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METHODOLOGICAL TOOLS INTEGRATION FOR ENGINEERING DESIGN

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1. Introduction and related problems

In order to remain competitive, companies must design products faster, better and cheaper. To efficiently carry out the innovation phases upstream product design, they have at their disposal numerous tools and methods.[Pahl 2007] Moreover, those tools are increasingly deployed exogenously in organizations. Thus, firms open up to external companies. Methodological tools and information are no longer developed only by internal networks of actors from a company but also by extended networks with external companies. This association of internal and external networks takes place in complex environments [Simon 1969]. As a consequence, in order to enhance innovation performance, it is not sufficient for exogenous solutions to be highly performing. Only a small percentage of the implementation of these solutions succeeds [Restrepo 2005]. To successfully integrate those solutions, it is necessary for external partners of the company to take into account company specificities at the relevant moment of the solution implementation.

This should help company to integrate and to appropriate itself the methodological tools, and thus to make those tools objects of performance. This paper focuses on the different phases of the implementation of methodological tools. Thus, it aims at characterizing the appropriation process. That should lead the company to appropriate itself these tools and to improve its performance while doing engineering design. Finally, this paper presents first elements about how to take appropriation elements into account in exogenous innovation tools integration.

2. Integration of methodological tools in engineering design

Innovation and methodological tools are increasingly numerous. Software designers are making them more and more competitive. Nevertheless, they often fail in improving performance. At least, they should be designed respecting affordance [Maier 2007] and usability requirements [Bruno 2007]. Studies emphasized on the relevance of taking learning and appropriation elements into account for tool deployments. Hence, research literature provides several theories and experiments to improve the way those tools are integrated in companies and to help those companies to make theirs new integrated tools. Thus, useful elements on appropriation can intercome at several moments of the software deployment process or at several abstract level of the process. To appropriate the solution, the user must be able to perceive the benefit gained. Not only from stated needs, but also from tasks to perform, suggested organization or latent needs.

New methodological tool integration in a company implies several groups of actors. Those groups can be separated into IT provider, customer and user. In addition, within the framework of tools integration, each of those groups can have its own view of the appropriation.

It is thus necessary to well define the frame of the study and the different levels of appropriation that can be implied.

In the literature, various divisions can be found. Furthermore, research papers about integration problems can use different keywords. In order to clearly present this research project, the assessed system is detailed in this section.

2.1 Groups of actors in appropriation process

Three categories of actors are defined for this study.
- IT provider company
- Customer
- User

The IT provider company is the structure which design and integrate design methodological tools in the customer company. This entity is considered as a group of actors. Its concerns each member of the Provider Company implicated directly or indirectly in software integration and appropriation.

The customer is the companies which buy software in order to improve its efficiency and competitivity. This entity is considered as a group. It should include every customer employee directly or not directly concerned by exogenous tools integration and related change management.

The user is the end user of the tool integration process. Considered as an individual, he is the one who manipulates the tool in order to make the customer company be more competitive.

2.2 Appropriation levels

There are three main processes taking part of appropriation stake in exogenous tools integration. Each process is linked to a group of actors as described in the previous section.

Table 1. Appropriation actors and related process

Actor	Considered Entity	Related process
IT provider	Group	Customer relationship process
Customer	Group	Change management
User	Individual	Individual Appropriation mechanism

In the tool deployment process, the provider interacts with its customers at different moment and with different ways. Each interaction takes part in the customer relationship process of the company. It should lead the customer to better integrate the new tool. Consequently, this process can be considered as the first level of appropriation.

The aim of a company, which invests in design methodological tools, is not only to improve the quality of its products but almost to improve its productivity. Knowing that each change in a company is followed by profits loss in a first time, change management process can be implemented to reduce those iceberg effects as illustrated by Figure 1. The quicker and better the end user efficiently appropriates the tool, the less those side effects impact on customer productivity. According to the customer company profile (size, resources, application domain,…) this change management process is more or less deployed and efficient [Filson 2000]. It is viewed as the second level of appropriation for this study.

While he is using the methodological application, the end user is experiencing individual mechanism in order to come to grips with it. He can be reluctant to use it or the driving force. Whatever how implicated the user seems to be, this mechanism are linked to tools appropriation. It should notably take into account cognitive behavior, learning mechanism. Within the framework of this study, it is called "appropriation mechanism" and it is mentioned as a third level of appropriation.
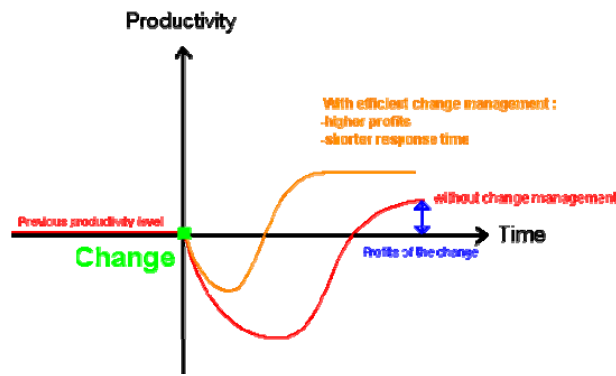
Figure 1. The aim of the change management process

2.3 Relation between the 3 appropriation levels and interactions

Relations between those processes can be illustrated by Figure 2 and Table 2.

