

The development of design methods and expertise

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1 Introduction

Design methods are developed by designers, e.g. by Pahl and Ehrlenspiel, and are based on engineering design and practical experience. The requirements of design methods are to provide a planned methodological, flexible and approvable process and to support the designer in working efficiently and finding good solutions. A further requirement of design methods is that they be teachable [1]. In order to fulfill these requirements design methods have to be properly applied. At this point, the following questions arise: What characteristics must a designer have to design methods that meet these demands? How can these characteristics be imparted? To answer these questions, this paper focuses on the development of design methods, their developmental context and the characteristics of the authors of design methods.

It is a challenge to teach design methods, because it involves more than the transfer of simple facts [2]. There is still no comprehensive teaching concept for design methods with explicit instructions on how to describe and impart them. This paper aims to gain insights of the characteristics of design methods as teaching content, the authors of design methods as design experts in their surroundings, and the development process of design methods in order to establish a suitable teaching concept for design methods.

2 Objectives: Gaining insights from the development of design methods

Designers have developed design methods as a means to identify problems when designing in industry. Their intention was to externalize their knowledge of design and to make it available to other designers in order to provide efficient design processes and support designers' thinking. This knowledge seems to be particular to experts, who are characterized by the following aspects: they have gained experience through many design projects, have seen many typical design failures, know strategies to solve problems, know a lot of design solutions and many technical facts, and in many cases, they know what makes people tick.

This knowledge was gradually accumulated through their work as designers. Thus, the knowledge and its structure, developed through extensive practice, seem to be embodied in design methods. The methods are deduced from this knowledge and the consequently gained insights. Therefore, it is of high relevance to analyze the development of experts in design, according to their knowledge, their cognitive development as experts and the development of

design methods. This analysis yields insights about the characteristics and essence of design methods.

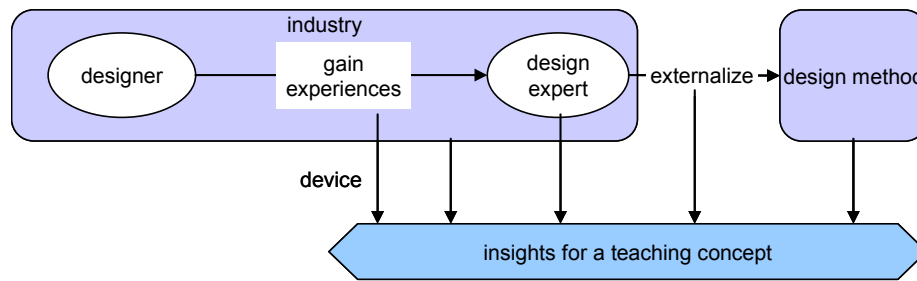


Figure 1. Starting points to gain information for a teaching concept

The aim of this paper is to find an answer to the following question: What can we learn from the development of expertise in design, from a practical and a cognitive point of view, for a suitable teaching concept?

3 Methods

As a starting point, the actual process of development of design methods is analyzed and important factors and elements for teaching are deduced. This is depicted in figure 2. The development from the designer to a design expert is investigated under the conditions of the company’s surroundings and the externalization of the design method. The information is gained from an extensive literature review and personal interviews with Prof. Pahl [4].

