

DESIGN METHODS IN PRACTICE - BEYOND THE 'SYSTEMATIC APPROACH' OF PAHL & BEITZ

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1. Introduction

Method makers in engineering design present their methods as normative, transferable tools for designing, and they argue that their methods will enable the method-user to approach matters in a systematic fashion, which again will guarantee certain virtues and results. This view of methods is so widespread and so taken-for-granted that there is almost no end to the number of examples, one might cite. Indeed, we suspect that the vast majority of the participants in this conference would consider it both common sense, and a well-proven fact, that a good design method guarantees a systematic approach as well as certain results.

It is however possible to seriously question this widespread and fairly optimistic view of what methods are able to do. And we intend to do so in this article. It is beyond our scope to investigate all that is said and believed about design methods. But we will take our point of departure in Gerhard Pahl and Wolfgang Beitz's book 'Engineering Design – a systematic approach' [Pahl & Beitz 1988], a book which is widely recognized for its systematic treatment of design methods, and which is often referred to as a classic, or even 'the bible' of design methods.

It should be clear from the outset, that we do not challenge the *usefulness* of Pahl & Beitz's text in the hands of engineers, or any other methods manual for that matter. We have little doubt that the Pahl & Beitz draw together a vast amount of experience, good practices and reflections. What we do want to challenge, however, is Pahl & Beitz's basic understanding of *what a design method is*. In this respect, we argue, their view is misleading. We will make our case theoretically as well as empirically. Theoretically we will draw on Ethnomethodology [Garfinkel 1967; Suchman 1987; Lynch 1993], a particular sociological school, which has thoroughly investigated, what it actually means to use a method in practice. These sociological analyses, we will argue, add up to a view of methods, which is radically different, and at odds with, the one presented by Pahl & Beitz. Empirically, we will draw on large number of case studies conducted by master students at the Design & Innovation Programme at the Technical University of Denmark. The students, 50 per year, all take a course in 'Design Methods' taught by the authors of this article. The course bears the imprint of our very different professional backgrounds. Elgaard Jensen is a social scientist with a special interest in the Science and Technology Studies (STS). Myrup Andreasen is an experienced teacher and researcher on design methodology and an industrial consultant. In the Design Methods course, the students are instructed to look into the practical circumstances and context of the use of particular design methods in Danish companies, and in the course of doing so, we suggest, our students have stumbled on a number of complications that are crucial to the practical use of design methods, but which are conspicuously absent from Pahl & Beitz's basic assumption about what a method is.

The outline of this article is as follows. First, we present Pahl & Beitz's view of methods. Second, we contrast this with the ethnomethodological studies of the practical use of methods. Third, we introduce the empirical material produced by our students, and we clarify our use of it in the present context.

Finally, we return to the question of usefulness through a discussion of what can be gained by moving beyond Pahl & Beitz's view of methods.

2. Pahl & Beitz's view of methods

Pahl & Beitz is a monumental book that attempts to move engineering work a significant step further in a particular direction. The name of this direction, as indicated by the subtitle, is *systematic*. Before we describe positively what a systematic approach means to Pahl & Beitz, it is useful so indicate some of the non-systematic approaches or ways of working, which Pahl & Beitz set out to improve, or do away with.

First of all, Pahl & Beitz want to do away with methods that are too bound up with specialist fields; They want their approach to be broadly applicable, to integrate findings from other disciplines and to facilitate the application of known solutions to related tasks. Non-systematic methods are methods that do *not* lend themselves to the project of building *one* coherent system of methods. On the contrary, Pahl & Beitz stress that design methods should assist broader, system-building efforts, such as “electronic data processing”, and “modern management science thinking”, i.e. reduction of workload, error, and cost. [Pahl & Beitz:5]

There is, however, a second important sense of ‘non-systematic’, which Pahl & Beitz want to eliminate. They are critical of methods, that rely on chance, and that do not facilitate the search for optimum solutions (Pahl & Beitz:5). From this it may seem that Pahl & Beitz's systematic approach will, inevitably, be defined as set of instructions that will constrain the user to a very high degree. This however, is not entirely true. Interestingly, Pahl & Beitz, introduces a bit of slack in their systematic approach, with the following remark in a foreword to the Student Edition of their book:

“When designing, a balance must be found between an intuitive approach and a systematic one. These two approaches are not exclusive, but are mutually supportive. If, because of experience or a flash of insight, the ‘best’ solution is found quickly, that is extremely fortunate and there is no reason to work through all the individual steps recommended in this book. However, things seldom happen in that way, particularly when learning about engineering design, and it is helpful to have a clearly defined approach to follow” [Pahl & Beitz 1988:x].

It seems, then, that Pahl & Beitz do recognize that solutions may come from different sources than a systematic approach, but they consider this ‘seldom’. At the same time they maintain that the engineer, who follows their systematic approach, is far more likely to find the best solution.

Pahl & Beitz's systematic approach is found in the book's central model of the design process, i.e. a design procedure of logical steps raising the chance to find a ‘best’ solution, and found in the many single step methods in the book, for search, variation, evaluation etc.

Pahl & Beitz's procedural approach entails a logical sequence, where the initial ‘encircling’ of the problem will hold during the subsequent stages. What is also implied is some sort of zooming in, that will eventually ‘tighten’ into an optimal solution. Again: a systematic approach is something which can be followed – like a road – and it will eventually lead to the desired destination. One might, of course, leave the safe road and enter the unruly terrain, which Pahl & Beitz call ‘intuition’. But since the systematic approach is there, stretching out before our feet, it would seem both pointless and hazardous to do anything but to follow the ‘systematic approach’.

3. The view of methods in Ethnomethodology

We will now leave Pahl & Beitz's efforts to pave the way for a systematic approach to engineering design, and we will turn our attention to a radically different attempt to come to terms with methods. Ethnomethodology is a branch of sociology, which was developed in the late 1960's and onwards based on the pioneering work of Harold Garfinkel [Garfinkel 1967]. Ethnomethodology is essentially concerned with closely studying the relationship between sociological practice and everyday language; Ethnomethodology attempts to understand the methods that people deploy (“ethno-methods”) as they go about their daily business. How do members of a jury (lay people with no formal training in law), decide if the evidence is adequate? How do two people end a phone conversation? How do people conduct themselves, when they visit other people's homes? Studies inspired by questions such as these reveal the nature of methods that are involved in practical daily reasoning, and the ‘local production’

of social order. In the following we will mention three crucial observations that ethnomethodologists have made of the use of methods. It should be noted, in passing, that the kinds of methods observed are not merely the methods of lay people, but also of professionals and of scientists at work in their laboratories!

The first observation is what ethnomethodologists' call the *accountability* of methods. Methods are not merely used, they perform in public so to speak; "A pedestrian's mere glance can *display* her projectable orientation to 'crossing the street', and this display is available to approaching drivers and is thereby constitutively embedded in the socially organized traffic of a public street scene" [Lynch 1993:15]. So the participants routinely produce *orderly* activities; the traffic tends to flow. These activities are not just orderly, but also *rational*, i.e. they are predictable and sensible to the people involved. And finally, the people who carry out the activities are able to explain and justify (account for) what they are doing.

A second significant feature of methods is called *reflexivity*. This term indicate the phenomenon, that the participants' account of what they are doing interact with the settings in which they originate. This means that the language is always a part of the activity, which again means that interesting questions can be raised about what it means to a particular practice, if a particular description of its method is introduced.

A third crucial point of ethnomethodological studies is the so-called *indexicality* of expressions. In language theory indexical terms, such as *here* and *there*, are terms that only make sense in a specific context. It is often assumed that such terms could be made universal by replacing them with something specific. Thus the term 'here' may be replaced by a geographical location, such as 'The Technical University of Denmark'. Ethnomethodologists would however point out that the meaningfulness of such terms depends entirely on the practice and the participants. 'Bring the package to the Technical University' might satisfy the national postal service, but certainly not the internal postal service. Consequently, it can be argued that there is never specificity enough to settle *universally* what 'here' means. In practice, however, many terms index something that is sufficiently clear and understandable for the participants.

