could be a document with a status of “updated information”, or “a document under-construction”. A common understanding will facilitate the identification of the nature of the document and will indicate to the receiver in what extent it’s content has to be handled[14].

This second vision of the Knowledge is actually relevant for the research we carry out. By the way, we prefer to use the concept of «knowledge mediation» instead of «knowledge transfer». Knowledge can not be transferred to the mind to an individual. We argue that the knowledge is a set of information that will be combined by an individual to reach a new understanding of a previous situation. The knowledge acquisition by an individual will follow a mental tracking. This mental tracking could be facilitate thank to the interaction with other people and the “reification”. The reification could be define such as the concrete use of the knowledge in the daily work.

3 BOUNDARY OBJECT AND INTERMEDIARY OBJECTS AT THE INTERFACE

The new boundaries between R&D and the new work division has to be accompanied by an efficient information exchange between teams. In order to qualify this exchange, the concept of boundary object was introduced by Susan Leigh Star and James R. Griesemer in a 1989 publication : *“Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable means of translation. The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds”.[15]*

The boundary objects are supposed to cross the technical functions and allow actors to understand each other. Star precises that "Boundary objects" are those *"(…) that both inhabit several communities of practice and satisfy the informational requirements of each of them"*. The concept of boundary object has been extended with the notion " **intermediary object"**, first presented by Jeantet and Vinck [16] [17]. The authors call "intermediary objects" (IO) items that are used or created during the design process. Intermediary objects include almost all the objects handled by designers to fulfill their objectives and to mediate the product or service designed.

Subrahmanian et al. [18] describe how boundary objects act as links to the "interface" enabling communities of different point of view to interact with each other. The word "interface" is usually related to connections, links, interactions, networks, relationships, interconnections between two or more organisations, industrial functions, teams or members. A model of interface has been developed by Koike[19] in order to characterise interactions between stakeholders of design process .

The interface model was completed by Surbier [3] who proposed an auditing tools to characterise interfaces. This auditing tool is composed by different grids but only the first one will be used and presented in this paper (table1).

Table 1. Intermediary object Gird adopted from the work of Surbier L.

Intermediary object	Description	General description			Information dynamic			Information Impact		
		Support	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***

In this IO grid, an intermediary object is characterized by different observable and measurable attributes.
After a general description of the object, its two main dimensions are qualified.

The first one is related to the information dynamic. It includes the "update frequency determination" that shows how often the information might change. It precises also the information evolution that informs about the velocity with which the information will reach its final value. Finally, the notion of modification is proposed and refers to the possibility or not for the receiver to include comments.

Besides, the author analyses the "information impact" using the characterization of "the information sensitivity", "the information update duration" and "the information structure". Concerning the information sensitivity, the aim is to evaluate the impact of the information changes on information users (downstream tasks).The criteria given are the following ones:

- High sensitivity of IO information means that a change in IO information will have a direct impact in the final delivery of the product.
- Average sensitivity of IO information means that an information change implies rework on some activities and thus, an additional cost but no delay for the final delivery of the product.
- Low sensitivity means that the global impact (in the project duration or project cost) was not significant.

The Update duration refers to the workload for the person in charge of the information released to update the information.

For the information structure, the following rules are established:

- if the IO was an official object, the IO information was considered as "Structured Information"
- if the IO information was referenced (for example, Excel-sheet columns with titles broadly known by the plant's actors) and if the document was shared by various actors without the need to be further explained or translated, the IO information was considered as "Semi-Structured Information"

- if the IO information was almost raw information (raw data) with no special layout and the person in charge of the IO is almost the only one to understand the information, then it was considered as "Non-Structured Information"

All these information characteristics allow a precise picture of the nature of the information exchanged between stakeholders through the interface. It helps us determining whether the objects are more a support to information sharing or to prescription.

4 METHODOLOGY

To collect data, in order to, on one hand, understand how members of the research central team and design office work and what type of information designers generally require to progress during the design activities and, on the other hand, in order to understand how the existing interface is supporting or not the needs of this organization, we have carried out an exploratory study during 12 months thanks to an operational involvement within each department for six months :

- Research central team - mechanical department
- Design Office (DO).

The particularity of this first exploratory study is that the central research team and the design office are both located in a same place. A lot of communication problems between central and local team could be attenuated because of this co-localization. Actors might know each other and share a same language… That is why an immersion within a design office abroad has to be done to complement our study.

The data has been collected as follow. The central Research team and especially its mechanical department were involved for six months. We focused our interest on its history, activities and interface. We started to collect statistical information from the IS & T department about the main technical database managed by the central Research team. Our objectives were to know the number of users, consultations, etc.

Besides, we interviewed members from the central research team and the Design Office. The Rogers methodology [20] was used. The principle of this method is to let the interviewee speaking about a topic of their choice. In order to avoid deadlock situations, interviews were introduced by the presentation of our operational mission. Each interview was recorded, reported and then forwarded for a review by the interviewees. Interviewees sometimes wanted to clarify some part of the interview or add information. These exploratory interviews were followed by closer meetings with all the central research team.
The open mind and the support from the involved protagonists of the unit greatly facilitated these first months of research.

