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TOWARDS A FLEXIBLE AND ADEQUATE USE OF METHODS IN PRODUCT DEVELOPMENT

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1. Introduction

Design methodology has become a major part of research in the field of engineering and offers a large variety of methods in order to establish effective and efficient product development processes [Ehrlenspiel 1995]. The main problem yet is that methods are barely used in practice or used in a wrong way. Corresponding to observations in industry, a survey resulted that there is no continuous use of methods in practice [Grabowski & Geiger 1997]. One of the main reasons for the insufficient use of methods may be that there is a wrong understanding of methods and their meaning, which again may be determined by a wrong design of methods. With this contribution we would like to present a more appropriate view on methods and the consequences for their design, teaching, and industrial use, not just to save design methodology in itself but to optimise development processes by effective tools and strategies. In this context, a method is understood as any tool, strategy, or proceeding that supports the solution of a problem or the achievement of an aim in general.

2. Current situation in design methodology

2.1 Reasons for the inadequate use of methods

The main reason for the insufficient use of methods seems to be that there is a wrong understanding of methods and their meaning, and by that wrong expectations. Often enough, designers think that there is or should be a method that directly leads to the desired result. If the desired result fails to appear, it will lead to disappointment, to a general questioning of methods and the non using of them. The results will not appear, if a method is understood as some kind of development process algorithm or automation. This in fact cannot be due to the necessary creativity and innovation, which somehow define design. By this, methods are used wrongly, both strategically or efficiently, i. e. which method to use, and operationally or effectively, i. e. how to use it.

The wrong understanding of methods may be determined by a wrong design and description. It is often discussed if methods prescribe a special procedure or describe a recommended or logical way of problem solving, while actually these differentiation between description and prescription must not be seen to narrow. The intention of describing phenomena in engineering design implies some kind of prescription by showing best – or worse – practices. Vice versa, the way to prescribe processes, methods, etc. is done by the description of an exemplary proceeding. To understand this is important for understanding methods and their description itself.

Another reason for the wrong understanding is that methods claim to be complete and generally valid. On one hand, these claims may be necessary in order to propagate the method and to gain a broader acceptance. One the other hand, these claims lead to the fact that designers expect completeness and general validity, which, again, cannot be fulfilled and leads to the above mentioned disappointment.

By the way, completeness means that each aspect of the regarded topic is comprised within the method; this is strongly connected to the general validity and signifies the above criticised because not possible automation of design processes. It somehow also negates other, contradictory methods, which may be also valid by regarding the problem from another point of view.
In the same way completeness and generality are delusive, the negligence of the necessity of technical knowledge is precarious. Methods do not claim to overcome technical knowledge, but they often lack to explicitly refer to it. Methodology is not a substitute for specialised or technical knowledge nor an alternative way of problem solving. It is the systematic general way to solve a problem that shall lead technical knowledge in the right direction. In this sense, the aim of a method is not primary the final result, but a structured and systematic proceeding to get there. When asked for methodical support, this is not possible without the integration of technical experts. Methodical and technical experts either have to work together, or there has to be a comprehensive methodical education.
Though most methods somehow attend to handle complexity, the problem of complexity itself is barely regarded. Methods may be the theoretical right way to handle complexity, e. g. by showing all relevant relations between the elements in a recommended representation. But how to regard really complex systems, e. g. with myriads of elements and relations, is not described, or the method even fails completely by handling them.
Talking of complexity, the amount of methods and problem solving approaches itself has become a problem, since there is no standard method or solution for a specific problem. Here, methods and tools in order to estimate the efforts of a method and to choose the adequate one are still missing. "Methods to estimate methods" shows the redundancy of the topic and by that what methodology means: it is mainly the self-reflection of one's acting. This means that there is always a superior level that allows a more general, abstract regard of the problem. So e. g. there is the description of technical knowledge, then the description of methods to handle this knowledge, and then the description of the flexible adaptation of methods or their implementation. It is one aspect of the incompleteness or an interpretation of the respective theorem, that this reflection will not end and by that no (meta) method can be complete. This is another reason why there has to be unconscious and intuitive elements within design processes [Wach 1994], either integrated in a general reasonable proceeding or not.
These and other reasons for an insufficient use of methods [Zanker 2000] can be rephrased as the following requirements on methods:

- concrete and specific formulation, not theoretical and complicated, practical
- user friendly and up to date
- no prescriptive character, regarding individual working stylea
- regarding distributed development processes explicitly
- regard flexible use in their description and offer methodical concept for their adaptation
- clear connection and integration of methods, superior structure, continuous description
- implementation strategies, as well as education, training, and coaching
- clear target and way it works
- reasonable and detailed classification of methods for a proper choice
- reduced efforts for the use of methods with obvious benefits
- no pressure to use methods, understanding their meaning.

