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# FLEXIBLE ADAPTATION OF METHODS WITHIN THE DESIGN PROCESS

Udo Lindemann

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## 1. The situation - the problem

Increasing requirements characterize the situation in product design and development. Competition in terms of time, cost and quality is one of the most important topics within industry and these points are linked to the need for higher flexibility, functionality and multidisciplinarity within our products and our processes. Because of these reasons the daily business within enterprises is characterized by the continuing education of the staff, regular adaptation of business processes, and the introduction of - again and again - new, additional IT-tools and methods.
The focus of this paper is based on an engineer's view on working methods in design and development. There is of course the need for additional views from psychology, business sciences, etc. Some of these additional aspects have had strong influence on this paper.
What happens to our staff, if we reorganize the processes within our company? All employees have to be trained, failures occur, the preplanned processes have to be adapted to the real requirements, coaching is necessary and we have to be carefully concerned with the motivation within the company. In addition there may be influences on customers and suppliers. Similar questions occur, when we just introduce new IT-tools and methods.
Some reasons for introducing new methods have been given above. Other reasons are new standards (e.g. ISO 9000), laws, and requirements of the customer, successful consultants convincing responsible persons of their specific offer of methods.
In addition new methods are been developed day by day in a huge number of universities and research institutes. For over a decade researchers in the design science community have claimed that their methods are still not accepted by industry in the way they expected. Surveys quite often show, that just a few engineers in industry work with methods developed by the design researchers.
Additional views will help and are necessary to optimize both the usage of methods and the methods themselves. A basis to adapt methods to the given situation and to develop new methods is also required. This paper should help to support the use of working methods in industry and to develop methods in science as well as in industry.

## 2. Methods in industry, success of method transfer

Why do some engineers in industry work intensively with methods and others do not? Good training in university combined with positive experience in the early days of working with methods can be enough motivation for individuals to introduce methods within their field of responsibility. Furthermore, trainers and consultants are sometimes happy, if part of their method oriented training in industry or results out of it will be used again and again. Moreover methods will be used, if the staff is forced to do so by the top management, by standards like ISO 9000 or by the customer. In all these

cases we have to look at the effectiveness and the efficiency of the methods depending on the acceptance.
A number of researchers like Stetter [Stetter 2000] have worked on specific ways to transfer capability and competence into industrial practice. At least some kind of coaching has to follow the initial training in order to overcome initial frustration during methodical work under new or modified conditions [Lindemann 2001] and under time pressures.

## 3. Suggested steps to improve methods

### 3.1 How to describe methods

The normal way to describe a method is a written document together with some successful examples. Today we also find a number of databases with information about methods and this information is structured in some specific way.
All this usually does not answer the question about the content of the method, of what is 'behind' the method.
Several authors like Miller/Galanter/Pribram (TOTE - Test-Operate-Test-Exit Cycle) or Heckhausen/ Gollwitzer (Rubikon-model) [Wulf 2002] have described basic methods. On this basis Wulf developed his micro-methods of "discursive problem solving" (fig. 1) and the "political process of asserting solutions in a team". In the following we will call these kinds of methods basic methods.