Table 2. List of functions interviewed

Methodology	Research Central Team	Local team / Design office
10 Open exploratory interviews >2 hours	6 people which: • 2 experts, • 1 principal engineers, • 3 Product engineers	4 people which: • 3 Product designers, • 1 Technical Product Managers
Formal interviews <2hours	• The whole mechanical technological center (excepted the calculation team) • 1 product manager	• 4 Product designers

To double check our outcomes, we have integrated the design office where we carried out eight focused interviews. We launched and animated workshops in order to collect the opinion of the actors about the Research central team and understand how concretely they access information and learn using the scenario methodology. This scenario consists in projecting the actors in an imaginary situation and ask them to describe how they will manage the problem or just act when facing different situations. Those workshops allowed us to understand how product designers work in reality and what kind of information they need to progress during the design activity. Six workshops were realised in 2 months, involving five product designers, four technicians, tree calculators and one Principal Engineer (Expert on going).

Table 3. List of workshops and functions involved and interviewed

Methodology	**Local team / Design office**
2 Workshops (scenario methodology)	• 1 principal engineers • 5 Product designers • 4 technicians
4 Workshops (scenario methodology)	• 5 Product designers • 3 calculators • 1 principal engineers
8 Formal interviews >2 hours	• 3 experts • 1 principal engineers • 3 Product designers • 1 technical product Managers

To classify the data collected, we have borrowed the auditing tool and especially the gird of “Intermediary Object”(IO) done by Surbier.

5 RESULTS

5.1 The objects at the interface between R&D

In the business studied, the design organization was sequenced between the back-office which provides rules and guidelines, and the front-office which develops and adapts these rules according to the local context. The interface set up between the central Team and the design office is supposed to facilitate the information and knowledge sharing.

Table 4. Interface between ”R” and “D”

Research Central Team :	**Interface :**	**Design offices :**
Research activities	Intermediary object	Engineering activities

We focus our attention on the intermediary object which compose the interface.
The main intermediary objects exchanged between the R and D are:

- the common design which are explicit knowledge. Concretely the common design are common rules, references and tools. They gather the various pieces of information and documents, such as drawings, models, calculation notes, dimensioning methods, solution recommendations, numerical models, etc. They formalize all the product know-how. Their aim is to structure and to facilitate the generic and specific design of the new product for each future project.

- the central technical instruction which are information on how design has to be carried-out.

- the parameterizations done on CAD software. These parameterizations generate automatic calculations and force designer to respect a logical way of thinking in order to fulfil a design activity.

Table 5. Extract List of main intermediary objects

Intermediary object	Description	General description			Information dynamic			Information Impact		
Common design	Gather various pieces of information and documents, such as drawings, models, calculation notes, dimensioning methods, solution recommendations, numerical models, etc.	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
		PDF	Research central team	Design offices	Low	Slow	Closed	High	several months	SI
Technical instruction	Define standards to be used during design	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
		PDF	Research central team	Design offices	Low	Slow	Closed	High	several months	SI
Drawing Proe	Parametrization	***Support***	***Person in charge***	***Users***	***Update frequency***	***Evolution***	***Modification***	***Sensitivity***	***Update duration***	***Information structure***
		PROE	Research central team	Design office	Low	Slow	Closed	High	few days	SI

Globally, each intermediary object listed here is supposed to bring coherence among the design activity and to rationalise the design practices anywhere in the world.

5.2 Focus on the characterization of the common designs

A. General description

The common designs are sent by the central research team to product designers in PDF version. They are under the responsibility of the Research central team and are used by design offices.

B. Information dynamic

The update frequency is supposed to be "low" because the know-how to design a product as complex as a turbine is not supposed to change quickly. There is no possibility to modify a common design or to insert information or comments. This is a top down logic and the designer comments or suggestions can not be taken into account through the object. The object is closed and does not support negotiation.

C. Information Impact

The content of the common design is crucial (High sensitivity) and needs to be strictly respected by product designers in order to avoid any risk. As mentioned by a product designer : "*We use the Common design to avoid risk. They include formulas and methods that must be followed.*"

A rectification or change within a common design always has a direct impact on the final design. Concretely, the product designer may need to change the way he makes his design.

However, we have noticed that the correction or revision process of a common design takes months (update duration=several months) and leads to critical issues with how the feedback on experience is taken into account. As reported by an engineer working for commissioning department "*In location B, we have discovered a problem with one of our product. We sent an email to the Research central team to inform them that there were some design problems with component A. Normally, all units should have been informed about it. We need to improve our reactivity to diffuse more efficiently that type of feed-back on experience in order to avoid similar mistakes in the future*".

