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CLEANING UP DESIGN METHODS – DESCRIBING METHODS COMPLETELY AND STANDARDISED

H. Birkhofer, H. Kloberdanz, B. Berger and T. Sauer

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1. Introduction

In the context of globalisation and new information and communication technologies, different requirements for product development arise. Flexibility and quick reactions of industrial companies are becoming more important, reflected in shorter product life cycles and increased product complexities. Thus, the optimisation of product development processes is increasing in importance.

Within the collaboration project "*thekey to innovation*" (*thekey*) it was aimed to optimise the description of product development methods using a standardised, extensive, and thorough framework. In collaboration with other technical universities, a common product development method pool should be built up and integrated in the prospective *thekey* learning, training, and teaching system.

2. State-of-the-art

In the range of product development a multitude of established and new design methods can be found in literature, method collections or databases. Examples are well known references such as [Pahl/Beitz, 1996] or [Ehrlenspiel, 1995], who assign design methods to certain design phases of product development or relate them to special access items. Within the internet the so-called MAP-Tool [MAP] is an example for a method collection especially arranged for industrial users. Approaches to characterising design methods and configuring them for flexible use are presented in [Helbig, 1994] and [Zanker, 2000].

However, the description often varies concerning the kind and volume, and is very often insufficient for applying methods in design projects. The kind of description differs in relation to the structure and content. The same circumstances or facts are described in various terms and in different sequences. Thus, the search for methods for both the learner, e.g. student at university, and the user, e.g. developer in industry, is complicated. Deficits in completeness and volume of single design method descriptions can be determined. Several authors have specific main focuses. A description of general conditions for different fields of application or limiting factors are often missing. Concerning the structure, descriptions of design methods often are insufficiently separated between processes, methods and product-models. Design methods are mostly described to impart knowledge, not competence. Didactical elements such as application-oriented explanations, hints, aids and assessments are seldom pointed out separately. The main target group is the scientific community; the needs of designers at work are seldom considered.

In the effort to improve the design process, it is aimed to optimise the description of design methods and the access to them for effective use in design projects, as well as for better support of learning and teaching them.

3. Processes in product development

The procedure of methodical developing in product development is characterised by step-by-step actions, the logical order and defined results and levels. Product development can be conceived as a process with many sub-processes. A process is defined as the changing of state using a procedure which transforms a defined starting state into a desired ending state.

In general the process of product development seldom runs off in a defined and straight order, but in many different ways depending on the actual situation of application [Fricke, 1993]. The designer has to plan and control the whole process by arranging the sub-process in a flexible way. To work effectively he often uses design methods. There are many different methods and tools to support single sub-processes (Figure 1). The designer uses an individual mix of methods. He selects the most suitable design methods depending on several factors, e.g., user skills, infrastructure and working aids.
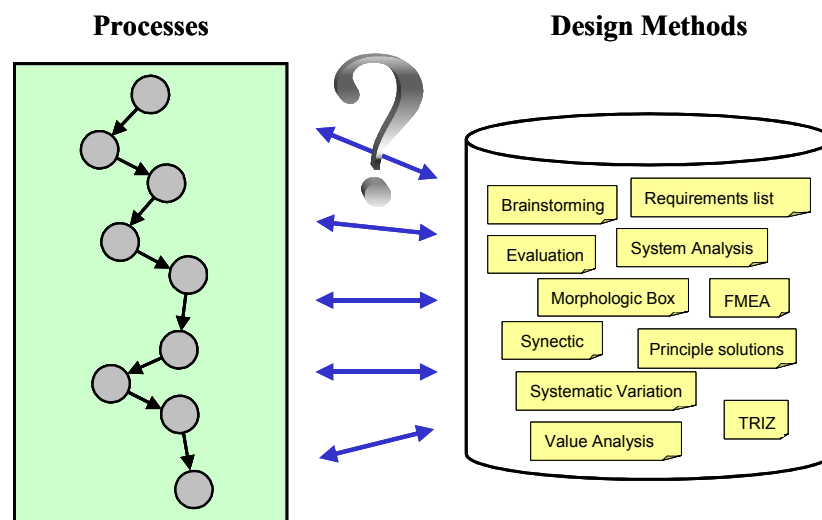
Processes **Design Methods**

Figure 1. Processes and design methods in product development

4. A Process oriented Method Model (PoMM)

In product development there is a wide range of different users and application. The users vary from students at university, just beginning to learn design methods, up to experienced developers in industry. Furthermore, teachers and coaches have different requirements for the contents, description and access of design methods for using and teaching them in product development courses at university or industry seminars. Besides the wide range of users, there are manifold different connected applications. The field of application extends from learning or teaching a single design method to applying the design method to a specific product development problem in practice. Furthermore, design methods must often be handled in a very flexible way, depending on the problem, the circumstances and the persons involved.