Table 2. Relations between appropriation processes. P stands for Provider, U stands for User and C stands for customer. Process 1 is customer relationship process, process 2 is change management and process 3 is individual appropriation mechanism

Process	Designed by	Impact	Impacted by	Lead by
1	P	P	P U C	
2	C	P U C	P U C	P
3	U	P U C	P U C	P C

Thus, in order to define its customer relationship process, the IT provider should takes into account not only elements from the customer change management process and individual mechanism but also from its own way of working. The final designed process should impact the three levels of appropriation.

The IT provider, to enhance its software deployment, may guide its customer in defining its integration methodology.

At least, the end user can be influenced by its company and by the provider company in order to better appropriate the methodological tool.

In the Table 1, the three integration levels are represented. The provider impacts the final user of the design methodological tools through different ways. Thanks to its customer relationship process, it interacts with change management process and individual mechanism. Furthermore, as a tool editor, it can also modify the final tool notably its ergonomics in order to enhance individual appropriation mechanism.

3. Approach and methods used in problem solving: framework for integration of methodological tools

The aim of this work is to lead to a better understanding and knowledge on appropriation theories for methodological tools. To be more specific, the selected approach is to provide a framework based on

those theories. For that purpose, an extensive literature survey is proposed and then, used to point out relevant useful elements integrated to a strategy.

The literature study design is proposed in order to classify and evaluate the different stages of the strategy.
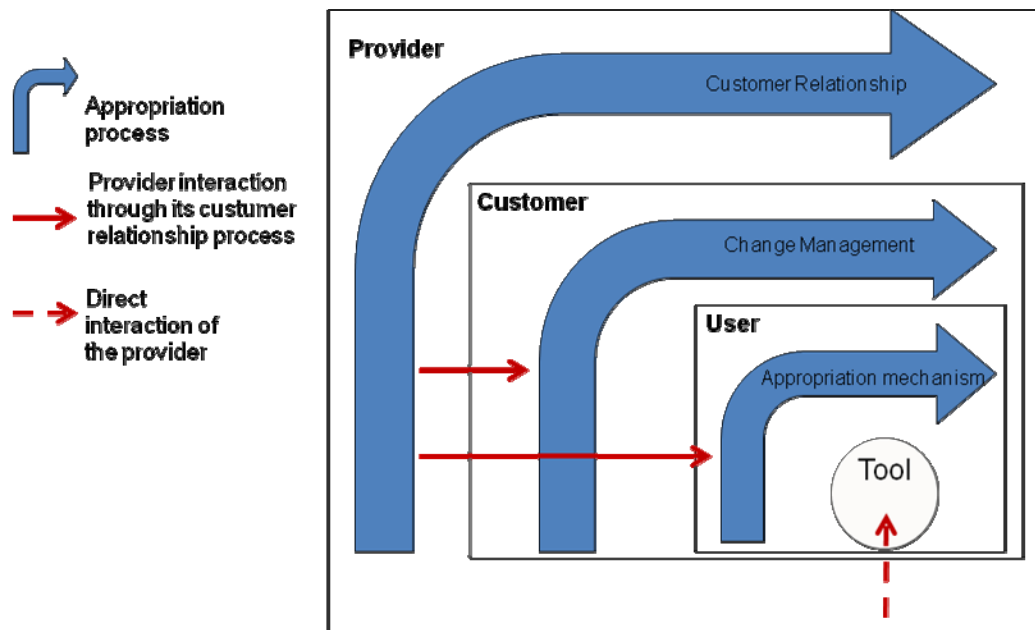
Figure 2. Interaction between integration levels and actors

3.1 Industrial context of the study

This work is performed taking into account not only theoretical aspects but also industrial points.

In fact, the research method includes appropriation elements from a methodological tools editor. This company, called TDC Software has published since 1990 an engineering software suite in the fields of need clarification, requirements engineering, risk analyses, system safety and problem solving. But does software exploit all methods of value engineering?

In order to help companies to be more and more competitive thanks to its methodological tools, TDC Software wants them to better integrate and appropriate it. As a consequence, it is necessary to strongly analyze the relevant elements required to design a solution. Some elements can be observed from industrial case studies and other from literature survey.