In other words, because of the high sensitivity of the common design, the person in charge must update it whenever it is needed. However, the update duration is very long and there is no possibility to insert an annexe to a common design with several points updated after issues has been reported on the project. The Feedback on experience process needs to be improved.

This detailed analysis leads to some preliminary conclusions:

- The Common designs clearly support a process of prescription. They are highly structured and official information. The common design does not share the characteristics of a boundary objects which are supposed to cross the technical functions and allow actors to understand each other. The common design does not act as links at the "interface" because they not enabling R&D to interact with each other. We will see later how the exchange is ensured.
- Most of the documents are considered as confidential by the research central team. The confidentiality of all common designs reveals the stake faced by the research central team to protect the Knowledge. However, this makes difficult for users to know to what extent they can share the common design even with their own colleagues and, of course, with suppliers involved in the design.
- Moreover, there is no way to qualify the content and to identify if any revision is ongoing. There is also no effort to precise the level of requested understanding and prioritize the information. All the content of common designs are supposed to be mastered by the designers.
- Finally, the amount of data and the way they are structured also cause access problems. The common designs are stored in a database that presents issues as outlined in the "lean information management"[21, 22]. According to several designers from the Design office, "*navigating in the database is difficult. There are many different storage schemes. Some common designs are stored by name. Some others are accessible through to the product name or through the "Partial Assembly". We often ask our expert and sometimes our colleagues how to find the requested document. The process is more efficient.*"
- Globally, we have found that the actors prefer asking their expert and local network how to find information and understand instruction rather than searching into existing databases.

In the next section we will explore how this social networking appears to be crucial for sharing this formalised knowledge.

5.3 Social networking as a tool to access and understand common designs

- *"When I need information on a precise topic, I look for someone who has worked on this topic before and who can answer my question".* (Designer from the DO of G)*"The use of our network is more productive than trying to find information into existing databases. A few years ago, we were warned against "cronyism." Cronyism is a pejorative way to speak about networking".* (Designer from the DO). Information and Knowledge access is basically ensured by the interaction between colleagues. The ability to weave a network seems to be even a requested skill to fulfil objectives.
- In the design office involved, we notice that almost all of the information exchange between the central and the local team was done through the expert. Indeed, Product designers ask the expert to find or understand an information every day. An expert is nominated for each unit. He is in the middle of the exchanges between central and local teams. According to the typology of Markus, the experts are the knowledge intermediary between the knowledge producer (central research team) and the knowledge user (Product designers). The objectives of the expert are to guarantee the quality of the designs and to ensure that product designers apply the right instructions and standards. He also tries to report the problems faced by the design offices to the central team.
- The collaboration between central and local teams is thus completely dependant on the expert who is overloaded. Also the learning are very local and not globalized with other design offices.

- There is no tool to pass from local exchange between actors to global exchange. As reported by a Product Designer “*We should capitalize on the questions that we ask to the expert. For example, all the questions I have asked about the bearing could be interesting for other colleagues in the future when they will have to design a bearing. We need to mutualize our questions.*”

5.4 Conclusion

The diagnosis proposed and the analysis performed on the interface between the Research central team and the Design office allows to highlight a paradox.
On one hand, the Research central team is inscribed in an “instrumental approach” of knowledge. The Research central team formalizes technical knowledge in structured objects which are stored in databases. These objects called common designs are supposed to frame the design activity. The common design characterization demonstrates that they support essentially some prescriptions.

On the other hand, the knowledge sharing practices are inscribed in the “practice approach”. We emphasis that Product designers access and understand common designs mainly through the support of their social network and especially their expert. The learning of product designers are thus very dependant on their colleagues and their expert who explains them how to be handle a common design according to the context. We observed in our study that these knowledge sharing practices are very localized and based on *adhoc* and informal contacts and meetings. Thus many difficulties may appear at the interface between design offices abroad and the central Research Team. That is why, the designers need some tools to access to a global network spread in different locations.

Today, new collaborative tools resulting from Web 2.0 (wiki blogs, collaborative platforms, etc…) open new perspectives to instrument the social networking.
This technology could address several problems of information and Knowledge management. These tools are based on the new approaches of the knowledge modeling, from research in cognitive sciences. Users can "tag" information or photos posted, post comments, share features such as drawings and information, and manage their contact list. According to Aurelie Girard [23], users become " actors at the heart of information sharing and who act as consumers and content producers”. Users to producers can switch role during the knowledge management process.
Technologies supported by “social web” may facilitate this global social networking required to manage such amount of technical knowledge.
Implementation and experiment of such technologies should be performed in industrial context if we accept that knowledge management is a matter of mediation and not only a transfer of formalised information. Today, no actual solution is developed and evaluated.

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Contact: Marie Fraslin
Grenoble INP
Department of Mechanical Engineering
Grenoble, 38100
Mobile: +33 680022697
Email: mariefraslin@gmail.com, marie.fraslin@power.alstom.com,