UNIVERSITY OF ZIELONA GÓRA
Faculty of Management
and Faculty of Mechanical Engineering
In association with the Design Society

FOURTH INTERNATIONAL SEMINAR AND WORKSHOP
7th - 9th October 2004
Zielona Góra - Rydzyna
POLAND

Engineering Design in Integrated Product Development
Management of Design Complexity

STUDY OF THE USE AND USABILITY OF METHODS FROM INSIDE A COMPANY

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Keywords: Design methods, Research from inside a company, Projects milieu, Implementation of methods

Abstract: *Models of the engineering design processes and design methods are extensive in the literature. However, their impact on industry is considered insufficient. This paper presents research work aiming to explore the problem of adoption of design methods by industry in the context of a specific company, Volvo Car Corporation. Research methods are combined, as conducted by two researchers located in industry. Three main research blocks have been carried out: understanding of the projects milieu where design takes place, study of the use of design methods, and analysis of the implementation process of a method for analysis support in car body development. Supporting engineers by encouraging creative adaptation of methods and preventing wrong modification of methods has been identified as future research required in the field of design methodology.*

1. INTRODUCTION AND OBJECTIVE

Models of the engineering design processes and design methods are extensive in the literature. They prescribe a number of design steps and the order in which they must occur. Potentially, these models and methods have much to offer in the complex multi-objective product design activity; however, their impact on industry is considered insufficient [1, 2, 3].
The objective of this paper is to present research work aiming to explore the problem of adoption of design methods by industry in the context of a specific company, Volvo Car Corporation (VCC). This research provides light in the understanding of the use of methods and processes in that company, and presumably in other automobile companies, as well as in the processes of adoption of methods and new processes. This knowledge is useful for the identification of industrial needs in relation to the subject of design methodology.

2. RESEARCH METHOD

Only with a set of complementary research methods can some light be thrown in the understanding of the use of methods in a company, and the needs of a company for improving methods and processes. In this paper different research methods are combined, as conducted by two researchers located in industry, sharing the same physical atmosphere, culture, and vocabulary of engineers [4]. Triangulated evidence is also a reason to combine research approaches.
The methods used include interviews, planned observation, spontaneous observations, participatory design, and document searches in a continuous exploration of the problem from inside the company, instead of the more traditional episodic studies.
Three main research blocks have been carried out, each of which have been approached with a combination of research methods:

- Understanding of the projects milieu where design takes place
- Study of the use of design methods
- Analysis of the implementation process of a method for analysis support in car body development.

3. RESULTS

The results have been organised according to the mentioned research blocks.

3.1. Understanding the projects milieu where design takes place

In order to be able to understand how to support designers, it is necessary to understand the context in which design takes place, i.e. the meta-process of innovation. The empirical investigation for this research is based on multiple sources of evidence. The

research process was first to gather information in an opportunistic basis for about a year, then to use that information to prepare and carry out a planned interview study that lasted for four months, and finally the information was matured in a more passive way for about one more year through discussion of results with engineers and academics.
Figure 1 names the types of projects in which the interviewees participated and maps the relationship between those projects.
The product development process at Volvo Car Corporation is based on an off-the-shelf solutions strategy. This involves that new solutions for systems are developed independently of car projects and are not implemented in a car until their feasibility and advantages in relation to the old solutions are consistently proven, with few exceptions. Only then do they become off-the-shelf solutions, i.e. system solutions becoming part of a stock with known performance from which to choose for car projects.

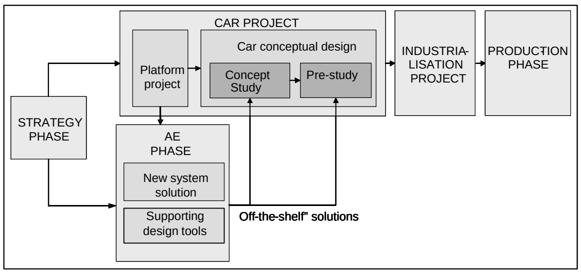

Fig.1. *Projects structure (from López-Mesa and Thompson, 2004)*

The activities carried out in each of the projects have been identified, providing information about the types of methods that can be required. Each of these types of projects is also characterised by factors like time availability, assigned resources, possible degree of innovation, etc., that condition the characteristics of the methods that can be used. For a thorough understanding of each type of project in Figure 1, the reader is requested to refer to [5].

