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THERE IS NOTHING AS PRACTICAL AS A GOOD THEORY – AN ATTEMPT TO DEAL WITH THE GAP BETWEEN DESIGN RESEARCH AND DESIGN PRACTICE

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1. Introduction

ICED conferences, as well as others dealing with the topic of design, suffer mostly from a lack of industrialists and seem to be of minor appeal for engineering designers. On the other hand, numerous convincing results of design work have been published, demonstrating successful results. Although a vast amount of knowledge, methods and tools has been elaborated upon by design researchers since the mid-1960's, where current design research has its origins, there seems to be a substantial gap between the output of design research and its application in design practice [Gausemeier 1997].

The view presented here is based on 25 years of intensive design co-operation with industries in a variety of branches like car producer, automotives, handling; packaging; robotics, medical equipment and consumer goods. Even if a picture of the design world is multicoloured, the understanding of deficits and needs might be supported by painting the picture partly in rough outlines and black and white colours.

2. Design in industry – a look behind the curtain

2.1 Design processes in industry

Viewing design in industries, fascinating products like sports cars, supersonic aircrafts, or mega-power plants immediately come to mind. On the other hand – and like a shadow on this picture of perfect engineering – the media intentionally publishes the deficits and weaknesses of new products, ranging from callbacks to serious accidents [Hales 2003].

Analysing the reasons for the weaknesses of products, it might be useful to transfer the view from products as an output of design work to the related design processes. To get a realistic and detailed picture, one might use the numerous results of more than fifteen years worth of intensive empirical design research [Frankenberger, Badke-Schaub, Birkhofer 1998] [Frankenberger, Badke-Schaub 2004]. It shows that design work in industry is not at all as convincing as it looks on the blue prints presented by marketing people. As in any business where people work together, mistakes also occur in design work, deficits are omnipresent, and the pressure of market and competitors forces strange effects [Figure 1]. Even if seems easy to criticize design in practice, being "far away" in universities, it should be allowed to point out some "wrong tracks" of industrial design work, if it is done with the goal of pointing out improvements and "remedies", too.

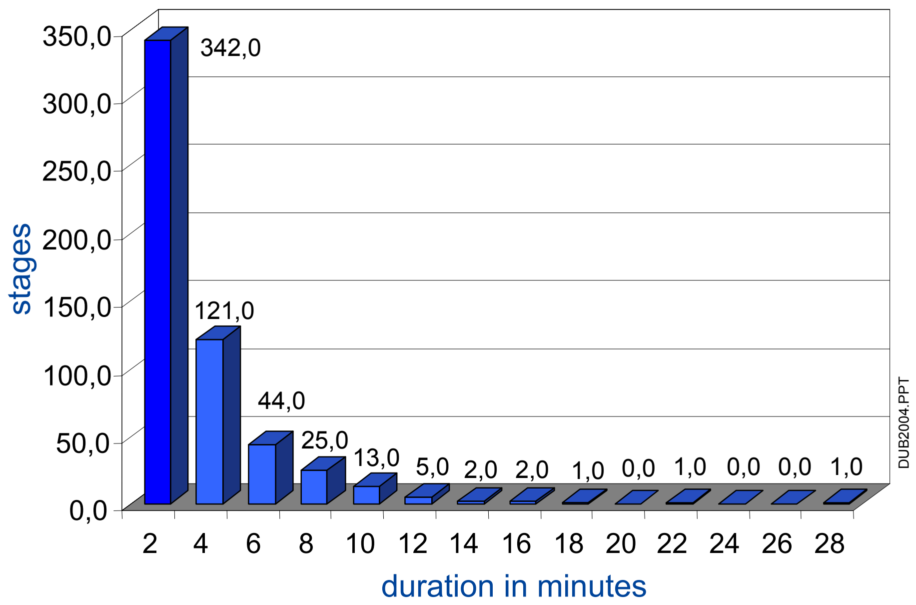

Figure 1. Sequences of continuous work of a group leader in design [Lüdcke 2003]