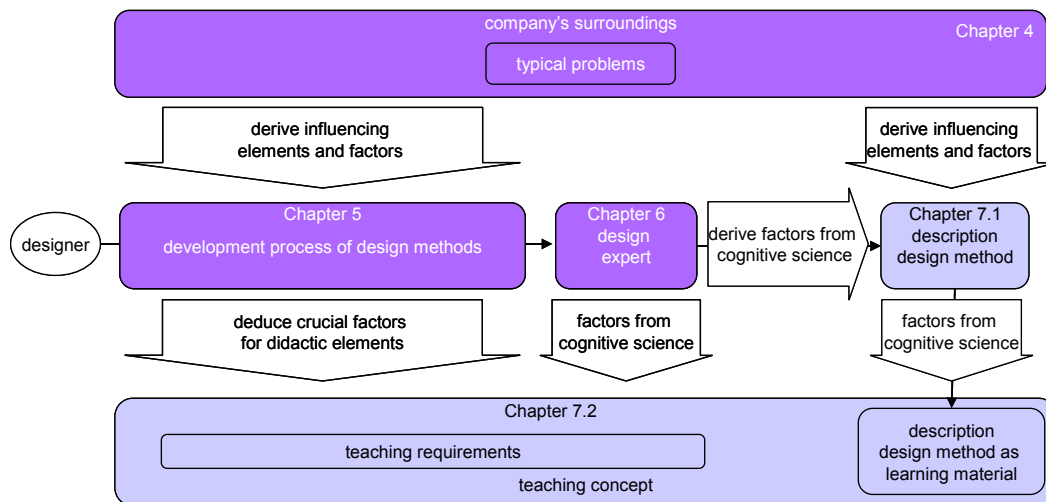


Figure 2. Gaining insights about the development of design methods

Initially, the company’s surroundings and typical problems are analyzed and elements and factors are derived, which influence the development process of design methods and the description of the design methods (see chapter 4). In the next step, the development process of a design method is explored and the crucial factors and elements of that process are deduced for a teaching concept (see chapter 5). In chapter 6 the characteristics of experts and design experts are analyzed in order to find decisive factors and elements for the description of the design methods and a teaching concept.

From the findings of these three fields, a differentiated view on the characteristics of design methods and their description is obtained and crucial elements and factors for a comprehensive teaching concept are derived.

4 Influencing factors from the company’s surroundings and typical problems

When investigating the company’s surroundings and typically occurring problems in which designers have become design experts ([1], [8], [9], [10], [12], [13], [14]) and have externalized design methods, one will find the following factors, which influence the design method with its description and the process of the development of design methods (see Figure 3).

The designers have worked in a certain company in a specific branch with a company structure, culture, employees and have designed a product, which has shaped the design process and the designers (see Figure 3).

Against this background, the designers have dealt with certain types of problems, such as organization or communication as well as those problems, which concern rather the areas of controlling and/or planning. Above all, technical problems have influenced the design process and the designer in his/her work. Oftentimes, the designers have worked a long time in a specific domain and have gained a lot of experience. They are very familiar with the product and the applied techniques, and quite often the problems. These facts have influenced their thinking and methods of working.

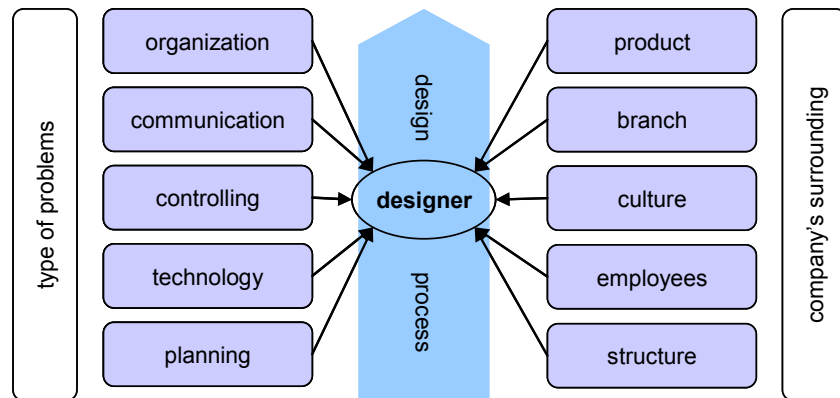


Figure 3. Influencing factors on the designer from the company’s surroundings

So, all these factors need to be considered when analyzing the development of design methods and their descriptions. Also, they have to be considered when compositing a teaching concept.

4.1 The consequences for the description of design methods

Design methods are tailored to these company product- and technology-specific problems with which the designer has always had to work. The methods are also formed and adapted to the internal work-flows and structures of the company. Also, the design method is directed towards fulfilling the company’s goals and fitting into the company’s culture. All these design

context-specific aspects figure in the design method without the designers having to be aware of them.

Regarding the different types of problems that occur mostly in the company, design methods can be more technology and product driven. In this case, the methods will be orientated on the structure of the product and its complexity. According to these points the focus, the degree of abstraction and specification of the design methods can vary strongly.

In other cases, the design method may focus more on problems of planning, controlling and organization. Here, the method will be more marketing or business driven. This happens mostly when the product already has a high degree of readiness. In this case, the methods will focus more on management and costs, etc. This orientation is not necessarily mentioned in the description of the design method. So, the method implies a certain awareness of the problem, which is not explicitly stated.

Subsequently, the transferability of the design method with its description to other problems is not guaranteed, even though the authors of design methods aimed for a universal design method. But in a strict sense, the methods can only be universal to a specific type of problem in a certain context.

4.2 The consequences for a teaching concept

Due to the fact that design methods are initially developed in practice for certain types of problems and greatly dependent on the context, it is important for a teaching concept to accommodate this fact. The teaching situation should mirror the practical context and the impartation of content should include the aspects of transferability and the flexibility of design methods to different types of problems. This means that the teaching concept must impart the identification of different types of problems and contexts and the adaptation of methods to them.

Thus, the teaching concept requires that the transfer of design methods be both abstract, in order to emphasize their universality, and concrete, so that designers learn to tailor methods to a specific context and problem.