3.2 Research methods

In order to perform this research work, a literature review is done. The goal is to gain knowledge on the three integration levels and its interactions in order to design an efficient customer relationship process.

Thereof, this research results are due to be used by providers to enhance the appropriation process of their methodological tools. In order to support this process, software improvement can also be experienced.

Finally, the research method aims at defining a framework. This framework must, then, lead to the structuring and characterizing of appropriation elements implicated in customer relationship process, and the interaction between the provider, its customer and its product (Figure 3).

4. Identification of appropriation factors

This work underlines the importance of a user centered approach to integrate methodological tools. The user has an important role throughout the appropriation of a product. In order to help companies

to improve their performance through exogenous tools, user properties and organizational aspects are analyzed [Pol 2005].
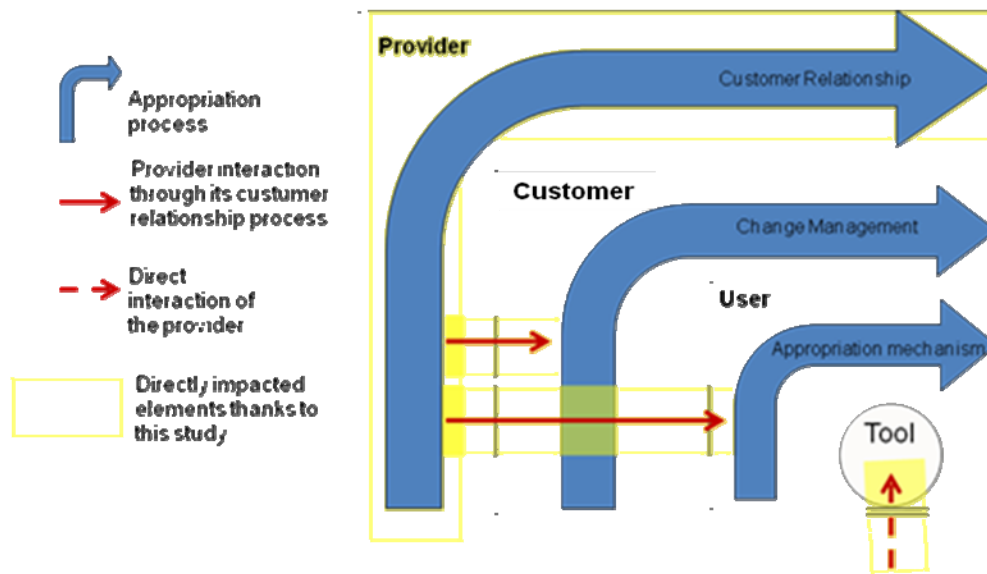

Figure 3. Framework for the research methods

4.1 Identification of the end user

The first point of the study deals with the identification of the user. In fact, as soon as a human centered approach is selected, to be successful in tool integration, the strategy may be adaptable to the user. Different behavior typologies are pointed up. It is noticed that the concept of behavior may not be separated from other elements like user context, knowledge and maturity. Once users can be associated to groups, it is interesting, then, to analyze how and where this group belonging impacts on appropriation strategy.

4.2 Knowledge management

The appropriation process is dynamic in so far as it takes into account the user changes faced to the methodological tools and associated concepts. When a new tool is being integrated in a company, in order to increase its performance, the company must appropriate both the tool and associated concepts. Thus, industrial knowledge management is also considered [Shen 2003].

4.3 Assessment of appropriation performance

While designing the tool integration strategy, works on performance improvement are highlighted. [Bernard 2008]. This may bring to measure and evaluation of the efficiency and relevance of the proposed elements for further application. Long term efficiency can be assessed thanks to industrial indicators.

4.4 Requirement management

One of the basic points is the respect to requirements. Those requirements can evolve along the deployment process [Pahl 2007]. In this section, il deals not only with product requirement but also with project requirement. As methodological tools can be implemented in various context, companies and groups of user, it is necessary that the solution is customizable. This customization must appear at the beginning of the appropriation process, while requirements are gathered. It may also interfere during the appropriation process to be in phase with the maturity and knowledge evolution of the user. The hypothesis explored in this part supposed that the appropriation is successful if the user, having raised a satisfying level of maturity, is able to propose its own way of taking profit of the solution.

4.5 Actors impact in appropriation

Within the framework of this study, the exogenous actors who interfere in appropriation process are considered. In order to integrate methodological tools in a company, various actors are implied. They take part of the process at different stages. Trainers for example, can impact the appropriation process while it is yet initiated. That is why for each appropriation tool, this work associates the specific actor.

5. The achievements and validation of the results

This work brings a strategy framework to better integrate methodological tools. It emphasizes on specific stages of the tool deployment process.

In order to validate proposed approach, the following reenginnering method is followed. This validation method came from the results of Girard and Doumeight [Girard 2004].