With the observations of accountability, reflexivity, and indexicality, Ethnomethodology draws up a picture of methods-use, which takes us quite a long way from the picture suggested by Pahl & Beitz. With Pahl & Beitz a method is essentially an *instruction* to carry out certain steps in a certain order. With Ethnomethodology a method is a *resource* that is deployed and enacted in a local situation, where a number of participants produce, or attempt to produce, social order. Pahl & Beitz and ethnomethodologists would agree in the observation that orderly situations are and can be produced: In practice, it is possible to coordinate actions, to follow a method, to construct predictable and good results. But the explanations for this orderliness differ. Ethnomethodology analyses how actors continuously read the signals of other actors, attribute meaning to these signals, make their own interpretations and intentions visible and accountable to others, explain to others what they are doing, and demand explanation and clarifications in the countless little situations where something goes wrong, doesn't seem right, or doesn't make sense. Social action, and the orderliness of social action, is produced by such ongoing, reflexive, accountable, interactional work. The methods, and the methodical nature of actions, are thus results of on-going work, rather than the premises of it.

In a rather stark contrast to this view of methods and social action, Pahl & Beitz's view assume a separation between actions on the one hand and methods or instruction on the other. The methods come first, they outline the path that the actions will follow - or divert from. This also implies that the methods stand, regardless of the actions, and that the collective work of making sense of methods, which ethnomethodologists explore at length, is missing in Pahl & Beitz's account. To Pahl & Beitz there is either 'intuition' which like 'luck' and 'good fortune' is rather impossible to explain, or there is the much preferred alternative of following the methods in which case Pahl & Beitz would argue that it is the logic, the rationality and the systematic nature of the methods *themselves* that explain the good result.

It will probably be no surprise to the reader that we find Pahl & Beitz's explanation wanting. We believe that even the most carefully thought through method needs to be carried by local interaction. For this reason it makes no sense to draw a too sharp distinction between prescription and description.

A prescription (a method manual) that drifts too far away from the actual practices is misleading. And for this reason, we believe that there is much to be learned about the workings of engineering methods by taking inspiration from ethnomethodological approach. In particular, we wish to understand what other resources beyond written instructions such as Pahl & Beitz's book, that engineers draw on when they produce methodological results in practice. It should be mentioned in passing that other authors within engineering studies done similar investigations of actual work practices, although their focus has not been on design methods specifically (see Bucciarelli 1994, Henderson 1999, Vinck & Blanco 2003).

In the following we will explore this question by means of a large and rather unique material, which our students have produced in a course we have taught for three years. We will also take inspiration from a rather notorious social psychological experiment, which Harold Garfinkel conducted in the early 1960's.

4. Research material and methods

As a part of his attempt to understand the methods people use in their everyday life – ethnomethods – Garfinkel instructed his students do to a series of so-called 'breaching' experiments that were a bit like practical jokes. In one case, he asked 49 students to visit their parents, and to act like strangers from 15 minutes to an hour. The students were instructed to be very polite, to avoid being personal, and to speak only when spoken to. The unknowing families vigorously tried to make sense of the students' strange behavior "you must be ill" "you must have been working too hard" "has there been another fight with your fiancée?". And they tried to restore the situation to normal "I don't want anymore of that out of you and if you can't treat your mother decently you'd better move out!" Many families responded with considerable anger and bewilderment.

In Garfinkel's interpretation, the experiment reveals the common background understandings by *breaching* it. What becomes apparent, are tacit assumptions and understandings, that must be shared, if the participants are to uphold a sense of trust that they know what is going on, and ability to coordinate their actions in a meaningful way. What is illustrated, quite dramatically, is how utterly dependent a simple social action – being at home – is on a continually negotiated production of order.

In the Design Methods course at the Technical University of Denmark, the students are asked to visit companies. We instruct them to behave politely, but so far we haven't worked up the courage to put them and the companies through a proper breaching experiment. And yet, we do believe our course can be seen as a mild form of a breaching experiment.

