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METHODS ARE NETWORKS OF METHODS

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Abstract

Quite often practitioners in industry are working sub-optimal in their processes in product design and development, as they hardly use methods. Quite often their experience in using methods is negative – the result was not as good as expected or it was time consuming or it did not fit to the situation. Because of these findings methods should be presented user friendly and more flexible. This has to be realised within a context, which is of high complexity concerned to processes, situations and participants.

This paper points out some aspects of the required flexibility and the target oriented use of methods by discussing different views of the networked methods within design processes. Standard process patterns are described and a model of method supports the work with methods, which are decomposed and addressed by questions. Case studies with students and in industry gave a first positive response to this kind of dealing with methods.

Keywords: usability of methods, design process, design of methods, targets of methods

1 Introduction

The complexity of products is increasing because of additional functionality, integration of different technologies and networking of the products with their environment.

To manage the resulting challenges a lot of efforts are invested in tools like CAD, DMU, PLM. In addition the market of working methods is growing because of standards like ISO 9000, the need for innovation, cost and time reduction, improvement of reliability or simple the control of the complexity.

Is there a chance for the designer to keep at the front line of the tool and the method development? What is the future role of consultants and specialists within design processes?

Within the complexity of products and design / development processes on the one hand and the complexity of tools and methods on the other hand there are complementary ways to solve the problem. Solution one is a strong support by software tools. Solution two is a similar patterns of action, to be used under different circumstances. Solution three is a method description assuring a high level of usability.

In this paper working methods in product design and development processes are addressed.

There is a huge number of working methods available [5, 6, 10], which is proposed to be used in product development processes. The implementation and use of working methods in industry is rather poor although there are numerous attempts of convincing, selling and

training. Quite often methods do not fit to a given situation or even the problem to be solved, at least they do not fit in the way the methods are described in standard literature.

Students as well as engineers in industry should be able to adapt and reconfigure methods depending on the situation and they should be aware of what they do in each situation. This is more than just following a set of rules and steps, there has to be enough knowledge about the elements of a method and their working principle

2 The problem

Since a number of years scientists claim that industry does not use their working methods in a comprehensive and adequate way. Within projects with industry we observed different situations of using or not using methods. Quite seldom methods are used in an excellent and efficient way. Quite often working methods were more or less unknown. Quite often they talked about brainstorming and it was just some kind of a discussion.

Case 1: A company in the automotive industry with some thousand employees tried to implement QFD. They asked consultants to train their staff by running a pilot project. After a few days in this project the QFD matrix grew up to more than 100 x 100. The project failed and there was no chance to start with QFD again – at least for a couple of years.

Case 2: About ten years ago a company (global sub-supplier in the automotive industry) started to work with FMEA and the used this method continuously. Then the discussion came up about the way they did it. The key question was linked to the reason why they were doing specific steps. Some kind of frustration came up – "We have to do it, but why?".

Case 3: Within a successful company we observed that the FMEA-forms were filled out without understanding why they had to do this. They were asked to do FMEA by contract and tried to fulfil this condition with a minimum of effort.