2.2 Current design work – conditions and environment

2.2.1 The complexity and dynamics of design work

In numerous branches, like the automotive industry, the requirements for designers have grown dramatically in the past. Mechatronics and the trend of becoming a systems-supplier raise product complexity and product-variants to a barely manageable extent. Whereas for designing components or even parts it was sufficient to have good disciplinary knowledge, nowadays interdisciplinary knowledge combined with faculties for managing interdisciplinary teams is needed. In addition, the intensive use of CAx-technologies raised the performance of design work to an unbelievable level. However, designers had to subsequently extend their competence in operating IT-systems with the challenges of using highly sophisticated hard- and software. The increase of requirements should normally have led to an intensive training of designers in efficient working techniques with methodical approaches. In reality, however, this kind of training often did not take place or remained insufficient. In addition, first skills and faculties, students gained during education decrease rapidly when they start design work in real business.

2.2.2 The pressure of time and costs and quality and…

Regarding design work in practice, there is an awful amount of pressure on designers due to restrictions and demands. Besides the standard restrictions of Dfx-targets, designers struggle with the demands of "time to market", target costs, product quality, life-cycle design and sustainability. In many cases, stress, mad rushes and rapid changes in organizational structure and ownership of the company cause an atmosphere that is not conducive to working creatively and taking time for thorough reflections. Despite all their benefits, current communication technologies, especially e-mail, create a data overflow [Ehrlenspiel 1997], where relevant information or even appropriate knowledge can hardly be detected. In total, one could argue that the pressure on design work has increased rapidly.

3. The power of a good theory for designing products and processes

Nevertheless, convincing examples of good products and well-developed processes were found, demonstrating the benefits of an "intelligent" use of methods. Some examples of own work are presented here, all of them realized not only be good-looking concepts but also convincing, marketable products.

3.1 Use powerful models for market success

In co-operation with a leading company in fastening technology, a mixed team of researchers and designers developed an innovative direct-fastening dowel to fix insulating slabs on concrete or brick walls [Figure 2].

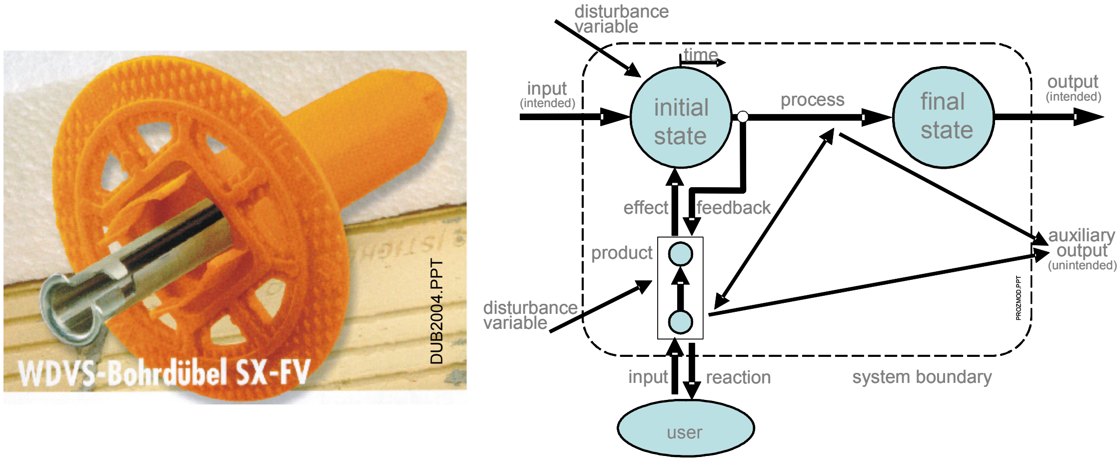

Figure 2. The direct fastening dowel and the process model used for design

The product was a full success at the craftsmen-market and is convincing due to its exceptional time-saving and reliable fastening-procedure. Even if the innovation could be labelled as most creative, it was, in fact, based on a systematic design done step-by-step, using a powerful process modelling approach. The whole design task covered the innovative dowel, a special drill, and the documentation of the entire fastening system using a standard drill-hammer. From the signing of the contract of the co-operative project until the start of the serial production, the project took about eighteen months, half of which consisted of the design phase.