5 The development of design methods

Design methods are developed by designers who have gained much experience in their professional life. One can say they have gained expertise in their knowledge domain. Obviously, they have undergone a successful learning process in developing a design method [1], [8], [9], [10], [12], [13], [14]. Therefore, it makes sense to investigate these processes in more detail, in order to find factors and elements which might be of use for a suitable teaching concept.

Of course, these processes are formed by the company's surroundings; the typical problems and the designer as an expert (see Figure 4). However, one will find many similarities by analyzing the approaches of different designers, who have developed design methods.

The starting point of design methods is, in most cases, similar and reoccurring problems during the designer's work. This phenomenon stimulates the motivation of the design expert to solve or avoid problems, in order to work more efficiently [1]. The design experts start to

analyze the problems and identify crucial factors and causes, and in doing so, reduce their complexity. This leads to the identification of different problem patterns according to different types of problems. After that, they start to search for solutions to the problem patterns and they come up with methods that might solve the problems. This step of success also generates more motivation to work on the new methods. The methods are tested and their essential success factors identified. By the time similar problems occur, the methods have been adapted and extended, according to their efficiency and suitability to the problems, the context and the personal inclinations of the designers. In the end, they formularize the method and a first description of the design method is generated.

Accompanying this process is an accretion of knowledge of the designer. The designer gains more and more knowledge about problems, solutions and facts in his/her working field. Thus, different sources of motivation help keep the process running, such as the particular inclination to plan, structure and systematize things and to develop the ambition to solve a problem.

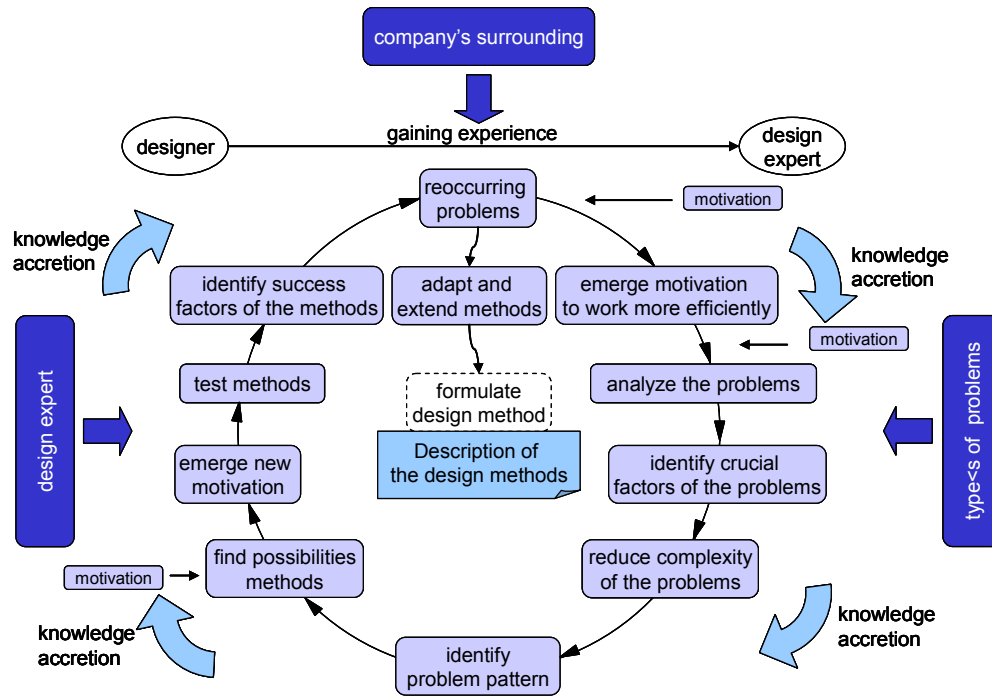


Figure 4. Crucial aspects within a development of a design expert

Another aspect that needs to be considered in this context is the personality of the design experts who externalize design methods. One can ask, why some designers externalize design methods. In the past the designers had basically the intention to investigate the design process, make it more planable and make designing teachable ([1], [8], [9], [10], [12], [13], [14]). Nowadays, one can add a commercial intention when a designer externalizes design methods. But it is also very dependable from the designers' personality if s/he externalizes a design method. It is the personal desire to externalize insights and experiences to others, in order to let them profit by them. So, it makes more sense if very experienced designers design design methods than novice designers with few experiences from practice. The designers who externalize design methods should also have notices about teaching and imparting knowledge.