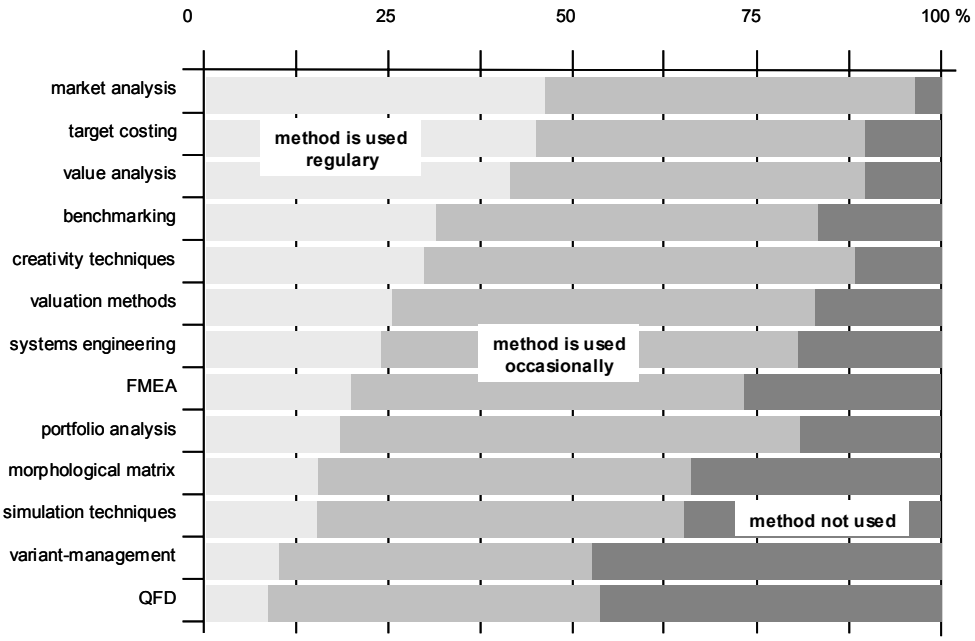

Figure 1: Use of methods in industry [8]

A questionnaire in 1995 [8] showed that industry does not use methods intensively, that they usually use methods just occasionally. If it is correct that the use of methods requires training and competence, the use of methods just occasionally can not be efficient.

On top of these points of discussion Furnham [7] found out that brainstorming does not work at all. When we discussed his paper with some colleagues from psychology they agreed that Furnham's findings are correct, at least referring to the standard form of brainstorming.

The main objective of our related projects described in this paper is to overcome at least part of these difficulties of training, implementation and acceptance. Improving the transparency of methods, the suitability concerned to the task, the possibilities of adaptation, the controllability and the reduction of the efforts to learn and train working with methods ("usability" following ISO-standard [11, 12]).

aspects	*questionnaire (examples)*
suitability for the task	Do efforts and benefits fit together? Is the method suitable in the actual situation (competence, time frame etc.)?
suitability for individualisation	Are there hints and possibilities to adapt the method to the given situation, the acting individuals?
conformity with user expectations	Do the results in quantity and quality correspond to the expectations?
self descriptiveness	How much training is required? Are all the suggested steps obvious? How much literature is required?
controllability	Is it possible to adapt the sequence of working steps? Is the procedure transparent to the acting individual?
error tolerance	Is it easily possible to recognise wrong usage? Is it easily possible to correct mistakes?
suitability for learning	Are there adequate test and training possibilities? Is a structured review of the process included?

Figure 2: Aspects of the usability of methods [12]

3 Methods and Processes

Methods will be discussed from two points of view. External aspects are seen within processes, where methods are used. Internal views of methods can be discussed, when the structure of a method is the main focus. To have these two aspects, a procedural model and a model of methods have been developed.

3.1 Model of Product Development Procedures

Product development processes as part of a development project have to be planned in advance to be able to control the project in total. Because of the creative nature of at least parts of the design processes it is quite difficult to create a plan which is sufficient for all details. Because of this difficulty and the aim of integration of different specialists within one design project, flexible "process building blocks" have been developed in a number of research projects [2, 14]. In between these process building blocks have been transferred to practical use in industry successfully. These process building blocks may be "evaluate properties", "clarify the task", "compare alternatives" etc.

Using these process building blocks typical patterns may be formed and standardised. The well known problem solving cycles known from systems engineering [5], ARIZ [1] and even

the TOTE-cycle may be explained by these process building blocks. Key elements are "analyse the target (the task)", "find solutions" and "select the (optimal) solution". This cycle was used for example by Ehrlenspiel [6] and other authors in a similar way.

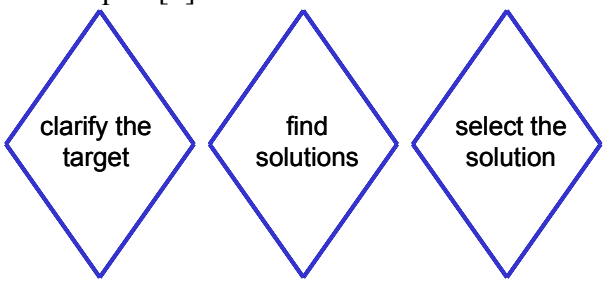

Figure 3: Elements of the basic design cycle

In real processes there are a number of iterations within the cycle. To symbolise this the elements of the cycle are overlapping (figure 4).