Regarding projects in collaboration with industry and universities, it often seems that industry cannot use the methods research has to offer while they have problems research cannot solve. This discrepancy may be on one hand justified in research's objective to think far ahead. On the other hand, it somehow shows the main problem of industry, that the will to solve a problem is more important than the ability. A method is not the solution, it is just a tool.

2.2 First approaches for a better use of methods and the positioning of design methodology

There are different approaches concerning an abstract regard of design methodology. First, there is the situative adaptation of methods. It bases on the model that methods consist of elementary methods supporting elementary activities of the design process and that their character is specified according to the boundary conditions, e. g. team or individual. The elementary activities are e. g. collecting, structuring, separating, comparing, creating, or deciding. A complex method can be assigned to these elementary activities, elementary methods directly support these activities. Elementary methods are e. g. matrices, portfolios, hierarchical trees, or flow-charts. Another basis of this approach is the classification of methods concerning the criteria structure (used elements and classes like work steps, priorities, hierarchies, etc.), formulation (principle, dialog, rule, etc.), representation (language, diagrams, symbols), tools (hardware, software), media (paper, computer), and user group (individual, team). These criteria can be regarded directly, and as superior criteria, where the mentioned specifications are the actual criteria that have to be specified, e. g. individual can be a manager, a designer, or a controller. The situative adaptation of methods now consists of the approaches: use of elementary methods for elementary activities, adaptation of methods on boundary conditions, and recombination of methods in large scale. The choice between these depends on the task's complexity, its importance and the available capacities.

Another pragmatic approach is the method implementation in integrated product development [Stetter 2000]. The described proceeding consists of the steps initiation of a method implementation process (identification of strengths and improvement potential, establishment of objectives, moderation and team building, etc.), analysis of the product development system (collection of information, intensive analyses of details, etc.), choice and adaptation of methods (choice of the appropriate method, adaptation of methods to individual and group prerequisites, etc.), the actual implementation of methods (method teaching, coaching, etc.), and the evaluation of the impact (quantitatively and qualitatively).

There are, of course, approaches to define a generally valid, comprehensive methodology [Grabowski, Rude & Grein 1998]. Such a design theory may serve as a discussion platform or a portal, but it cannot be complete or even consistent, i. e. free of contradictories. This is due to the fact that each process is different ant cannot be totally decomposed. This chaos or flexibility within the design processes is necessary for continuous improvement and creativity or innovation at all. It may be also what has been described as the discourse within the design process or the action orientation in design methodology [Lindemann & Wulf 2001]. This means that new solutions are generated within a dialog – an inner dialog of one person or a dialog between a few individuals – where analysis and solution are not strictly separated and boundary conditions always change arbitrarily. There also has to be an alternation of systematical (level of results) and associative (level of action) procedures. Though there are both action oriented methods such as brainstorming or synetics (for teams), TRIZ and mindmaps (for individuals), and description and documentation oriented methods such as functional structuring, morphological matrices, evaluation methods, etc., it seems that design methodology focuses on planning, directing, and controlling instead of thinking and acting.

For a clear understanding of design methodology, there shall be a description of its positioning within product development as shown in Figure 1. Objective of each development is the product, placed here on top and represented by different product models. Each model, requirement specification, functional structure, CAD-data, etc., is a representation of the complete product, though of course not regarding each aspect. The product is result and outcome of the development process, which is very fuzzy on the above mentioned action oriented level, but can be described as a reference on the abstract level of results by building blocks, tasks, milestones, etc. These processes run within specific resources and boundary conditions represented in the bottom and influencing one another. These are the organization of the enterprise, its culture and markets, its employees with their characteristics, money, time, as well as methods and tools. These methods and tools can support single process steps concerning different levels of the product representation. They cannot completely describe the whole process and do not work without appropriate boundary conditions such as the company organization, experienced, qualified, and motivated employees, and respective capacities [Pahl & Beitz 1996]. The results of the process or single process steps are again the input of new processes or process steps and also influence the boundary conditions and resources. The borders within this model are of course fuzzy, e. g. the product representations are again steps or milestones of the process while the abstractly described process can be understood as a resource of the enterprise. This model may give an impression of what is covered by design methodology and shall help to understand the aim and integration of methods. The emphasis is on a flexible description of methods for different design processes and methodology know-how regarding employees as the companies' most important resource.