3.2 Do it methodically

A company producing instruments for the quality-check of glass fibres for tele-communication purposes needs small instruments to adjust the end of a fibre to either a laser emitter or an electronic receiver. The first sample of such an instrument was developed by a technician within the company [Figure 3 left hand side] and failed totally due to serious functional deficits, an unattractive style, an overstepping of planned manufacturing costs of more than 30%, and a complete disregard for customers.

After this disaster, a second order was given to an engineering office to develop a marketable instrument, fulfilling the requirements originally set, and to design the instrument within a space of less than 6 weeks! The new product [Figure 3 right hand side] was convincing in its overall properties and was a real market success.

Whereas the first designer worked conventionally, the designer of the engineering office was trained to use design methods [Figure 3 centre]. Especially the conceptual phase with a functional decomposition, the use of catalogues with solution-principles and the technique of systematic variation are causally connected to the success. Serious time restrictions on the design process could be adhered to, as the elegant and truly simple adjusting-mechanism saved a lot of time and effort for the embodiment and detailed design afterwards. Evaluating the second design process, it might be mentioned that it ran better and faster due to the methodical knowledge of the designer and his competence in adapting methods appropriate to the task.

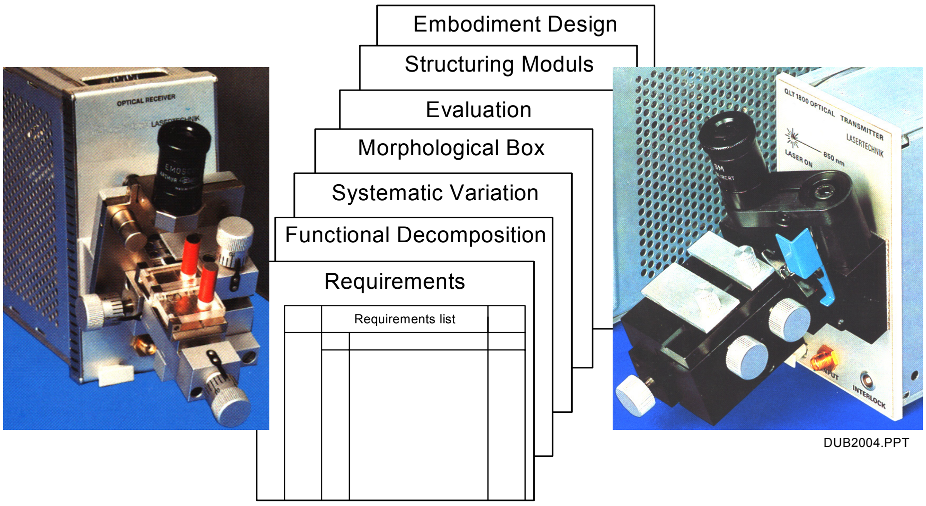

Figure 3. The adjusting-instrument – first miss, afterwards methods used and final success

3.3 Do the right things at the right time

Design methodology focuses on the early design phases, but gives valuable hints for the embodiment phase, too [VDI-2223]. Besides many rules and principles, guidelines for structuring the embodiment design process could be used most effectively and efficiently. The new design of a high-tech unit for stacking foil-bags within production equipment should top all performance ever known. Fully equipped it should produce more than 1.5 Million bags per shift, an increase of 45% compared to existing equipment [Figure 4].