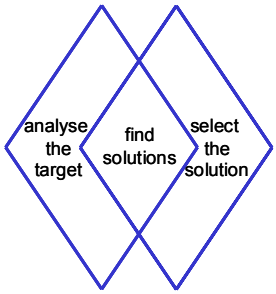

Figure 4: The basic design cycle

If you go into a more detailed view of "analyse the target" and "select the solution" you may find it helpful to split these elements to detailed building blocks. The analysis of a large number of product development processes lead to a set of seven process building blocks, which may be used as some kind of a standard. As this patterns is some kind of a model of procedures we have standardised it as the "Munich Procedural Model" - MPM. This model wants to explain the content of typical processes (sub-processes) within design and development and the flexible relation between the included process building blocks.

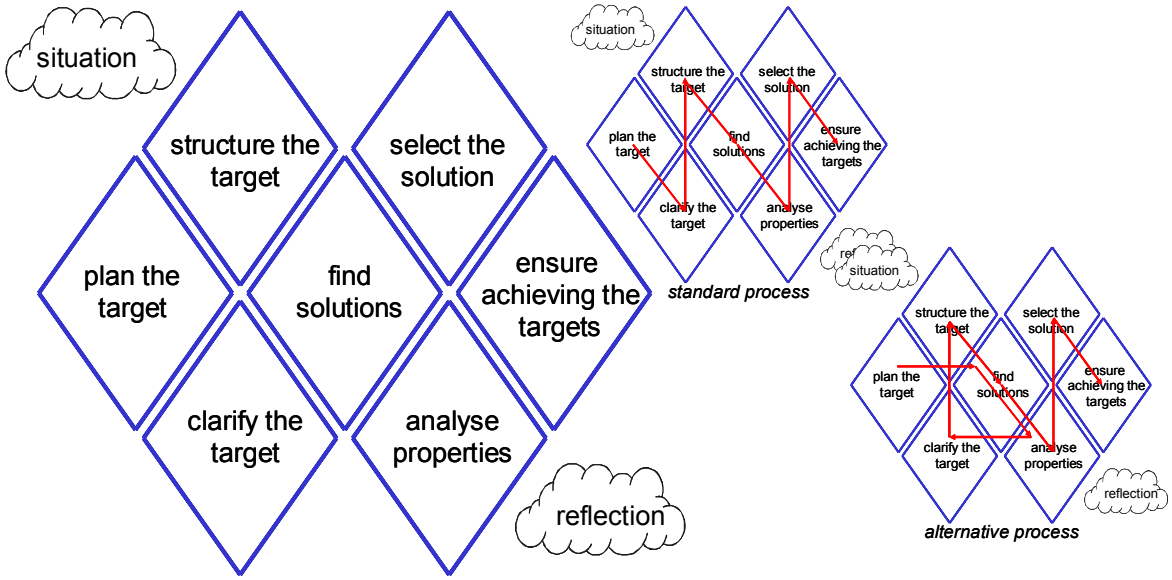

Figure 5: The Munich Procedural Model – MPM

The base is the actual situation where one starts to act and the refection of the process before one switches to the next cycle. As content there are the elements “plan the target”, “clarify the target”, “structure the target”, “find solutions”, “analyse properties”, “select the solution” and “ensure achieving the targets”. Depending on the situation and the progress within the overall process it is possible to switch from one building block to another one, as long as the output-input parameters match.

Within a “normal” development cycle the general way will be as described above. But if the target is quite new and the available information is scarce then it may be useful to switch from “plan the target” directly to “find a solution” and then to “analyse properties” in the sense of fast prototyping to learn more about the problem and then do the “normal” development. This pattern will be used with cycles within itself, in iterations and in a recursive manner. It may be used in small detail sub-processes as well as on the top level of a project.