The context of several design methods and the chronological order are as important for successful problem solving as the individual description adapted to the specific problem. Thus, a model for description of design methods has been designed, named Process-oriented Method Model (PoMM). The Process-oriented Method Model supports processes in product development and describes design methods in a standardised and structured way, but also enables an individual and flexible access to single parts of them.

4.1 Support of processes in product development

Analogic to product development processes, the application of a design method can also be conceived as a process, namely the planned procedure transforming a given input (starting state) into a defined output (ending state). The output of a method corresponds to the ending state of the actual process, and also to the input of a method supporting the following process (Figure 2). Therefore, the designer, who

selects and uses the methods, needs a process-oriented description with the specification of the input and output, as well as information on influencing parameters.
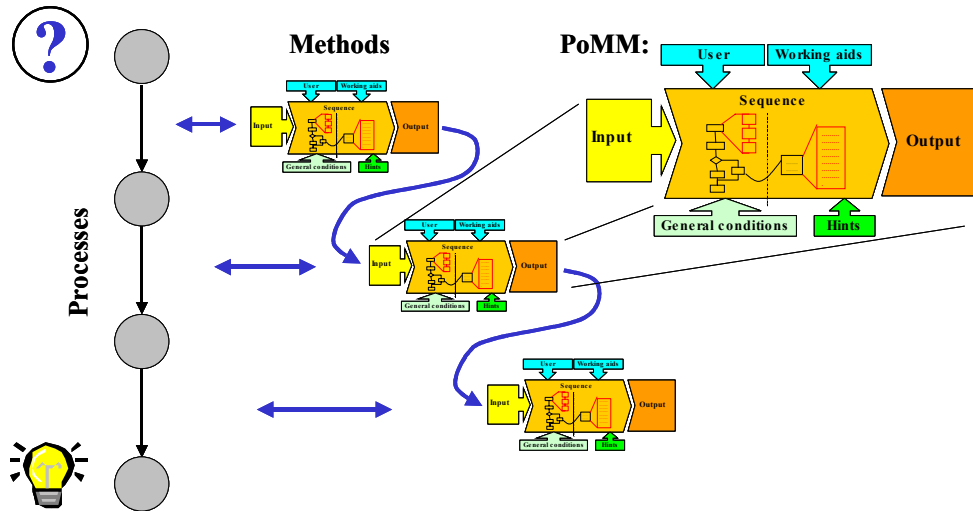

Figure 2. Design methods step by step supporting the product development process

The Process-oriented Method Model describes design methods in a process model, namely input, sequence, output and other influencing parameters, e.g., user skills and infrastructure, to support the processes of product development and to ensure the linkage and useful application of the method.

4.2 Contents of the Process-oriented Method Model

To fulfill the requirements of different users and various applications, the Process-oriented Method Model contains different modules for a standardised and structured description of design methods, but also for an individual and flexible access to single parts of them (Figure 3).
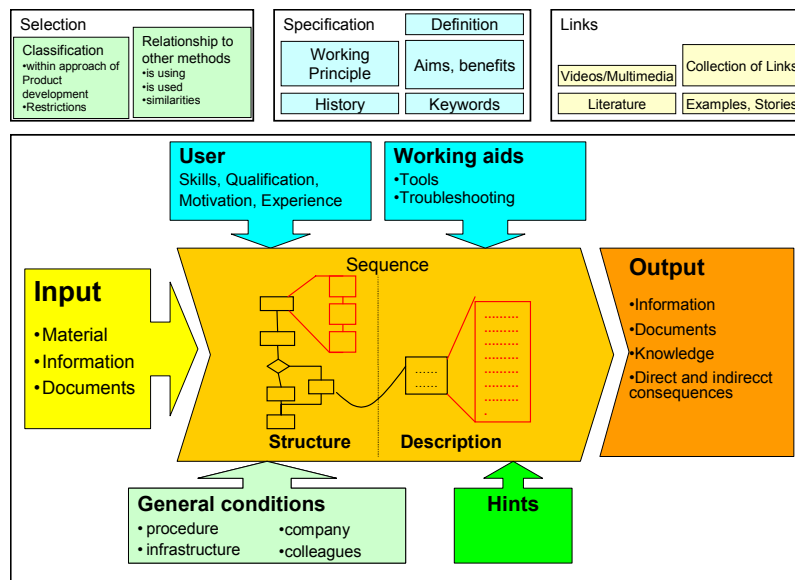

Figure 3. Process-oriented Method Model (PoMM) for product development

The description modules are organised into two sections - the process modules and the access modules.