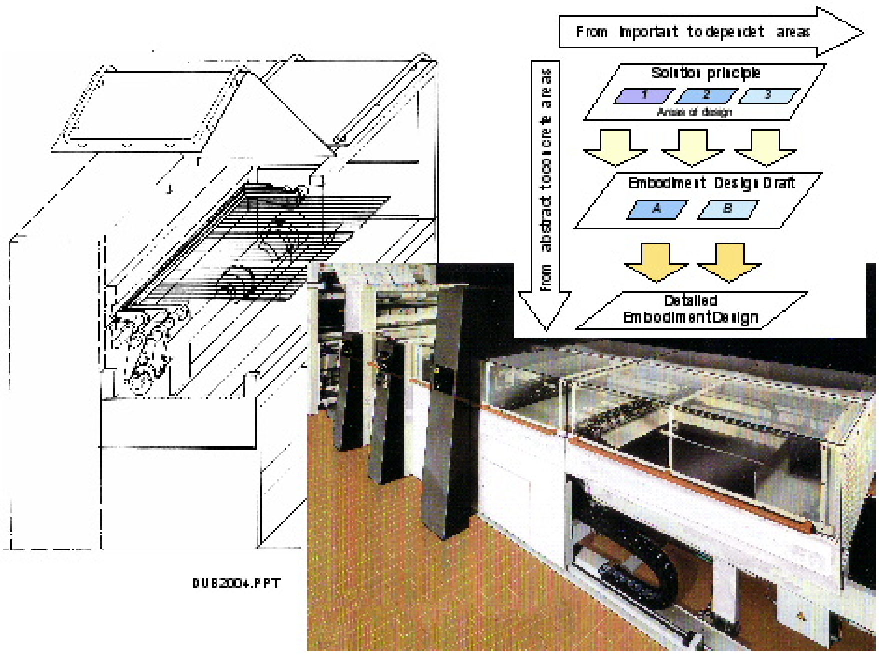

Figure 4. The high-tech unit for stacking foil-bags – draft, embodiment design process, and unit, integrated in the final production equipment

A first and rough draft of the unit was prepared, the embodiment design should have been started. Same as with the adjustment-instrument (chapter 3.2) an experienced internal designer began it and totally failed. After 6 weeks intensive work e.g. the gearbox as part of the unit was detailed almost completely, but the crossbeams with extreme requirements in accuracy and dynamic remain undesigned almost totally. Not until a conscious structuring of the embodiment phase of a separate design started the unit could be designed properly as the "heart" of the entire equipment [Figure 4]. Following the procedure given by the guideline VDI-2223 was one key to success. However, upon looking back, the major reason for its success was the intellectual grasp of the embodiment process in general with the need for the priority of product components to be worked on and deriving an appropriate sequence of process-steps.

3.4 Save time and costs, increase quality and customer benefits

As a last example, a production unit for coating Compact Disks (CD's) should demonstrate the improvements in terms of time, costs and quality [Figure 5].

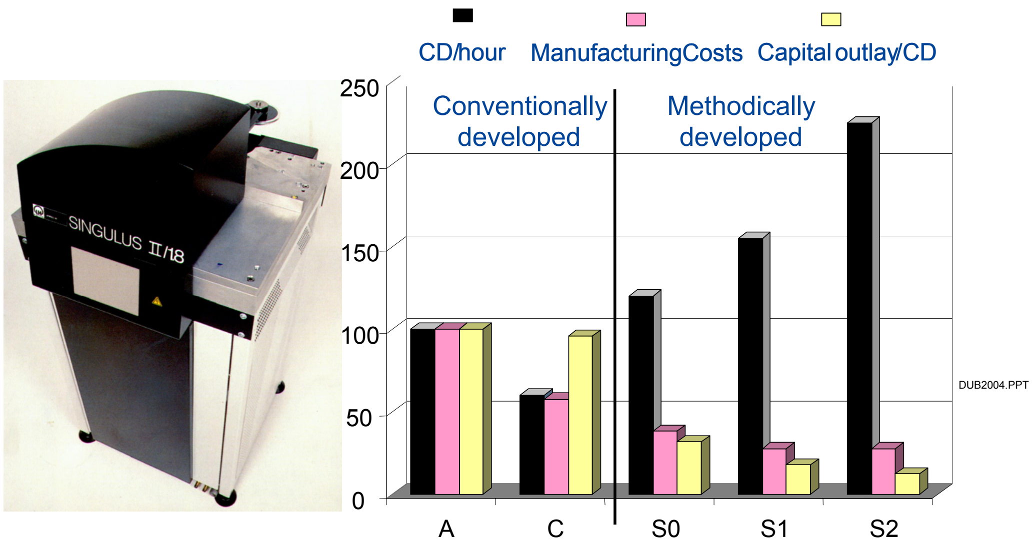

Figure 5. The coating-CD machine and different steps of redesign

Several prior attempts to increase output and reduce manufacturing costs at the same time failed. The capital outlay for customers came down to the same. Not until a new process-management with high competencies in design methods and a deep understanding of the nature of process-structuring started was there success. A well founded analysis of processes in the whole life-cycle-chain, a systematic overlapping of processes (Simultaneous Engineering) and broad competence in designing methodically increased the output substantially and decreased time and costs dramatically.