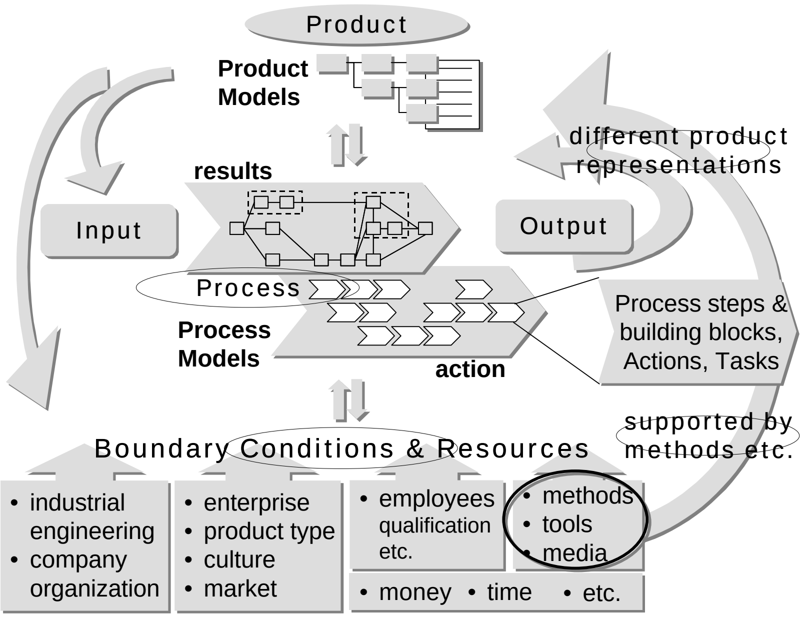

Figure 1. Model of product development

3. Further implications and conclusions on methods of product development

3.1 Elementary methods and their integration

To have a methodology that is both continuous throughout the design process and manageable with reasonable efforts, it is recommended to develop more elementary methods on one hand, and on the other hand show their connection and integration in the overall concept. A lot of methods seem to be self-contained within the design process, such as benchmarks, requirement lists, functional structures, etc. Of course they are located within the design process, but the connection of the single methods and their interaction are not formulated clear enough. Furthermore, depending on the scope of the method, there are many redundancies, overlaps, and even contradictions within the methods, e. g. comparing value analysis and the problem solving cycle, or e. g. matrices within the design structure matrix or within quality function deployment. There are also many comprehensive methods or tools that are only described as a whole – barely manageable – unit. Objective for design methodology as well as each single method of any complexity is to offer single, manageable methods comparable to the elementary methods described above but in a more concrete form (matrices, tables, diagrams, procedures, etc., together with their dimensions, parameters, characteristics, etc.). All these clear methods have to be integrated in an overall context, i. e. it is to show how they work together and can be put into a workflow. This may be possible by explicitly described connections, but not only input and output. It shall not mean that there is one clear described design process, but it shall bring transparency into design methodology and enable to find a reasonable way in development processes. Or in other words, this shall not overcome single-standing methods nor complex methodologies, but it shall emphasize and demand to always regard both aspects – manageable methods and the overall context.

3.2 Constituents of a method or a tool

Next to the differentiation of elementary methods and their integration stands the aspect of the constituents of any method (Figure 2). According to this, a comprehensive method shall have a described process containing the respective work steps in their right arrangement, the language with which it describes the product or the regarded aspects of the systems (graphical symbols such as in UML or functional structures, matrices in QFD, etc.), tools that can be of any kind, either based on paper or on computers, and finally rules both valid for the method and valid for the system regarded with that method. The borders between these constituents may be sometimes blurred, but this model shows the aspects that are to regard by building up a method.