Our students have usually spent at least four years at the technical university. They have taken numerous courses, in which they have learned a number of 'rational' and 'systematic' design methods, including a number of those methods described by Pahl & Beitz. It is fair to say that the students come to us with a common background understanding that design methods can be followed, and that they will lead to good results.

In our course, the students are asked to choose a particular design method, to find a company that uses this method, and to conduct a case study of how the method is used in practice. We supply the students with a series of questions, in order to direct their attention toward the specific actions involved in the method, and towards the organizational practice of which the method becomes a part.

- What – exactly – is the method?
- What is the method supposed 'to do'? Where? To what? For whom?
- How is the method used?
- What context or agenda is the method a part of?
- How is the method interpreted – and by whom?
- What are the expected and the surprising results and consequences of the method?

In the beginning of our course, students often view methods as well-prepared roads that the companies should follow if they want to do things right, and the students tend to get worried when they encounter companies that do not follow the prescriptions of a particular method. In these cases, we always point out that the companies are actually producing things and making money, so somehow the methods must be working. We also make it clear that the students' task is not to *criticize* the companies for

improper use, but rather to *discover* how the companies manage to use the methods in ways that are meaningful and productive for them.

We can now clarify wherein our breaching experiment lies. The baseline, so to speak, is the students' background assumptions about what it means to follow or use a method. This baseline is subjected to vigorous testing, when they are sent out to companies and asked to focus on how these methods are 'done' in practice. The students are hardly as bewildered and angry as the parents to Garfinkel's students. But they do come home with observations that leave them a little shaky: "They simply skip parts of the method", "they do some of the steps in reverse order", "they mention the method on their homepage but they actually don't use it", "they use the method for a different purpose than what it was intended for", "if you interview three different project managers, you get three different ways to use the method", "it is unclear if they use the method at all", "they say that this methods is *the* standard method, but there seems to be an enormous number of exceptions", and so on.

5. Anomalies

In a nutshell, one could say that Pahl & Beitz describe a design method as a road that allows an individual to take a certain *object* (or problem) through a series of well-defined *steps*, in order to reach a particular *goal*. In the following we will present some of the real-life complications and interactions around objects, steps, and goals, which our students encountered when they set out to investigate the use of methods in Danish companies. We will refer to these complications as *anomalies*, because they breach the normal view of methods, which we find in Pahl & Beitz and elsewhere.

5.1 Anomalous objects

One might think that the *input* to a design method, the *object* it attempts to deal with, or the *problem* it attempts to solve, is somehow lying in the companies, waiting for the design method to be implemented and used. This however does not seem to be the case. One group of students investigated a large industrial firm, which used a method called 'technology planning' to build an annually updated road map for technology and product development projects. In principle, the logic of the method is to give this traditional engineering company a stronger market orientation by matching *markets pulls* detected by various divisions of the company with *technology push* in the form of new ideas from the research & development unit. In practice, however the markets pulls were expressed, not by marketing people, but by engineers from the company divisions, and these engineers happened to be very good at expressing market needs in a format that fitted the possibilities in the R&D department. Further exploration of the 'technology planning' method, also revealed that a large number of the company's projects (roughly 30%) were results of other initiatives than the formal technology planning.

What this case suggests is the fundamental difficulty, with which a simple planning method accesses and controls its object. The market needs and the technological opportunities are not given objects, but rather the outcome of interactional processes between the engineers and various other actors in the company. It seems that these elusive processes not only define the objects that the method will deal with, but also control whether combinations of market needs and technological opportunities will emerge as a result of the technology planning method, or if these combinations will find alternative routes into existence.

Other students have described situations where the methods' control over its objects was even looser. One example is a manager, who was asked to do a *lean* project by her senior managers. She subsequently had to negotiate with different company units before she could find an sufficiently cooperative and interested organizational unit that would make it possible for her to produce a lean project, which would satisfy the senior managers' expectations.

In general, the cases suggest that methods cannot be described as active interventions on otherwise passive matter. The case is rather that methods themselves, their scope, and their very existence within organizations are at the mercy of other and very lively processes.