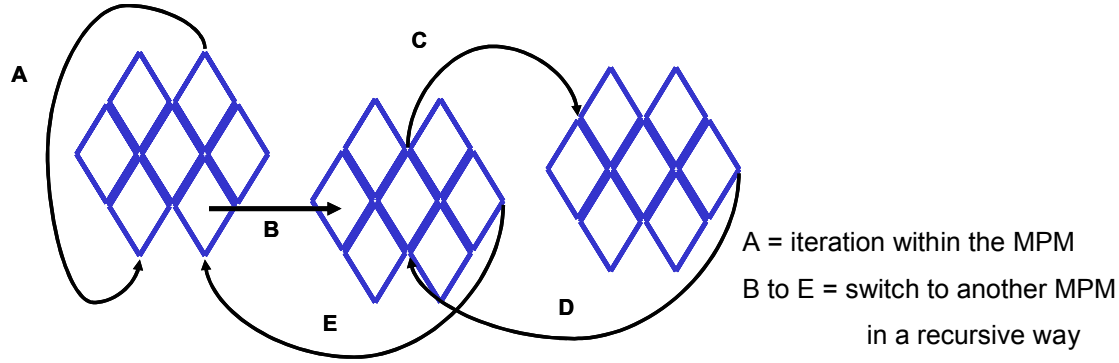

Figure 6: Using MPM in an iterative and in a recursive way

This gives us in total a very complex process pattern, but the elements are of the same structure, which on the other hand supports the similarity.

This is one level of a network of methods, as we have to use methods within our processes of the MPM.

If we want to act within one building block, we may use different methods. If we want to “clarify the target” we may for example do that by using methods like QFD, brainstorming, questionnaire or use a checklist. So we are able to use different methods within one sub-process and we can even combine these methods.

This is another level of a network of methods, as one method may be used in different types of process building blocks and in addition within one building block different methods may be used.

3.2 Model of Methods

Now it is important to know more about the structure of a method. Some methods like TRIZ, QFD, Value Analysis or FMEA seem to be complicated, as training is offered for in some cases for more than 20 days per method.

If we are in a situation of high complexity, we should try to switch to another level of abstraction and / or split the system into a number of smaller sub-systems. Because of this known strategy we started with the hypothesis, that the modularisation of methods will help us to get a better understanding of the function of the different steps within a method. Another issue is the aim to have higher flexibility to adapt a method to different general conditions [15]. We decomposed and reconfigured methods.

Another issue is the hypothesis, that an action oriented approach works much better than a descriptive one. The base of this hypothesis is the observation of the successful implementation of TRIZ or parts of it in industry. One way to achieve or at least support this is the combination of questions and answers. We transferred the method description to sets of questions to be answered.

The structure of the description is following a model suggested by cognitive psychologists, which contains in addition to the method itself the elements aim, condition, user, tool, effect and side-effects [9].

Some attempts have been made to define a model of methods [3, 12]. Our model has been defined to support the selection, adaptation and the use/application[13].