The process modules are designed in a process-oriented way to be adjusted to the aimed design process as well as possible. The contents of the process modules have direct influence on the

application of the design method. Process modules are namely input and output, sequence, user, general conditions, hints and working aids, and they are described as follows:

- Input, Output: Short description of the starting state and the expected ending state of the method application. Specified contents are required documents and information describing the kind of result at the starting state and the desired kind of result and results at the ending state. Furthermore, contents of the output are direct and indirect consequences out of the reached result, such as to check and reduce the huge amount of results after a brainstorm.

- Sequence: Description of the procedure of the design method. The description should be worked out as a structure, e.g., a flow chart, as well as a coherent text passage. The structure enables a quick visualisation, especially for experienced users. The description with coherent text passages is suited especially to learners of the design method. To cover different users and different applications it is recommended to store different kinds of coherent text passages, e.g., a short version and a long version.

- User: Description of desired abilities of the users, primarily including skills, qualification, motivation and experience. These abilities may have a strong influence on the application of the design method [Schneider, 2001], e.g., highly motivated people are positive for intuitive methods, and high qualification and experience are necessary for complex methods, such as FMEA.

- General conditions: Description of influencing external parameters on the design method such as kind, size and structure of a company, infrastructure (e.g., meetings rooms, flip chart) and internal procedures. These conditions may have an influence on the method concerning available time (e.g., invitation to meetings) and acceptance of application.

- Working aids: Description of recommended workings aids, forms and tools for the application of the design method, such as a pin board and cards for collecting ideas in a brainstorming, a requirements list form or certain software for calculating the results of a value analysis.

- Hints: Useful hints and recommendations for successful application of the method, e.g., relaxing atmosphere during a brainstorming session, separated room and no killer-phrases. Hints can differ depending on the situation of application, e.g., number and hierarchy of participants in a brainstorming session depending on the problem. Thus, a choice should be enabled.

The access modules have a superordinated characteristic and they are designed for a flexible and detailed access to design methods. Direct search via keywords and other characteristics is supported and further design methods within the same context are related to each other. Access modules are the classification of the design method, relationship to other design methods, specifications and links. They are described as follows:

- Classification: Assignment of the design method to certain phases or processes in product development, e.g., clarification of the task. In addition, the design method can be characterised by the kind, e.g. intuitive methods, discursive methods, evaluation methods.

- Relationship to other design methods: Design methods can be divided into three categories: strategies, master methods and basic methods [Zanker, 2000]. Thus, depending on the category, a design method (e.g., functional analysis) can be used by other methods (e.g., value analysis) and vice versa. Furthermore, relationship to methods within the same category and within a similar context can be described.

- Specification: Description of specific items and attributes concerning the design method, such as keywords, working principles (e.g., brainstorming: intuition, association, group dynamic), aims and benefits. In addition, a definition of the design method is given, which is important for a quick overwiew or introduction. The history of a design method is supporting the understanding, the motivation for application and may be interesting for a deeper understanding or for didactic processes, e.g. in a lecture at university.

- Links: Further information concerning the design method are provided by a collection of links, e.g., internet-links, literature and other modules in a knowledge pool for product development. As examples for learning or application, e.g. stories, cases or multimedia links are provided.

5. Working with the Process-oriented Method Model

As described in the beginning of the paper, a wide range of different users work with design methods in different situations and for different applications. To point out the different specifications, three exemplary scenarios are described in the following passage.

Students of engineering design at university have to learn design methods. Two kinds of learning are offered by the professor: On the one hand, the professor primarily teaches the theoretical context of the design method in a lecture. Therefore, he/she might need, for example, the definition of the design method, the history, the classification, and a more or less detailed description of the input, procedure and output. On the other hand, the students have to apply a known design method for a task in a student design course. Therefore, they need a brief instruction for the procedure or a flow chart, examples to get ideas, forms and useful hints.

Another scenario involves a developer in industry working on a practical problem. He has to search for specific design methods suited to his problem and the design process. Therefore, he would probably look for the classification and relationship to other methods. Further conditions, such as the infrastructure, skills and experience of the user and working aids, are of special interest to him and enable his decision whether the design method is suitable to his problem.