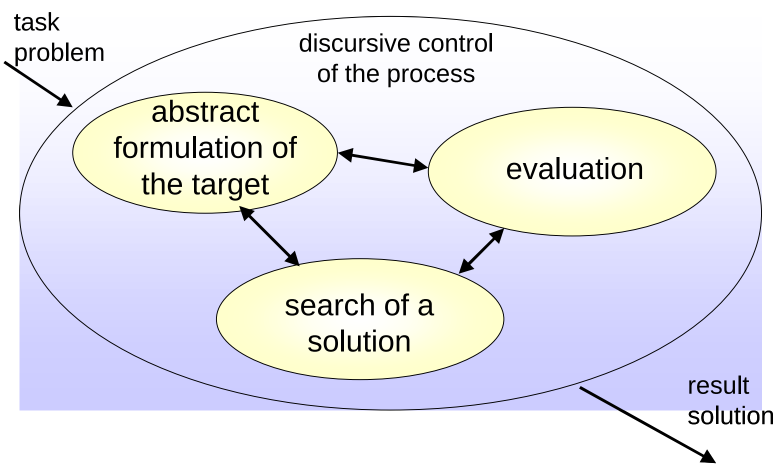


**Figure 1. Discursive problem solving ([Wulf 2002], [Lindemann & Wulf 2001])**

Another level of structuring complex methods was given by Zanker and by Ambrosy [Zanker 1999]. They discussed elementary methods like 'analyze', 'compare', 'combine', etc. as key elements of the methods we use. Knowing about these elements, we have the possibility, to analyze, compare and restructure our methods. Further we will use these elements as elementary methods.
Methods like brainstorming, design structure matrix and methodologies like TRIZ (teorija resinija izobretatel´skich zadac) and QFD (Quality Function Deployment), which consist of several methods, are further levels, which will be used. The structure of these four levels has been proven by a number of research projects.

### 3.2 Methods to analyze methods

Up to now there are hardly any ways of analyzing methods in terms of effort and benefit. Trial and error as well as consultancy based on experience, is the mostly used way of gathering information about methods. Just a few systematic and scientific researches are known about this question.
Because of very good and useful experience with the TRIZ-based functional analysis concerning useful and harmful functions during product development processes, we are sure that this method can be used during the evaluation of the strengths and weaknesses of methods too.

Another method used in process and organizational optimization projects is the SWOT model, which helps to analyze strength, weaknesses, opportunities and threats by specific and systematic surveys. By adapting the questions and categories of SWOT it may be used with great benefit too.
The results out of this analysis gives a better understanding of using the specific method with higher efficiency and it can be used to adapt a given method to specific boundary conditions and requirements or to develop a new and special method. We are sure, that it will help to get a better understanding of strengths and weaknesses of the different kinds of methods, but further research and discussion is required.

### 3.3 Adaptation of methods - design of new methods

Some examples may give an idea of the adaptation of methods due to different reasons:
Brainstorming has been modified to brainwriting, gallery method, method 6-3-5 and other derivates. Within literature on QFD we find a number of different and specialized adaptations. Gaul [Gaul 2001] suggested to use the House of Communication to analyze and plan communication processes in distributed product development processes. FMEA may also be used to cut the cost of a product.