5.1 The consequences for the description of design methods

The design method and its description depend on the individual course of the development process. It is governed by the context-specific conditions and the sources of motivation. These aspects influence the focus and sequence of a design method's composition and description. It also influences the types and amount of intermediary results within the design method and the universality of application.

Regarding the description of the design method, one might have to deal with gaps according to accuracy, wording and sources of motivation. But one will also have to deal with the indication of intermediary results. So, it might be that more intensive phases of the development process are elaborated upon more than others which have the same degree of importance.

5.2 The consequences for a teaching concept

When investigating the development process of design methods, one finds many elements and factors which play a crucial role in teaching. The first element is the similarity of recurring problems. This element is the initial situation to reach an awareness of and an understanding for the problem, and the motivation to solve it. These conditions cannot be examined separately, because they influence each other. In the case of a successful process, they even build each other up. The greater the problem consciousness, the better is the understanding and the motivation. Also, the development of the method itself is driven by these conditions and leads to the conditions of understanding the design methods and identifying their essence and success factors.

The element 'similar or reoccurring problems' and the intensive work on these problems leads also to an accretion of knowledge and the achievement of skills and abilities in this knowledge domain with time. Especially the abstraction of problems, the transfer of methods to the problems and the concretization of the method in order to apply them and to solve the problem belong to these skills and abilities. Thus, it seems very important to work intensively and constantly in a specific domain to achieve the conditions mentioned above and the knowledge, skills and abilities.

The condition of motivation can also be initiated by the sense of achievement, the possibility to work independently and by working intensively on a problem for a long time, etc. But it seems hard to describe what it really is and how to initiate it. So, motivation is a decisive and exceptional condition within this process. It can come from the process and its conditions or from the designers themselves. The motivation supports the progress and quality of the process. Therefore, motivation is a key element in a teaching concept, though its sources and triggers are still not completely known.

6 The characteristics of design experts

6.1 Background: The cognitive resources and their limitations

Ending at a design expert as the author of design methods, the findings of cognitive psychology in the field of memory and expertise need to be kept in mind. The development or learning processes of experts also belong to these considerations.

To start with a designer as a cognitive system, we need to consider the cognitive resources and their structure with all its functions and limitations. Cognitive resources are the information processing of human beings. According to Dörner [6], it comprises perception, attention, working-memory and long-term memory (see Figure 5). Perception carries information to a sensory memory. If the information in the sensory memory is processed, it gets passed on to the working-memory. From here it can be processed and stored in the long-term memory. Not all information that is perceived can be stored in the long-term memory; there are various parameters of limitation.

The limitation depends on different factors [11] in the different spheres of human memory (see Figure 5). The perception process is limited by the capacity of the sensory perception. Attention is limited by the capacity of the visual-sensory short-term memory [3] and the working memory is restricted by the storage of information.

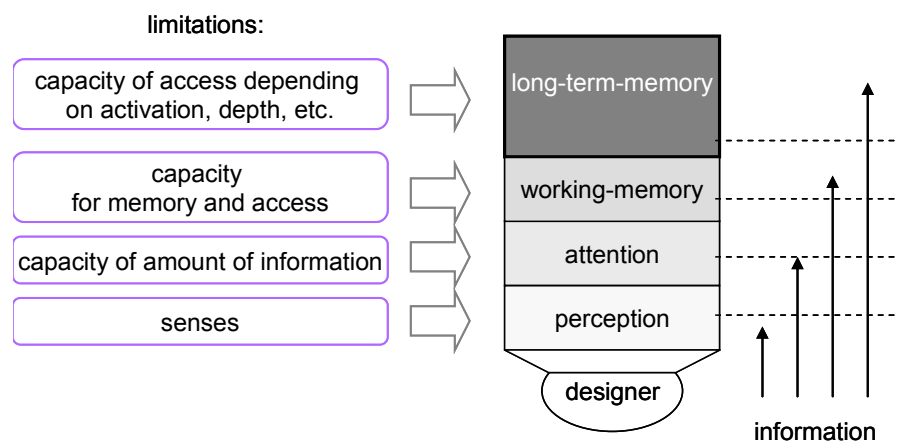


Figure 5. Cognitive limitations of memory

The different levels of memory have different structures with certain processes, which present the cognitive skills and abilities. Especially the long-term memory has a specific structure with certain functions and dimensions that play a decisive role in learning and storing knowledge.

The information in the long-term memory is organized in an abstract concept of schemas on different hierarchical levels with different dimensions. A schema is an abstract class of objects that one can have information about. It is the structure of storage on different levels and provides slots for information about objects in the form of attributes and values. The hierarchical dimension of schemas is organized in supersets, subsets and instances. The superset is the most abstract level and contains information about an object class. The subset inherits properties from the superset for certain objects and provides a storage structure for certain instances of an object (see [3]).