3.5 Design success – the models behind it

Most of the design projects mentioned above were carried out by former or current design researchers. Looking back one might count several reasons for the projects' success:

- The match of expertises of industrialists (material, technologies and suppliers) and of researchers (design methodology)
- The researchers' view from outside and their experiences from other projects in different companies and branches
- The good relationships with the "mixed" team and its mutual confidence

But, without any doubt, one key to success was the use of the powerful strategies and methods. Based on the "good theory" of systems engineering and adapted to the needs for product development, design methodology has the makings of a powerful support for design work, as well as a for redesigning process-chains within a company.

4. Why not? - The gap between the needs of practice and the outcome of research

In industrial design work the use of design methods plays a varying, but mostly minor role. There seems to be a substantial gap between the needs of designers working in a competitive industrial environment and the outcome of design research. The question is why all these results and outcomes of more than 40 years of research do not have more influence on design in its entirety.

4.1 Unrealistic expectations of designers in industry

It is no wonder, therefore, that the use of design-methods and tools in industry is often called too complex, which means too theoretical and poorly suited for the actual design-world with its pressure from customers and competitors. Viewing the actual design situation in industry, one could understand the expectations of designers fulfilling their most urgent needs. Methodical support in design

- Should need as little effort for learning and training as possible
- Should be easy to use
- Should solve problems "in no time"
- Should produce convincing results for complex problems
- Should not be islands of support, but integrated in the existing design environment

It is evident that these claims make unrealistic demands on design methodology. Compared to the effort needed to learn and use 3D-CAD-systems, FEM-tools or project management tools for multitasking, which "only" support a limited part of design work, in some way it seems to be ridiculous to expect that simple methods solve the entire design problem. We have to accept that simple methods and tools probably produce no more than simple results. In consequence, we have to expect, if methods and tools are successfully used in real design work, designers must contribute to an adequate intellectual level. And without the appropriate amount of time for learning and training and without the motivation to modify their own behavior in problem solving, the success of designing methodically can hardly be achieved.

4.2 Overstated promises from design research

Dealing with the use of methods in design practice, it would be one-sided, to claim only about the reserve of designers. There have to be mentioned, too unrealistic promises of researchers, who produce new methods with enthusiasm, but neglecting at the same the effort for learning, for adapting and integrating them in practice. Using the full power of design methods and tools therefore entirely requires an at least basic understanding of the principles and models behind them and their mental internalization. This "look behind the curtain" needs intellectual faculties, educational effort, time for reflection and a consciousness of other principles and fundamentals.

The dissemination of methodical work will be extremely hindered by the scattered landscape of design research. Just looking at ICED-proceedings, I wonder if someone would be able to get a full overview of the methods and tools produced in the last decade. Even fundamental requirements for a breakthrough of research results, like a commonly agreed upon and used terminology, are not fulfilled. After 40 years of design research, the research community has not succeeded in defining finally such an important term as "function"!

In addition, researchers tend to pick out the most spectacular issues in design work. The "creative design process" is a long-running issue in all design conferences. Even though this topic might be important for research-purposes, we have to consider that creative phases in design practice are in the minority [Frankenberger 1997] and phases with routine tasks like documentation or information are in the majority. In consequence, the design research contributions which deal with such "odd issues" as the definition of quality guidelines in design or structuring company standards can be counted on one hand.. It seems logical that methods such as FMEA, Target Costing, or QfD, widely agreed upon in industries, have their origins in economic science and production research, long before design methodologists woke up and took them over for their purposes.

5. Some comments on current design research

Coming back to the statement of the gap between research outcomes and industry's needs, there is no question at all that deficits can be detected on both sides. To bridge this gap, therefore, both partners have to make a move. As to the responsibility of the design research community, some requirements are formulated below.