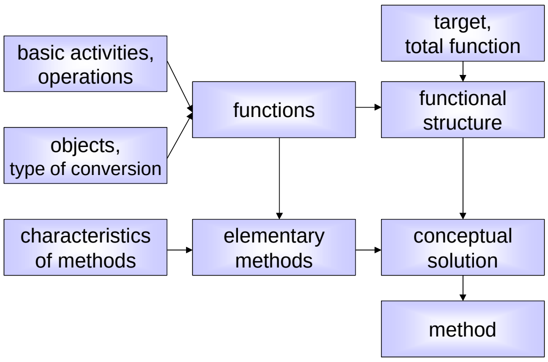


**Figure 2. Functional description of methods ([Gerst 2002])**

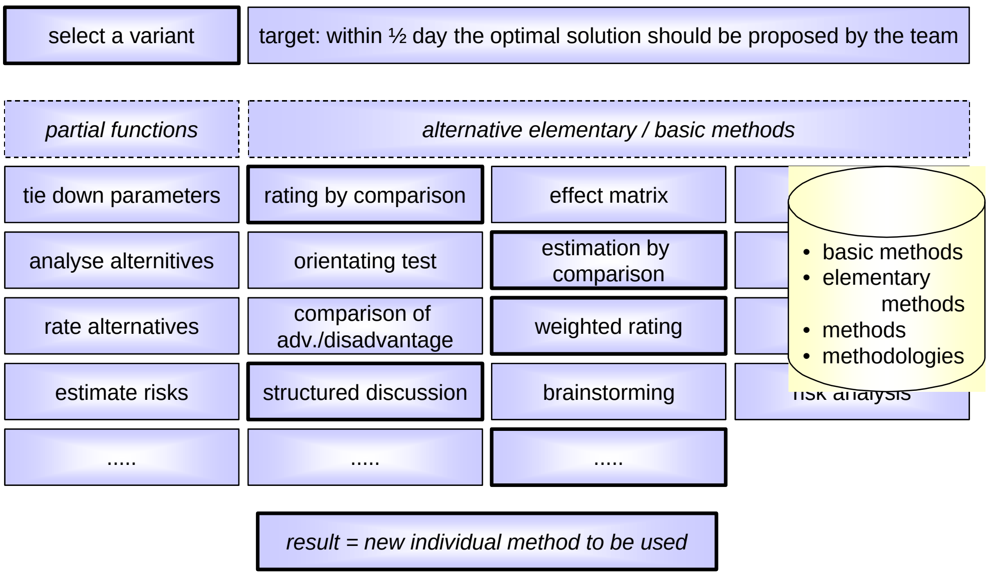


**Figure 3. Morphological method for designing methods**

These and other modifications came up by accident or because of an isolated idea. It is our approach that methods may be developed like products in mechanical engineering. That means that we have to discuss the requirements for a method. Gerst [Gerst 2002] suggested working with functional structures of methods and elementary methods using their characteristics to form conceptual solutions for new methods (fig. 2).

The well known morphological method may help us to find the right combination of elementary methods as well as complete, well known methods, to form a new or a modified version of a known method or methodology (combination of methods) depending on the actual requirements (fig. 3). In addition a database of elementary methods, usual methods and methodologies may support this process. For experts also the basic methods may be of interest in this matter.
A lot of research has been done in this topic, but there are still a number of questions concerning the situation and target driven adaptation.

### 3.4 Quality standards for methods?

Why do we think that a method works fine and gives us the required benefit and output? Why do we prefer some of the huge number of methods compared to others? How do we evaluate a new method?
We know how to prove the quality of our products. We try to measure the quality of our processes and improve them based on the philosophies of Total Quality Management using ISO 9000, the EFQM-model (European Foundation for Quality Management) or others.
But how do we measure the quality of a method? We tried to follow this question and compared IT-tools with methods and came up with a number of differences plus a number of points in common. On this basis we tried to find out, if the standards to prove the usability of software [Pache 2001] might be usable for testing and qualifying methods. Usability following ISO 9241-10 [ISO 9241-10 1996] is defined as the product of effectiveness, efficiency and satisfaction of the user. We are convinced that these general points fit exactly to the key issues of a method, although it is hardly taken into consideration in the software business. In addition we tried to transfer the detailed aspects of ISO 9241-10 to the requirements of methods, some examples are shown in figure 4.
It is our understanding that this is a first step, which has to be explored deeper by further research and investigations.

| *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 4. Aspects of the usability of methods**

### 3.5 Model of methods

Depending on the requirements and the aims, different models of methods have been developed. One example is given by Zanker [Zanker 1999] - his model is based on a number of elementary methods linked together depending on basic activities and parameters describing the boundary conditions. Another model was published by [Birkhofer et al. 1999], which is process oriented and completed by hints for the selection, the specification, links, required general conditions and tips. Based on these models and the additional above discussed points we want to suggest an expanded model for methods (fig. 5).

Our model includes of course the process of using the method with input and output.
This process is explained in the process description with all the steps, points of decisions, iterations etc.
The purposes of the elements of the method are explained with help of the flow oriented functional structure [Gerst 2002], which gives another overview of the structure and intentions.
The analysis of the method by the functional analysis as well as the SWOT analysis points out useful and harmful elements, strengths and weaknesses, threats and opportunities. The result is a better understanding for the usage itself and a basis for adapting a method to the situation and its boundary conditions.
The support for users supplies additional information such as for example IT-tools, working material, experience, examples, literature and hints.
Finally the quality check and description specify the usability under certain circumstances.