Thus, research process will be divided between 5 stages, as illustrated by Figure 4. Research validation process: Analysing existing system, Modeling existing system, Evaluating existing system, Modeling theoretical system, Applying and validating theoretical system.

- In the first stage, the existing system is analysed. Thus, factors are defined in order to analyse existing customer relashion ship. The organization and the structure of the system is observed, taking into account actors and their impact on it. In addition, knowledge, know-how and methods are studied. Individual and group maturity, used tools are also considered. This stage aims at improving autors knowledge on the IT provider process and its impacts on the other process. Step by step, this stage leads to a better understanding of the system.

- The second stage involve a modelisation of this existing system. Specific indicators are definied in order to utterly and accurately describe the system. For exemple, maturity scale is determined in order to differentiate recognized expert on a tool from those who discover it. This maturity scale has to also underligne their knowledge and know-how on the method supported by the tool. The third stage consist in establishing a diagnostic on the modeling system. Based on literature review and on experiments, an evaluation of this system is carry on. It takes into account appropriation elements pointed out in this paper. In this assessed system, two groups can be worked out.

- The first group consist of every element that should be kept as it is. It has been decided for this group that its content may be beneficial to methodological tools appropriation. Nevertheless, the second group is made with elements that have to evolve in order to enhance methodological tools appropriation.

- Then the following stage brings to a new modelisation of the system. Considering last analyses, enhancements are proposed. From defined indicators, referring to what should evolve, in order to improve customer efficiency, thanks to its methodological tools, this new theoretical system is designed.

- Lastly, the relevance of those proposed elements are evaluated at the end of this research method.The difference between what should be done and what can be easily done in a company with its environment may be addressed. The results are faced with deployment process of Knowllence, a company which sells and integrates methodological solutions for design and innovation.

6. Concrete conclusion and future work

This paper is a first step towards the structuring and the characterisation of appropriation elements for methodological tools integration. Framework for future research is proposed. The aim of this work is to improve IT provider deployment process, in order that customers better integrate and appropriate methodological tools for design. Research method for this project is given in order to analyse and evaluate existing system, and then to design a "process that enhance tool integration".

In this paper, three integration levels are underlined. The first one, focuses on the tool provider company. It deals with the different interactions between the customer and the provider taking part in the customer relashionship process. The second one concerns the customer. In order to help its employees to better integrate the tool, it may design and implement a change management process.

Lastly, the fird one concentrates on the final user. This one is faced to personal appropriation mechanism when using new applications.
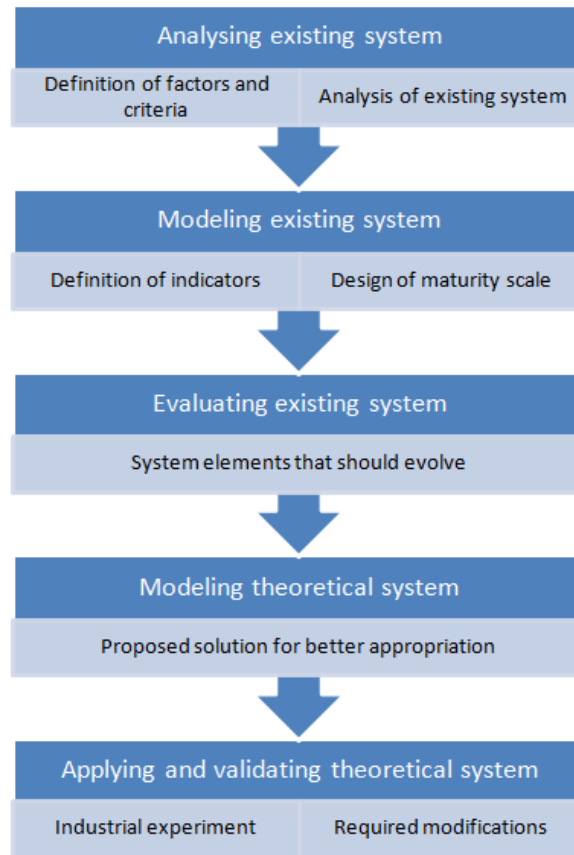
Figure 4. Research validation process

Nonetheless, it can be noticed that at least two other levels can be analyzed and taken into account. Firstly, in order to lead its customer, the IT provider should firstly appropriate its way of working. It is necessary for provider to well understand their customer internal process. In addition, while the provider company has designed its appropriation strategy, there is an other appropriation level. In fact, provider employees should appropriate this strategy in order to correctly apply it.

The provider tools integration process must be design as part of a whole system including its customer. For that purpose, bridges between the deployment process of tools integrator firms and the one of the receiving company may be pointed out. Further research works on specific elements are given. Notably, research will focus on the implementation of the proposed system both in provider and in customer companies.

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