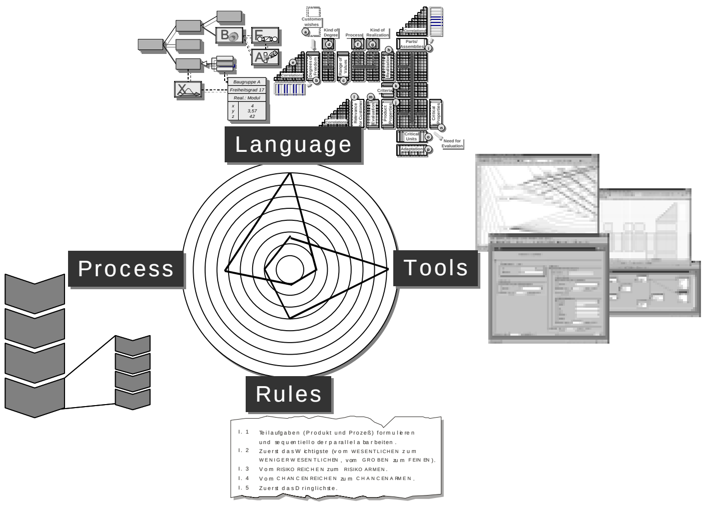

Figure 2. Constituents of methods and tools

It also helps to classify existing methods and identify potentials to extend them (e. g. QFD is focused on the language, CAD on tools). This is represented by the graph in the middle of Figure 2, i. e. that all four aspects shall be regarded nearly equally. This also implies that the 'method' behind a computer tool has to be clear [Ambrosy 1997]. For a classification, there are of course more than these four criteria (e. g. efforts, user group, targets). The aspects are iteratively connected to each other, e. g. one step of the process is supported by a specific representation (language) or even again a method, while a process also describes how to fill in the language, e. g. in form of a matrix.

3.3 Regard of methods as products

A pragmatic approach to improve methods is to regard them as products themselves. By that, a method has to be developed, tested, offered, and sold, as well as there has to be a service and training for it. It also implies that there may be different competing or alternative methods, that methods can have success or not, which will only be shown by the market, that there is a life cycle of the method with growing and declining, as well as also a final end of the method, to which another method may follow. Comparing methods to products means also to refer to similar requirements, as there are e. g. an ease of use, also if the product itself is complex, safety and reliability in its use, modularity and customers' variability, fulfilling strategies like product families or platforms, etc.

3.4 Collaboration of industry, research, and education

Both the implementation of methods in industry and the closely connected need for methodology know-how lead to a strong emphasis of the collaboration between industry, research, and education. The need for knowledge in methodology shows the importance of the individual and the individual education. This means in contrast to the before described regard of methods as products, that methodology is closely bound to persons, as knowledge of it is by definition. This is on one hand the main way of transferring methods into industry, when those individuals go into practice. On the other hand it is one of the main that principles of methodology to instruct individuals to both dynamic and systematic acting, just supported by methods. This is in student education as well as in the further education integrated in graduations or dissertations regarding design methodology.

This collaboration benefits in the three dimensions learning, testing, and thinking ahead. Industry learns new methods, proceedings, and techniques, i. e. method implementation, students learn about praxis in early phases, and research learns about management and general problem solving. The testing concerns new methods and proceedings, also for all three of those groups. This also refers to some freedom in research and progress by trial and error, i. e. that not all results need to be economical meaningful which otherwise could also be topic in industry. The thinking ahead is important for the progress in industry as well as in research and in the personal development. Talking of collaboration, research has a main part in the link between industry designers and software designers: industry can often only show the need while software designers only see the implementation; the underlying and linking methodology is part of research, which unfortunately sometimes seem to be competitor of commercial IT-companies.

3.5 The narrow meaning of science regarding design methodology

Talking of flexibility in design methodology in order to cope with ever changing processes somehow contradicts the main principles of design science or science itself: just to find the consistencies within different systems, to 'define' in the meaning of differentiating things that actually belong together, all in order to handle complexity and allow a precise acting. This is what methodology represents, generally valid procedures or tools. But due to the fact that design processes are highly complex systems, where an accurate comparison is nearly impossible, a method again will never be complete and all someone can come up with. It is some kind of tightrope walk or dialectics between strictly describing and prescribing methods for industrial product development and advocating flexibility within design methodology. So both aspects are right, there is a need for a strict methodology in order to have a platform for discussion and education as well as a reference for design processes, and there is an even stronger need of understanding that design methodology is a very flexible and dynamic instrument. This dialectics may show an aspect where design science has to go explicitly.

4. Summary

Though design methodology has become a major part of engineering science and industry is aware of its need, the use of methods in practice still has to be optimized. It may be reasoned by a wrong design of methods, that they are not understood und used properly. It is important to offer flexible and manageable methods that are connected to one another along with clarifying that a method is just a supporting tool, that it needs specialized knowledge, and that it is no design automatism. A strict methodology – e. g. in form of a design theory – may be necessary for discussion and education, which is in fact one of the major aspects of this topic since methodology is closely bound to individuals. The dialectics between clear methods and their flexible use seems to become a main topic of design science and shall be regarded in theses describing methods explicitly.

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