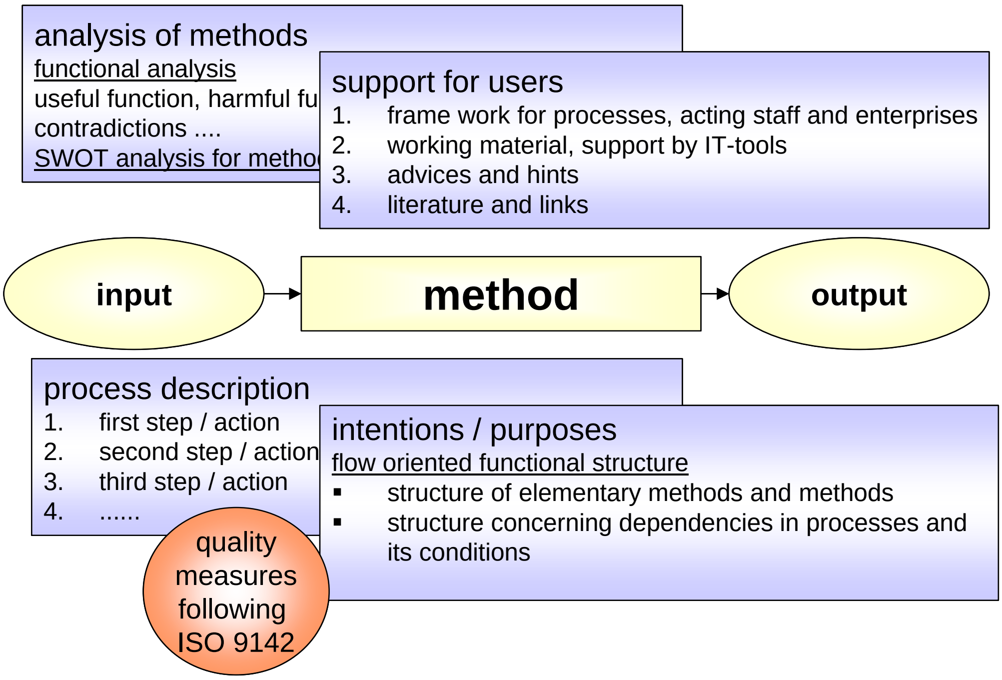


**Figure 5. Model of methods (working methods)**

## 4. Conclusion

The key to success when working with methods is a very good knowledge about the situation as well as an understanding of what the methods are about. Training and coaching are essential to gain net benefits from using complex methodologies.
Students should be trained in using and working consciously with methods as early as possible. However, today they start this training maybe at university or even after that in industry.
To support the use of methods many universities and a number of consultants are supplying computer based information systems with general or specialized contents about methods. These tools contain quite often more or less structured information about methods and in some cases computer tools are included as interactive method tools.
Since much literature about methods is available, we think that the most important step is to structure the area and to build up a network of basic and elementary methods. To support users we are working on a web-based tool called CiDaD (Competence in Design and Development), to give the right support at the right place to the right person. The content is modularized and will be netted step by step. The Bavarian government supports the development and we will start the test phase with a group of SME (small medium enterprises) during 2002. We will be able to report on our experience in 2003.

Nevertheless a lot of research is still required to prove some of the above-described ideas and to proceed in all the problems of transfer. By that we would like to integrate methods into industrial processes on a much higher level than it is realised today.
The key points we want to emphasize are the adapted use of the functional analysis and the SWOT analysis, in addition with a usability test similar to ISO 9142-10 to check, prove and optimize methods. The understanding of the effects of basic methods and their meaning is the second important point, why we added the discursive problem-solving model. At the level of elementary methods and of methods, a functional description supplies transparency and a better understanding of why certain elements are included in specific methods.
The above ideas and questions are the basis for a successful implementation of a system like CiDaD and an improved transfer of methods into industry. Measurement of the quality of a method, depending on the description of the given situation, will help to assess the method before introduction and training.

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Prof. Dr.-Ing. Udo Lindemann
Technische Universität München
Boltzmannstr. 15, D 85748 Garching, Germany
Tel. +49-89-289-15130, Fax +49-89-289-15144, Email lindemann@pe.mw.tum.de