The kind of presentation is as important as the contents of design methods for different users and applications. Especially for most of the process modules, i.e. the procedure, the description has to be available in different levels to fulfil the different requirements of usage.

For a learning document, such as a script, a coherent text including explanations and contexts is provided. For teaching in a lecture using slides, the focus is on pictures and graphs with prompts, explanations using multimedia elements or examples are suited to motivate the audience.

For a method instruction document used for a certain application, it is necessary to provide only a short introduction and kind of guided tour, such as a flow chart or a short step-by-step instruction, limited to a single sheet, if possible.
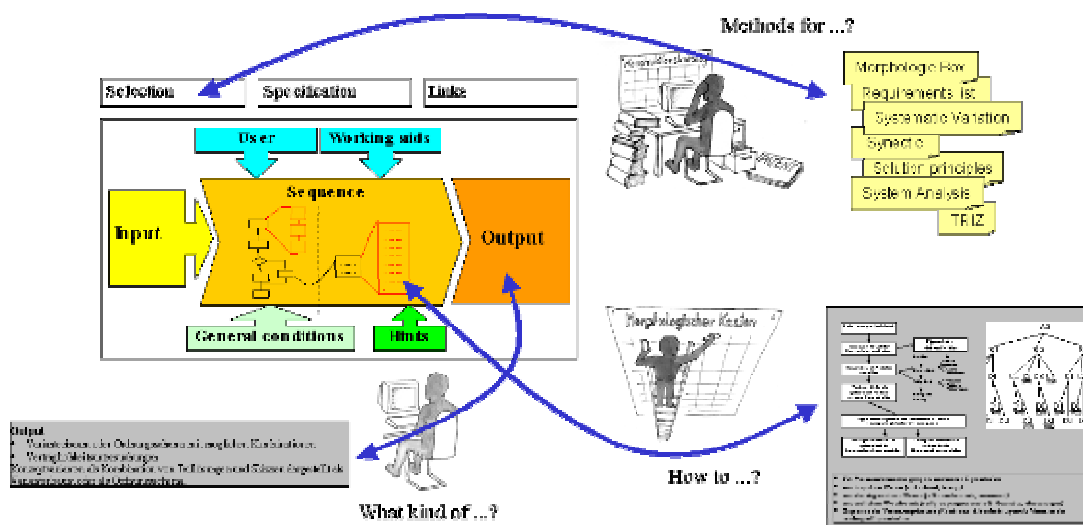

Figure 4. Contents of the PoMM and individual kinds of presentations

To achieve these highly flexible and different kind of contents and presentations, it is necessary to separate the contents (representation) and the presentation form (Figure 4). That means, the structure of the Process-oriented Method Model has to be understood as the representation of the design method contents, not as their presentation.

However, the Process-oriented Method Model has proven as a useful checklist for describing design methods. Beyond this, it is well suited as a guideline for teaching and applying design methods. The modules of description are appropriate to computer-aided working, can be retained in a database, and common software solutions enable an easy search and detailed access. Users can browse individually through single parts of a design method using hyperlinks.

6. Conclusion

The description of design methods with the Process-oriented Method Model puts together optmised support for product development processes and flexible and individual access to design methods. Furthermore, contents are described using modules on different levels to choose the most suitable content and presentation. Design methods can be described in the following ways: application-oriented, far-reaching complete, standardised and structured. A far-reaching completeness of design methods and contents is ensured by both the integration of several authors and standardised structured modules, which can be used as a frame for their work. A detailed search, and the flexible access and easy navigation are practicable because of the defined modules.

So far, the description of methods using the Process-oriented Method Model has proven as a useful aid in several design courses at the universities of technology in Munich, Darmstadt and Zurich and furthermore, in several training programs in industry.

The description of design methods based on the Process-oriented Method Model will be optimised by utilisation in practice, both at universities and in industry. Furthermore, volume and quality of the design methods database will increase by involving more authors.

The modular structure of the Process-oriented Method Model enables the integration of the contents into a modular database of a holistic learning, training, and teaching system for product development, such as is aimed at in the collaboration project *thekey* [Birkhofer, 2001].

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Prof. Dr.-Ing. Herbert Birkhofer (President of The Design Society)
Chair of machine elements and engineering design Darmstadt University of Technology

Magdalenenstr. 4	TELEPHONE:	+49 6151 16 2155
64289 Darmstadt	FAX:	+49 6151 16 3355
Germany	E-MAIL:	birkhofer@muk.tu-darmstadt.de