3.2. Study of the use of design methods

The analysis of use of methods is done by describing the behaviour of engineers in relation to methods. The aim is to understand the value of developing design support techniques, and the processes of methods adoption by industry, thereby providing insight into how researchers can support designers.
This research block was done using a combination of research methods, namely:

- An interview study about the methods used, covering methods used in all types of projects of Figure 1.
- An observatory study of the practice of design for Car Body Development and planned and spontaneous interviews.
- Analytical study of documented methods used for concept selection and discussions with the users.

The results of this study can be summarised as follows:
A distinction has been observed between explicit methods, procedures applied according to plans for a concentrated period of time to achieve a goal, and opportunistic chain of actions, i.e. actions taken during different occasions by making the most of the impromptu opportunities that form part of a general goal, as already suggested by [6].
A considerable number of explicit methods are used (16 types of methods were had been used by 22 interviewees), but few methods are consistently and uniformly used. The concept selection methods used resemble those described in literature, but they are applied with modifications. Modifications to methods were found to normally produce two types of effects in the implemented method:

- Creative adaptation of method. It occurs when a method is applied to a situation with modifications that increase its value and without reducing its reliability.
- Unreliable modification of method. It occurs when a method is applied to an unsuitable situation or with modifications that reduce its reliability. A number of frequent mistakes leading to unreliable modifications were identified.

Examples of methods used, of creative adaptations and unreliable modifications can be found in [7].
It was also observed that the notion that different engineers have on the concept selection process and the way they approach it is dependent on their background and on their problem-solving style.
Engineers that were seen using or promoting the use of explicit methods, even if they did not refer to their procedures as methods, were often judged to be skilful by their colleagues.
Certain methods used in a company result from a strategic choice of management or a department. Some methods introduced in a top-down manner have been abandoned because they were not perceived as contributing to success. It was observed, however, that the principles of certain abandoned methods remain in the way of thinking of engineers or being incorporated in in-company created methods. When the use of methods originates from the needs of users, in a bottom-up occurrence, the chances of getting the method systematically used are lower. A general lack of resources (proper descriptions and examples, software support, facilitation, proper training, etc.) is the main cause. However, the common phenomenon of engineers trying to implement design methods by themselves is indicative of the value that design methodology research has for industry.
The conclusions for this research block were that academia should study how to prevent unreliable modification of method and how to promote creative adaptation of method, as well as to solve eventual gaps in design methodology.

3.3. Analysis of the implementation of a method for analysis support in car body development

The analysis of the successful implementation process of a framework for car body development provides us with valuable knowledge about the process of understanding the needs of companies in relation to methods. One of the authors (Bylund) started and led the development and implementation of the method.

Although Computer Aided Engineering (CAE), has been used for many years within all major industrial companies its use is mainly concentrated to assigned departments. It can be said that design is *simulation-verified*, i.e. analysis is used to verify the design well after it has been made. At the company in this study, VCC, this has been identified to be the case. Results from CAE analysis take approximately four to six weeks to come back from analysis department to the design department.

A way to improve product development with respect to product performance and lead-time could be to use simulation more proactively, i.e. parallel to design. This is indeed a way to support concept selection in design phases. To achieve this, the design engineer doing the actual design would be required to do part of the simulation himself. This way of working is named *simulation driven design by designers* [8]. This can be done by providing design engineers with requirements according to their design area and corresponding easy-to-use analysis tools. The analysis tools needed have been designed and developed at VCC with the participation of one the authors of this paper (Bylund). The process of understanding of the needs for those tools is addressed next.

In 2001 VCC got access to a tool looked promising for being used by design engineers during design. However, it was soon discovered that even under ideal circumstances could a skilled analyst not use them, because of the many "bugs" (or inexplicable errors) that it contained. Even more disappointing was that the tool gave the visual impression to be as complex as the advanced simulation tools used by analysis engineers. It was clearly no option to use this tool to introduce simulation to design engineers. It was understood that a considerable effort both in time and money had been put into the tool. The goal at VCC was instead to make an easy-to-use tool (easy-to-use is defined as a tool that is possible to use after a short introduction, that would be "fool-proof", and that would not require continuous every-day use not to lose the ability to use it) on a stringent budget in short time.