5.1 The lack of a commonly agreed upon terminology

A commonly agreed upon and widely used terminology is a fundamental requirement for every body of science. It seems to be a primary task for design researchers to generate and extend such a terminology before or at least while creating methods and tools. This would provide not only substantial support for young researchers like PhD's, but it is a fundamental prerequisite for the universal understanding of design researchers and for a greater acceptance in design practice. Even if the way is long and stony, design researchers should consider the example of Newton's concept of "force", which was heavily disputed at the beginning, but was finally accepted with outstanding benefits to science as well as practical applications.

5.2 What principles and models design research is based on

Using the full power of design methods and tools also requires the proper understanding of the principles and models behind them. This applies to design methods and tools, as well as to every other method and tool. Of course, one can use e.g. a Finite Element Method (FEM) to calculate strength and stresses in a complex part without any understanding of the material's strength properties, implications of notches, or selection of a mesh rate. The result will hardly be realistic and probably lead to quite the wrong conclusions.

In design research a lot of models are described, but only few contributions [Hubka, Eder 1996] [Andreasen, Hein 1987] define a convincing set of principles and models related to each other. Own research work in modelling design products and processes demonstrates the convincing simplicity of models, reducing the complicated picture of design to a few fundamental concepts. In addition, experience in designing and in design teaching demonstrate that mental internalization of these principles and models [Lindemann 2003] is "a" and probably "the" key to unlock the full power of methods and tools. Starting with enthusiasm, the lack of knowledge about and awareness of these principles and models might be the reason why methodical work in practice often ends in frustration.

5.3 Not invented here

It seems to be the nature of researchers that they tend to overemphasize their own findings and underestimate those of others. In addition, if information retrieval is not supported sufficiently, researchers tend to cut themselves off. For example, one can observe a dramatic loss of consideration for previously published knowledge:

- In the 70's, when design methodology was extensively published in the German language, but due to language problems hardly recognized abroad
- In the early 90's, when the internet grew to a worldwide tool and only electronically published contributions received reasonable recognition

It should be a task for design researchers to approach a body of knowledge and models, worked out by an international team of relevant working researchers, which might be agreed upon worldwide.

5.4 The proliferation in design research areas

Design encompasses a great many aspects, views, and specialities. Design research is, therefore, an area with which an individual or even a school is not able to deal completely. Task sharing could be a solution to the proliferation problem. But, whereas in industry the sharing of complex tasks by defining sub-tasks, clarifying the interfaces und delegating responsibilities to individuals and teams is a standard procedure, task sharing seems to be totally unknown in global design research. On the contrary, asking somebody to share research areas and tasks with others would be considered an imposition.

Of course, on one hand, there is a substantial benefit in working on the same topics at different locations, especially on poorly defined research areas. Competitive approaches could highlight the problems and converge upon a solution. On the other hand, however, total research freedom seems to be a gigantic waste of faculties, labor, and resources.

5.5 The gap between research topics and real-world problems

Design research has to have goals and objectives. The pure curiosity about the very nature of design should, of course, be one driving force for research, the need for applicability another one. Which problems should be solved by a specific design research project and what are the benefits for science, as well as for industry and society? Unlike researchers in natural science design researchers have to measure their findings based on real-world problems. They have to involve themselves in the design processes in industry, as well as in the processes of transferring scientific results to design practice. Design research should run like a control circuit: from practice –into research - back to practice - and so on!

A further requirement concerns the reality of objects treated in design research. Coffeepots, cork-screws, or bike carriers might be valuable to teach students or could highlight some principles with a smile. However, they hardly convince people designing robots, electro hydraulic power units, or gas turbines.

6. Conclusion

Criticizing current design research should be supplemented by constructive proposals. Basic requirements for stepping forward are international co-operative projects under one well-organized 'roof'. Even though it is in its infancy and growing, the Design Society may have the chance and the power to do this. Its explicit objective is to "create a formal body of knowledge about design". Especially the so-called "Special Interest Groups (SIG's)" should take the task to proceed in their own field of expertise, to consolidate research results and to start working on a well-defined terminology. The signs of the times are positive as English has become the standard language for communication worldwide, and e-mail and the internet greatly support the exchange of contributions. With the instrument of the Design Society, design researchers have the key in their hands. Let us use it!

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