Information is stored in this so-called semantic network. The different dimensions of relationships establish the connections between pieces of information, and the different kinds of association capabilities allow navigating between them. The structure, the links between the information and the possibility to create new links and new information of the long-term memory provides declarative and procedural knowledge. Declarative knowledge presents more static and factual knowledge and procedural knowledge the skills and abilities.

6.2 The cognitive characteristics of experts

Generally from a cognitive point of view, experts are primarily characterized by their broad base of declarative knowledge which is well-structured and accessible. Secondly, they dispose of procedural knowledge that can work within the framework of declarative knowledge. This knowledge belongs to a specific domain and is not easily transferable to other domains [3]. In particular, the expert's procedural knowledge shows distinguishing marks compared to the novice's procedural knowledge. An expert is seen as someone, who can use his/her cognitive resources in an optimal way and compensates the cognitive limitations.

The expert's procedural knowledge is much more sophisticated and flexible than that of the novice. Experts know more and better procedures and they can access them more efficiently. Thus, the navigation through their whole knowledge base is very effective and efficient. Much of the knowledge is highly automated. This means that experts provide a lot of implicit knowledge, i.e. knowledge that exists silently and perhaps can not be expressed. One could also say that they have a finely woven semantic net. This also applies to design experts and their capabilities. So, the question arises as to how these findings from cognitive science can help teach experts in design and design methods.

6.3 The development of expertise

The expert's knowledge developed from a learning process, which is adapted to the structure of the human memory. According to Andersen the acquisition of knowledge and abilities is a process with three stages:

In the first phase, the cognitive, a declarative encoding of the procedural content takes place. This means that one memorizes the facts relevant to the procedure. This knowledge of facts becomes available only slowly while the procedural encoding is happening.

In the associative stage, the proceduralization of the knowledge begins. The connections between the elements learned in the cognitive phase are strengthened and thus readily available for processing. Declarative and procedural content still coexist in this period and the interpretation of declarative elements is still time-consuming and error-prone.

In the autonomous phase of ability acquisition, the procedure becomes automated and very rapid in usage. The degree of automation also increases through use. Declarative knowledge is transformed to procedural knowledge. This is because perception and attention processes become also automatized and need less cognitive capacity.

Cognitive psychology postulates the reasons for this: The first mechanism is referred to as the fine-tuning of operators. With practice the so-called productions with its conditions [see Anderson] become more definite, and as a result, it is more efficient in usage. In addition to this fine-tuning of operators, the phenomenon of implicit knowledge has been identified as a crucial component in the development of skills and abilities. This refers to the fact that after a certain amount of practice the knowledge of the task does not have to be consciously recalled. The information is processed subconsciously and experiments show that, in this case, the activity consumes less cognitive resources. This is necessary when applying design methods ([1], [7], [8]). In order to teach designers with the regard to expertise, these findings from cognitive psychology should be considered when teaching design methods.

6.4 The characteristics of expertise in design

Achieving expertise in design means that designers, who have gained many experiences in their domain, possess the characteristics of an expert as defined above. These characteristics concern the automation of all types of procedures, implicit knowledge, domain-specific knowledge and all types of cognitive skills [5].

Through the repetition of many similar problems and situations, the design expert has passed through the three stages of skill acquisition. So, s/he has had the chance to automate many procedures for recurrent situations and problems. S/he is able to focus the main part of his/her cognitive resources on the critical and new parts of situations and problems. And s/he disposes of a sophisticated navigation in his/her semantic network with a high quality of the process of association.

Considering the limitations of the designer's resources, the intuitive command of a skill (implicit knowledge) leaves the designers with spared capacity for the consideration of higher demands of the task. In experimental studies of design research, the occurrence of implicit knowledge had also been considered. Ehrlenspiel, for example, distinguishes between the so-called "Rationalbetrieb" ("rational operation"?) and a "Normalbetrieb" ("normal operation") where the designer does not consciously control his actions. Pahl calls for an intuitive command of design methods.

Regarding the many situations and problems a design expert has encountered and solved, s/he has acquired a distinct domain-specific knowledge. Therefore, the designer is able to access to a large pool of possible and successful solutions and procedures in his/her knowledge domain.

6.5 The consequences for the description of design methods

Design methods are determined by designers with their cognitive resources and their degree of education as experts. Thus, the characteristics of experts and their skills and ability to externalize knowledge have to be considered when investigating design methods. The characteristics of experts influence the description of design methods in regard to their completeness, focus and individuality, cognitive requirements, and prerequisites of domain-specific knowledge.