A feasibility study was therefore made, which lead to a usable tool. Despite that the program was made without much of participatory design [4]; it was soon accepted by the users. In this case, the technical matters to overcome were the focus. The strong personality of one of the development engineers and his strive for user friendliness contributed to the success. Nevertheless some ideas put forward by the users when the program had been introduced could have been valuable to put in earlier.

The success of the first tool stimulated the development of another easy-to-use analysis tool, both of which were to be used by design engineers and analysis experts. This time a more explicit involvement of the users was planned. A future user, a drafter/ design engineer that had experience from using the first tool was asked questions and looked at demo versions through the study. The first tool worked very well but the focus on making it easy for design engineers had made it inflexible for analysis experts with desire to override default parameters and introduce new features. This was lesson learned that lead to the addition of an advanced analysis section in the second program. Also the IT department at VCC and the IT company hired by VCC were involved during the development of the second program. Their input regarded aspects such as how to make the maintenance and eventual changes of the program easier, as well as how to make the program more robust with respect to changes that occurs in other parts of the computer system.

A side effect not realised at the outset of the development of these programs was the empowerment experienced by the drafters/designers. By making analyses the design engineers can prove that their ideas improve the sub-system they are working on. The empowerment effect makes the interest in the tool bigger.

After being in use for almost two years the first developed in-house program started to be out of date, due to several changes in the computer hardware and software. The programs became less robust than in the beginning.

A third software development project was launched to improve the first tool. This time participatory design techniques were more extensively used. Users, developers and other stakeholders met at several occasions and demo versions were presented and discussed. Balancing the requests from different stakeholders was not easy but the result of the project was a much better tool with respect to both ease of use, safety and speed.

The success findings are corroborated by research studies with industrial examples both at pilot level and in full scale [8]. The implementation of simulation *driven design by designers* is still ongoing and increases in up-starting projects at VCC. This short story of the implementation process shows that developing a method or tool involves successive learning and inclusion of social aspects.

4. Discussion

The three pieces of research presented contribute to the understanding of the use and usability of methods in different manners.

The results of the first piece of research, about the understanding of the projects milieu where design takes place, are descriptive. The deployment of the projects structure and of the design activities is useful to identify what methods can be required, and what characteristics they should have. However, most of the usefulness of this type of study remains tacit until it is triggered by a research opportunity. Most of the knowledge acquired for years being located in industry and having access to the "context" of design is of tacit nature. Its value shows when the knowledge can be applied for further knowledge or method development.

The second piece of research about the use of methods in industry has a more prescriptive character. Needs have been identified, namely supporting creative adaptation of methods and preventing unreliable modifications of methods. The processes of adoption of methods have also been described as well as the behaviour of engineers in relation to methods.

The third piece of research about an implementation of a new process and development of corresponding support tools make evident the importance of certain research aspects for successful implementation of engineering design support tools. Social aspects must be taken in consideration when developing tools, and this can only be done by close cooperation with industry. Progressive learning of the needs is essential for success. Engineering design research is characterised by not only developing knowledge, but also methods and tools [9]. Progressive learning implies that all the needs for which tools are developed cannot be identified from the beginning. Design research is similar to design practice in the sense that solutions have to be found for problems, and that the knowledge of the problem evolves with the development of the solution.

The numerous methods and engineering design processes that have been collected in books for several decades originated from best practices studies. Implementation of methods is difficult as pointed out by numerous authors [1, 2, 3]. Therefore, copying best practices, which is what implementation of design methods is about, is not a simple task. Unreliable modifications occur often, i.e. methods are used for wrong situations or with changes that diminish their reliability. This lesson-learned can be used for a better development of solutions to the problem of improving design practices by developing solutions for prevention of unreliable modification of methods that encourage creative adaptation of methods.

5. Conclusions

Being located in industry has allowed the authors of the paper to develop knowledge about what happens with engineering design methods and how to develop support tools in industry. Contextual knowledge of the practice of design, considering the social aspects of design and a progressive learning attitude to research have been identified as key factors for successful development and implementation of support tools for engineers. Design methods are used in industry with modifications. Their usability can be increased by addressing the subjects of unreliable modification of methods and creative adaptation of methods.

Acknowledgements: We acknowledge the assistance of all the engineers from VCC that contributed to the research described in this paper. Gratefully acknowledged financial support has been provided by the Polhem laboratory at Luleå University of Technology and VCC.

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