5.2 Anomalous steps

A crucial feature of a method according to Pahl & Beitz is its sequential nature; a specific number of steps have to be carried out in a specific order. However, many of our students have encountered a rather different practice. One group of students studied a 12-step sequential method used by a design firm to develop a complete branding package for other firms (including logo, graphical identity, etc.). It quickly became clear that the entire sequence was the exception rather than the rule. The customers were often only willing to pay for a few of the steps, and in the case of returning customers many of the early steps were skipped.

Another group of students studied a medical device firm that claimed to be using a methodological process of user-involvement, prototype development, and user-testing as a part of their product development. In the case studied by our students, the process of extensive user involvement was initiated by the book, so to speak, but because of emerging time pressures the selected group of users were replaced by a group of external experts, and the process of generating ideas with the users was turned into a process of choosing between the designers' existing ideas.

Many other cases from our students indicate that the steps of methods are routinely changed, skipped, or squeezed as a result of various pressures such as lack of time and money. It is also a common observation that managers above the level of the direct methods users often usher certain projects through by letting them pass quickly through initial the phases of the standard methods. Moreover, it is a common observation that there are widely different interpretations of what the steps of the method actually are. One group of students investigated a project manual in a medical firm. This manual outlined some *possible* requirements and documentation needs on various stages of product development, but the manual also clearly stated that these 'requirements' had to be adjusted in relation to the complexity, size and general nature of the specific project. The explicit policy was thus be flexible, and to avoid over-documentation. What the students found, however, was that younger project managers, and employees from the controller department (who would often be blamed in the case of failures), tended to ignore the flexibility of the method. These methods-users would often attempt to live up to the maximum requirements despite the nature of the specific project. Only seasoned project managers seemed to 'dare' to use the flexibility of the method.

In sum, it seems that the description of method use as 'taking one prescribed step after another' is grossly inaccurate.

5.3 Anomalous goals

The observation that has probably surprised our students most is the degree to which different, or even conflicting goals can be related to a single method; a sociological and organizational fact, which is entirely absent from the writings of Pahl & Beitz. One group of students studied the ways in which a medical device firm involved nurses in their product development. Initially, this method was intended to gain feedback on the designers' prototypes for new products. Later, however the company began to use the methods as a part of its effort to develop positive relations with key customers and player in the market. At present, the company openly acknowledges that the involvement of nurses serves the dual purpose of product development *and* marketing.

The method just described is (now) characterized by two rather clear purposes. In other cases, particular methods seem to be very weak in terms of measurable effects, but very strong when it comes to attract goals. An example, which has been studied by several groups of students is the method of creating so-called 'ideas banks' or 'internal competitions' in companies. These initiatives often come from R&D department or other staff units, and they often take the form of an internal web application, or an annual competition, where employees can submit ideas, which will be stored and evaluated. Subsequently, the best ideas will be publicly recognized, supported with funding, and developed further. The stated purpose of these initiatives is to stimulate and harvest the good ideas that are 'lying around' in the organization, but which 'get lost' in the normal R&D processes for a variety of reasons. What our students have observed, however, is that this seemingly logical and straight-forward method (harvest-select-support) is subject, in practice, to a variety of different goals. First of all, the employees view ideas banks as one possible outlet for their ideas, but very often they prefer to keep their ideas to their organizational unit, or to themselves. Second, our students have found that

ideas banks or competitions often function as a vehicle for the departments that organize them. These initiatives are important ways to generate attention and funding from senior management, and to gain importance vis-à-vis the functional divisions of the companies. Thirdly, ideas banks/competitions are often seized by senior managers who see them as spectacular occasions to communicate their strong appreciation of innovativeness to the employees, as well as to the companies' surroundings. Corporate image is thus another goal, which often attaches itself to these methods.

In sum, our students have found that the goals of methods are neither given, singular, nor timeless.