Due to the high degree of automation of procedures, the implicit knowledge of design experts is very extensive. Experiments [3] have shown that it is hardly possible to externalize implicit knowledge. Thus, it is likely that design methods do not contain these parts of implicit knowledge which might be very helpful for novices who do not possess this knowledge at all. Regarding the description of design methods in the context of a teaching concept, there is the need to check the design methods for knowledge that is absolutely necessary to apply the design method, but that does not exist in the description. Therefore, we have to deal with some gaps in the descriptions of design methods. These gaps might also comprise the intention of the design method, the context, the type of problem, and the requirements for a successful application. The expert is so familiar with the design method that some of these points do not have to be specially stated.

The cognitive skills and abilities of experts are very distinct. The experts use these skills automatically when applying and describing design methods. So, they do not see the need to write about these skills. Cognitive skills are the silent prerequisites when learning and

applying design methods. They must be also learned, when the efficient and successful application of design methods is desired.

The distinction of cognitive skills of experts varies according to their personal nature. So, the experts base their design methods on their personal disposition of skills and abilities. Accordingly, they will describe aspects or skills which are not included in their cognitive reserves. This brings an individual aspect into the design methods and their description. The expert strives to obtain support from design methods when compensating for his own shortcomings. This could give the design method an individual focus which is not explicitly pointed out.

Experts dispose of a finely-woven domain-specific knowledge. They have gained it over time and through many experiences. The knowledge is comprised of declarative and procedural knowledge. They use this knowledge base when applying design methods. Thus, it is a prerequisite to using the design method, but is not integrated in the design methods description. Of course, it is not possible to integrate all of an expert's knowledge, but it might be helpful to emphasize the need for a broad knowledge base when using the design method. However, the acquisition of a knowledge base has to be at least partly encompassed by a teaching concept.

These requirements must also be considered when setting up the description of the design method. They should conform to the hierarchical structure of the long-term memory. It makes it easier to understand and memorize the information. One possibility would be to structure the information coming from a specific instance or example and abstract it to a class, or come from an object class and deduce its instances. So, it is very sensible to explain structuring techniques according to object classes and show possible links between them. It has been proven that it is much easier to understand and to memorize knowledge, if it can be linked to existing knowledge. Also, it makes sense to describe things with objects and attributes because they correspond to the storage types of schemata. Using similar terms and figures to represent different meanings should be avoided. This could cause confusion because the semantic networks try to relate them, when it can not identify a distinction.

There are many more instructions from cognitive psychology (see [3]). Thus, the description has to present the method in two forms: an abstract form, in order to provide an overview and a concrete form in order to demonstrate the instance of an application. Obviously, these two forms of presentation should be linked together to present the transfer processes from abstract to concrete, as well.

6.6 The consequences for teaching design methods

Regarding the development and the characteristics of expertise in design, it is possible to derive some important aspects for a teaching concept of design methods. The primary elements concern the content of a teaching concept, the teaching method and the personal prerequisites of designers. The content of a teaching concept is, according to the theory of expertise, divided into two parts. Firstly, we have to contribute to a knowledge base with the goal of domain-specific knowledge. Secondly, we have to impart skills and abilities. Teaching method: When imparting these three content parts we have to consider the cognitive prerequisites of human beings and the three stages of Anderson.

Regarding the cognitive prerequisites, we must look at the limitations of the cognitive resources and especially, the structure of the long-term memory. So, when preparing the learning material, we have to structure it to conform to the structure of the long-term memory. That means moving from general object classes to concrete instances or vice versa. It also means taking the existing knowledge of the designer into account and linking it to the new knowledge. This affects the teaching of background knowledge and design methods.

Above all, when teaching design methods we need to consider the three stages of Anderson, because the application of design methods implies action and skills than pure knowledge acquisition. Also, we have here to regard the existing skills of the designer and to compare them with the required skills of the design method. If we find distinct lacks, these skills must be integrated in our teaching concept. Then, we must start with the design method as declarative knowledge and tell the designer what the intention and the content of the design method is and what the result should be. After that, the associative stage has to be started. The designer has to apply the design method to a simple problem in order to proceduralize the declarative knowledge of the design method. These stages need time to practice. The designer has to understand the design method and to eliminate errors in his memory. And it will go into the next stages where the design method has to be applied with more difficult and complex examples in order to make them autonomous. Another point which needs to be taken into account is the gaps in design methods.

When preparing the description of the design method as teaching material, it is necessary to identify possible gaps in the knowledge and skills and to complete and supplement the description of the design method or integrate the missing aspects in the teaching concept.

In sum, one can say that teaching design methods is not a one-sided job. It must always be regarded with the student of methods and the knowledge domain in which the design method should be applied.