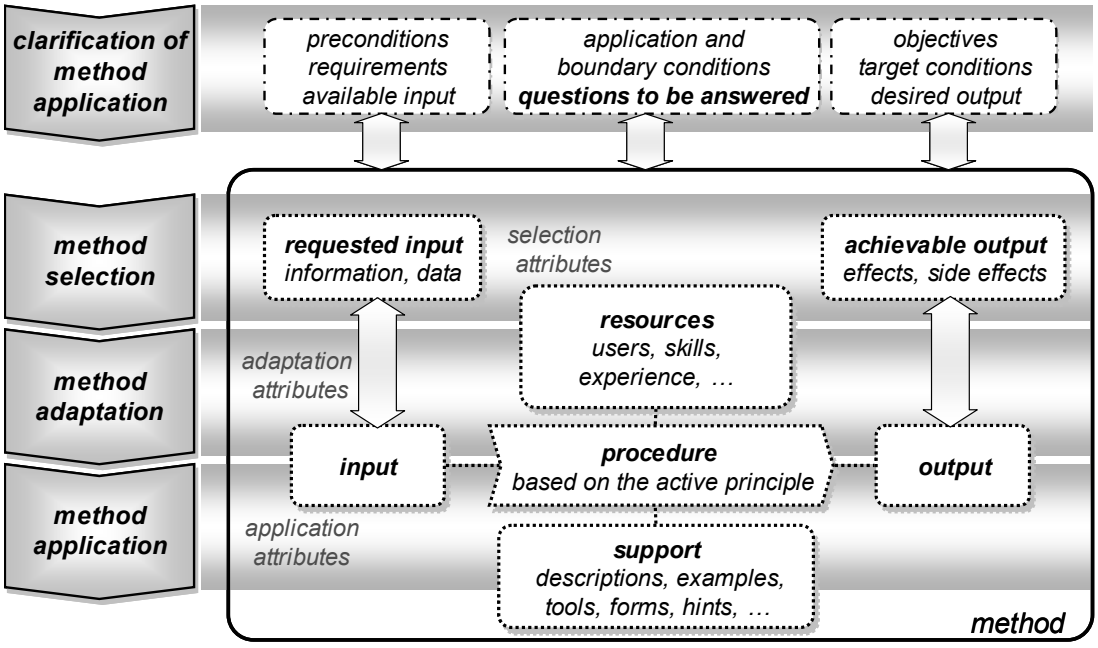

Figure 7: Munich Model of Methods - MMM

Whenever one wants to use a method, the wanted application has to clarified in advance. To prepare the selection of a method and its adaptation to the specific situation the following points have to be clarified in advance:

Which question has to be answered by using the method? What is the available input and the required output? What are the boundary conditions, requirements and objectives?

When selecting a method the discussion of effects like creating new ideas and side effects like improving teamwork and social competences are very important. These effects should not be mixed up with advantages (e.g. easy to use) and disadvantages (e.g. time consuming). If an effect or a side-effect is an advantage or a disadvantage depends on the evaluation in an actual situation. In addition the competence of the proposed staff using the method should fit to the required skills and experiences.

Within an actual process specific situations can be observed that may have influence on the required characteristics of the method. Because of this circumstance the given method has to be adapted to the situation [15]. This is one reason why we can observe a number of methods deriving out of brainstorming as for example brainwriting, the gallery method or the 6-3-5 method [6, 10, 13].

When using a method, the support like descriptions, examples, hints and tools is welcome.

Transferring methods into practical use is quite difficult, as usually the training effort is quite high. In addition training and consulting is a business, so there is no real incentive to increase the efficiency of all the offered trainings. If one analyses different method, you will quite often find elements (sub-methods) you have already seen within another method. The terms are different but the active principle behind it may be equal or at least similar. This gives us a modular structure of methods [4].

Analysing the practical use of methods in industry as well as with students we observed sometimes, that a method was used like a cooking recipe in a rather stupid manner. They know, what the next step in the procedure is, but they do not really know, why this step is necessary. Because of these observations even when looking at experts we decided to split methods into a number of questions to be answered (see above – action orientation).

As there are usually several possibilities to give an answer to the question by using different methods there is an advantage to adapt the method to the given situation or develop a new method by just using different sub-methods. Doing QFD you may ask the question "How do we get information about the properties of the product X of our main competitor Y?". There is a number of possibilities to answer this question as for example "questionnaire with your sales and service staff", "analysis of literature, web-based information etc", "product benchmarking". If you decide to buy the product and analyse it, there may be the question "How do we find out the production cost?". Again there are different possibilities to give an answer – think in alternatives!

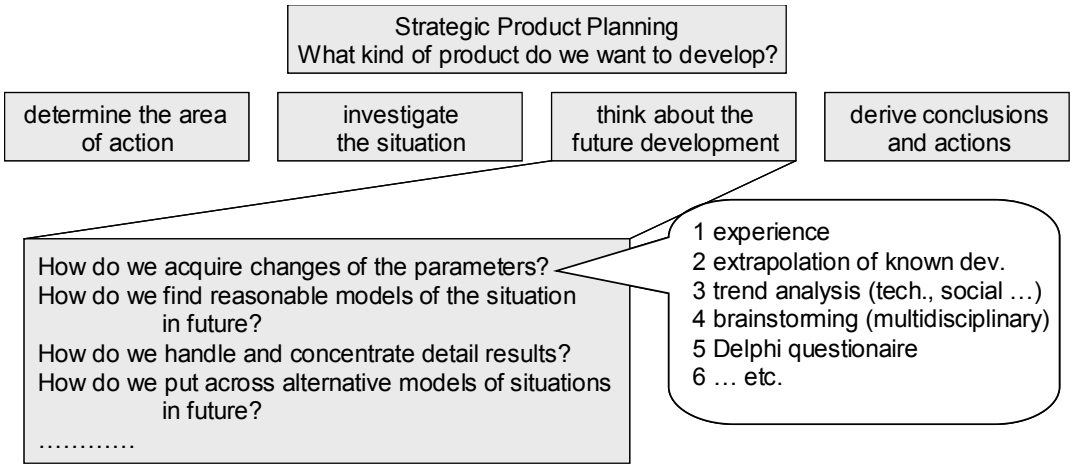

Figure 8: Product planning - four fields of action - questions and answers (fraction)