6. Conclusion

In this paper we have taken our point of departure in Pahl & Beitz view of design methods, which we have contrasted with the findings of Ethnomethodology and our students' case studies. The contrast is striking. Pahl & Beitz view methods as prescribed roads that will allow an engineer to take a particular problem through number of steps, which will lead to a particular goal. Our alternative sources suggest that the nature of the problems, the actual steps taken, as well as goals attached to particular methods are outcomes of local interactions and sense-making processes in the companies. So in actual practice, neither problem, steps, nor goals can be taken for granted in the way that Pahl & Beitz do. Furthermore this means that positive results of methods-related activities cannot simply be attributed to the build-in-logic of the methods. Like the effective flow of traffic, the effective flow of work is the results of groups of actors, who collectively use methods to make themselves accountable to others, who interpret the methodological actions of others, and who figure out how to make sensible interpretations of formal methods in relation to the circumstances at hand. It is precisely this kind of work, that comes into focus in Ethnomethodology, and which strikes our students, when they encounter the actual use of methods in companies, and which is completely familiar to any practicing engineer.

Put in these rather strong terms, it might seem a bit of a mystery, how Pahl & Beitz could overlook something which is common knowledge to any practicing engineer and which can be observed by almost any engineering student who is instructed to do a case study? We would like to suggest two supplementary explanations. First of all, Pahl & Beitz approach seem to be premised on the view of method-work as a sort of information processing. The proper bits have to be gathered and assembled in the right order. Pahl has later elaborated this information processing agenda and clarification of the role intuition ("Denkmuster") through his collaboration with cognitive psychologists (Pahl 1994). With this view comes the idea that the methods-user can be likened to an individual mind or information processor. This starting point, we suggest, makes it exceedingly hard for Pahl & Beitz to see method use as a social, political or organizational process and it makes it almost impossible to imagine that the goals of methods-related activities can be any other than getting the information right. The ideas that methods can be used to impress other, to balance between groups of actors, or to maintain a common sense of what an organization is doing, are pushed beyond the scope of imagination by Pahl & Beitz informational focus.

Another possible explanation for Pahl & Beitz's omissions is, we admit, somewhat more harsh. It appears to us that Pahl & Beitz have confused the *result* of design method and the *process* of using a design methods. The *result* is in Pahl & Beitz's own terms a product with well-defined boundary, structure, inputs, outputs, as well as a clear definition of the flows and conversions that will take place within the system. In short the result is neat, clear, and orderly. However, it does not follow from this that the *process* of reaching this orderliness is in itself as neat and clear. In fact it may well be that orderliness is a result that slowly emerges out of a process that looks entirely different. This, at any rate, seems to be the lesson of Ethnomethodology and other close-up empirical studies of how orderly results are produced. Pahl & Beitz's error, we suggest, is their implicit assumption that neat processes must logically precede neat results.

Our aim, in a broad sense, with this paper is to argue that we need to study design methods in a way that does justice to the actual work practice of effective engineers. This also implies that we might find different things about methods to appreciate. On this note, we would like to end this paper with an observation of engineering culture, which we find very intriguing. We have encountered that many engineers are willing to attribute the positive results of their work to methods, even in cases where it is

obvious that methods are not doing much work themselves. This suggests that to engineers methods are much more than a simple tools. Methods is a positive common project, we want them to do good, and we feel that we have done something honorable, when we have reached results in a *methodological* way. Just as other cultures may feel that their good results are particularly honorable, if they have been based on, say, consultation with the forefathers, or the proper balance of yin and yang. We are saying this not to mock method-users, but simply to point out that they way we talk and feel about methods, individually and collectively, is a crucial part of the method-phenomenon.

The fact that methods are so constitutive of engineering culture, also suggests a different possible lesson of our analysis. Precisely because we care so much about methods, and precisely because we are willing to mobilize all sort of resources to make methods work, it becomes impossible to add a few factors to existing text books and methods in order to make them work as recipies for engineering students to follow. Instead, we suggest, that the best we can do is to sensitize the students to the vast number of processes and resources, which in practice may play a role for designers who are charged with the difficult challenges of practicing, staging and conducting methods. So ultimately, our aim with this paper is not to pin down design methods, but to open them up.

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