7 Results: A first approach toward a teaching concept

This chapter summarizes the insights achieved as to the nature of design methods and the relevant elements and factors from their development and conditions, comprising a first concept with instructions to teach methods. The conversion into practical application is the major matter of this concept.

7.1 The description of design methods as teaching material

We have identified the three main fields, which have formed the description of design methods and the design method itself: the designer's surroundings, the development process of the design methods and the author of the design method as an expert (see Figure 6).

The designer's surroundings have formed the design method and their description according to their operational area and the types of problems which are to be solved using the design method. In the end, these factors influence the problem consciousness and fixation described in the design method. The design method has been formed by the individuality of the development process with its surroundings-specific course and different sources of motivation. These factors influence the individuality of the description to assist in certain situations and the amount and types of intermediary results. This phenomenon is represented

by the gaps in universality, accuracy and motivation of the design methods and their description.

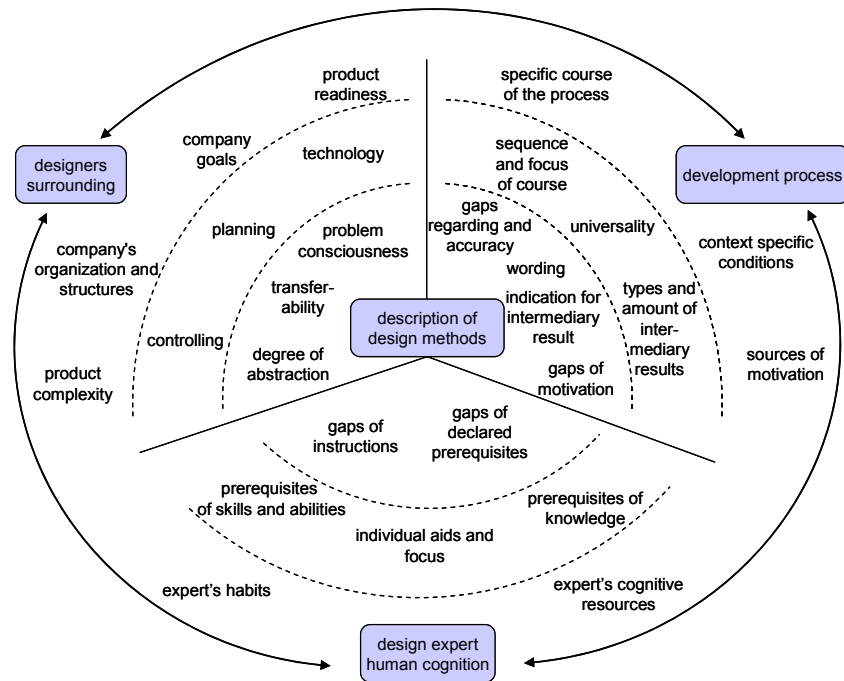


Figure 6. Aspects of design methods

The design experts as authors with their human cognition influence the design method and its description by their cognitive prerequisites regarding skills, abilities and knowledge and their expert habits [11]. These prerequisites lead to individual aids with a specific focus on the design methods. In the end, this causes gaps in the instructions and declared prerequisites. These factors need to be considered when compiling design method descriptions as learning material.

Besides these gaps and inclinations of design methods one has also to consider the transform and transfer processes of the design methods from the design expert's head into the description and into the student's head (see [2]). In this process we will find also a lot of aspects which influence the successful application of design methods.

7.2 Teaching requirements

Becoming an expert requires transferring the types of knowledge mentioned above to the novice. This transfer has to follow the requirements of adequate cognitive teaching methods. The fundamental teaching methods which need to be considered are the three stages of Anderson: the way to learn problem-solving using examples and instructions and the requirements which result from the architecture of the semantic networks.

When regarding teaching methods, the way of describing the content plays a crucial role. The type of knowledge, the content, the structure, and the layout are decisive factors [2]. By

considering these teaching methods, a didactic concept can be set up to support novices in becoming experts in design methods, according to their cognitive requirements.

When composing a teaching concept, one has to first set up the learning targets adjusted to the content (see Figure 7). Considering the three fields of investigation of the paper, one will find the following conditions which can be understood as learning targets for design methods: problem consciousness, problem understanding, method knowledge, method understanding, method competence and general aspects like identification of context-relevant factors and factual and procedural knowledge. Sub-targets like those mentioned in figure 8 also belong to these learning targets.