An example may be the strategic product planning, which has to answer the question, which products should be developed for the future success of the company. This process has to be established and there are different possibilities to run this process depending on the requirements and the actual situation. One step within this process is the discussion and evaluation of what the future might be. Within this step a number of questions may arise as for example "How do we acquire changes of the parameters, which influence the positioning of our product in the market within the next 10 years?" or "How do we find reasonable models of the situation in 10 years from now?". These questions may be answered for example without using any method just depending on the sense of a manager or by analysing technical and social trends by a multidisciplinary team.

The combination of methods of the whole process may be created with support of a morphological box, which contains possible solutions (methods) to answer the given questions.

In addition the questions have to be adapted to the actual situation too.

This is a further level of a network of methods.

If we analyse the steps of a typical and successful processes using the method brainstorming, we can recognise, that within brainstorming a number of different methods may be integrated. For example mind mapping, gallery method and others can be observed even within a method with rather low complexity compared to TRIZ or QFD.

This again is a level of a network of methods, as methods may be used as sub-methods within a step of the actual method used in the process.

4 Evaluation of the Results

In parallel to the development of the Munich Procedural Model and the Munich Model of Methods a number of tests have been done to evaluate the models and the targets as well as the hypothesises behind these models. The tests were and are done by case studies with students in university (individuals as well as teams) and with design engineers in industry.

The procedural model as some kind of a process pattern based on process building blocks and problem solving cycles was proved by analysing completed product development processes. In addition preliminary tests have been done on actual projects with students and in industry in form of case studies.

The model of methods was partly evaluated during the past years, the main part of the further development still has to be done, as many of the existing methods have to be reworked following the above findings. The conscious target orientation of all the steps within a method worked quite well in all cases.

An open question is the utilisation of the advantage of high flexibility and the conformity with task and situation in conjunction with the complexity of the network of methods. The similarity of procedural patterns seems to be one advantage that should help, there are some indicators for this hypothesis.

Heuristic rules like:

- If there is a complex situation, then it may be helpful to structure and split the system / problem in partial systems / problems.
- If the implications of decisions have considerable consequences, then it may help to call one or more individuals with required competences.
- If there is an advise of experts, then this advice should support the decision maker instead of making him obsolete.

may help to improve the navigation through the network.

The preliminary results of working with the proposed kind of description of process patterns and methods are positive. The number of method training hours can be reduced and more knowledge may be transferred. The understanding of the background and the reason of doing some of the steps within a method is much better. The choice of working with question – answer techniques was proven.

Some of the above aspects were evaluated and tested in student projects, which were related to tasks from industry or at least similar to that. The broad rage evaluation will be done within the next two to three years.

Within an industry project (Strategic Product Planning) the flexible adaptation and combination of methods was tested in conjunction with effects and side effects. An example out of this project: Instead of pointing out the most important properties considered to have influence on the future development of their specific business with help the method DSM (influence matrix), they used a simple scoring method. They saved time in the project, but an additional measure (method) was required to prevent to much subjective influence of some of the participants.

Within a number of further case studies in SME's it was possible to implement sub-methods of TRIZ and some other methods like FMEA within very short time in a sustainable manner.

5 Conclusions

The proposed way of describing patterns of processes and of methods

- supports users to be flexible and adapt processes and methods to the given situation,
- reduces the enormous number of different methods to a limited number of basics and achieve much higher transparency in what they really do,
- is action oriented,
- is improving the usability of methods,
- is asking for specific support to navigate within the network of methods.

Tests with students as well as practitioners were in general positive and gave a number of hints to further improvement of the system. Further research is required to improve the knowledge of an optimal granularity and the way to handle cross-linking the knowledge elements. Extended tests in university as well as in industry are planned.

This way of structuring and describing process patterns and methods may be used on paper basis or with a computer-based tool. To support users working within this field of granularity and flexibility a web-based user-interface in combination with a specific database has been developed. It gives additional benefits because of the cross-linking possibilities.

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