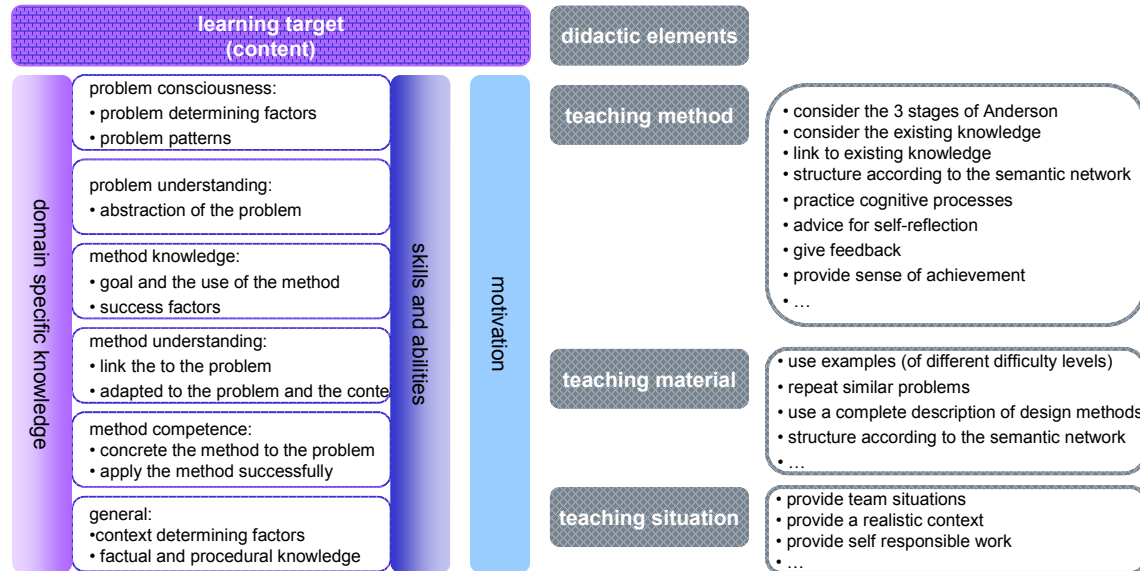


Figure 7. Didactic concept

Thus, the learning targets when teaching design methods consist of domain-specific knowledge in combination with skills and abilities. In order to reach these targets the didactic elements have to provide these three functions: to impart knowledge, to impart skills and abilities and to fuse these two parts to make them work together. The didactic elements consist of the teaching method, the teaching material and the teaching situation. They are the basis for the transfer of information to the student or designer and indicate motivation and internal learning processes.

The teaching method requires teaching especially the three stages of Anderson in compliance with the cognitive prerequisites. Also, the method has to provide motivation and self-responsibility. This is very important for teaching design methods, because they require a high degree of action, skills and abilities, which work on a sophisticated knowledge base.

The teaching material refers more to the description of the design methods and the examples. At this point it is decisive to draw up understandable and complete descriptions and instructions according to the cognitive prerequisites. One element is the repetition of problems. The teaching situation demands authenticity regarding the real surroundings of the design methods, and therefore requires teamwork, a real context and working independently.

8 Conclusion

Design methods have been developed and externalized by design experts. However, they do not contain all of the design expert's knowledge. Implicit knowledge, sources of motivation and information about the context and required background knowledge are probably partly missing. They must be considered more when preparing descriptions of design methods as teaching material. The motivation to develop design methods comes from a practical need and the intention to teach designing. This source of motivation should be also imparted, in order to show the intention and benefit of the method and create motivation to apply the method. The method should not be applied in self-interest. Thus, the method should be imparted as an intelligent cognitive tool to support the human resources.

Other points which need to be considered more intensively are the cognitive conditions of novices. If we want to transfer expert's knowledge to a novice, we have to shift this knowledge to a level and a presentation with which the novice can assimilate and work. This requires the incorporation of findings of novice and experts knowledge from cognitive science. The difference between a cognitive system of a novice and one of an expert must be investigated, in order to impart the knowledge appropriately and effectively. Of course, one cannot adapt the description of the design method to each individual prerequisite, but one should at least adapt it to the cognitive resources of novices. And one should always keep in mind that the use of methods should be an obligation, a chance to overcome cognitive limitations.

Another aspect which is not considered in this paper is the complete imparting process of the design method to the student. This paper considers basically the possible gaps and inclinations of a design method's description, so the difference between the design method in the author's head and its hard copy. But it is also necessary to investigate the (learning) process from the description of the design method to the student's head [2]. Investigating these two processes together will map the hole imparting process of design methods and will provide many insights for a teaching concept.

The fact that there is still no teaching concept for design methods after so many years of research shows that more efforts must be made in order to embed methods into designers' memories. According to the investigations, considerations and findings of this paper, there is still a huge research potential to share findings from cognitive science, engineering design and experiences from practice in establishing a suitable teaching concept. This paper suggests a first approach to this.

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