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# CHECKLISTS AS TOOLS FOR REFLECTIVE PRACTICE FOR DESIGNERS

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## ABSTRACT
Methodical designing nowadays is an important topic when developing competitive and successful products. But to work methodically means to overcome many obstacles and problems. With reflective practice one is able to surpass these problems. A critical analysis of product, process and the design context will reveal important measures which can be raised and implemented to methodically improve designing. This paper presents a tool developed for exactly this purpose: a checklist to support designer reflection of methodical procedure. First, the term reflection is defined and second, the checklists as tools are described. After a short digression on "methodical competence of designers", structure and contents of an appropriate checklist are described and a short outlook on the usage of the checklist in a professional environment is given.

*Keywords: design, methods, reflection, checklist, competence*

## 1 INTRODUCTION
Several problems can occur when methodically working in design. Although method usage in companies is often a measure to increase efficiency and effectiveness of designing and to ensure quality throughout the entire product life cycle, many method deployments end unsatisfactorily [22].
Reasons for failure when methodically designing can be for example:

- Methods are deployed too often.
- Too many methods are used.
- Not all relevant aspects are methodically worked on.

Therefore, methodical competence is needed for successful methodical designing. Special competences and skills are essential (such as expertise, soft skills and self competence). These are already trained in programs especially developed therefore by the BEMAP project of the TU Darmstadt and the University of Bamberg (see also [6]). But 100% retention of training contents and of newly acquired skills can never be achieved or guaranteed. With passing time, participants forget details, so from our point of view, a follow-up measure is necessary for self-reflection, self-evaluation and – by resulting measures for further progress – for self-control while designing. Reflection-on-action is essential to gain understanding of one's work.
Eder [4] and Stempfle [16] stated that when designing, important topics and questions a designer has to deal with are those regarding the "what" (subject or content) and the "how" (procedure resp. process). To answer these questions, designers must reflect. Nonetheless, designers usually don't reflect on their actions and neglect documenting them as well [5, 6, 15]. As reflection is not a ubiquitous topic in design education, supplements for reflection with methods or tools are necessary [10].
The requirements of such tools are:

- They must help the designer become aware of his current situation.
- The use of the tools or methods must not cost too much time.
- The benefits must easily be recognized (e.g. by shorter process or higher quality of solution).

So – seeing the necessity of design reflection-on-action (="thinking about doing after doing" [11]) and considering these requirements – we developed a tool for designers to support systematic reflection on their actions which helps to assess their situation and thereby aids them to improve their procedure.

## 2 REFLECTION IN DESIGN

Wallmeier sees reflection-on-action as a method and/or tool to realize and assess weak spots and their consequent effects. To define this term, according to Tisdale [18] and Wallmeier [21] »reflection« is a view into the past to analyze thinking, actions and feelings in specific situations (for a more detailed overview of the history, types and scopes of design reflection, see Reymen [11]).
Reflection helps to understand the integration and combination of "process" and "content" of design activities and supports designers in particular during the conceptual phase [2].
According to Reymen [10] the design context is a set of factors influencing the design process and the product being designed, which can be understood as a kind of “situational characteristics”. The design situation itself is defined by the state of the product, the state of the design process and the state of the design context at a certain moment. This is equivalent to Eder [4] and Stempfle et al. [16] adding the above mentioned situational characteristics.
Reasons for designers to keep high awareness of design situations are [10]:

- By making a situation explicit, one creates a profound base for decisions.
- The awareness of situational characteristics has great influence on one's (next) actions.
- To improve the design process, it is important to gain a better understanding of it by relating the design context to the state of the product.
- Awareness of the design process leads to improvements in future processes.

When designing (Dorst [2] sees »problem solving« and »reflective practice« as the two sides of design), a designer always influences both the product and the process [11]. Thus it is important to be aware of one’s own actions while designing.
To support the two aspects of designing (product/subject/content and process/procedure) and to prevent failure, methods can be used that help detect, correct or minimize the individual, team-, environmental- and situation-specific shortcomings and problems [4, 22]. These weaknesses and shortcomings are system-immanent according to Zanker [22]. This in turn means that they will always appear in some form and they must be minimized by means of method deployment. These methods have to be deployed flexibly and according to the situation (not in the usual fixed and un-reflected way).
The use of reflection tools should not seriously interfere with the creative process, so therefore it is not desirable to keep up with situation changes at all times [10]. At the same time, reflection only at the beginning and at the end of a project or a project phase is not enough. To improve designing (e.g. through an iterative loop in the embodiment design phase; see e.g. VDI2221 [19]) regular reflection after design sessions (which according to Reymen [10] are "uninterrupted working periods of designers") must take place.

## 3 CHECKLISTS AS REFLECTION TOOLS

### 3.1. Structure of checklists

A checklist is a feasible and appropriate tool to support procedure and task which can be integrated very easily into the process [17]. Checklists also have the (e.g. by Zanker [23]) required reasonable balance of effort and benefit. They are similar to catalogs according to Spath [17] and have generic structures as they are often arranged in a classification/structure part and an accessible part. Catalog structures can be one or two dimensional and can have separated main and access parts ([14]. Based on these matrices, relevant matrices can be acquired, structured and grouped into checklists. These checklists should in our case be one-dimensional to ensure a sequential, easily understandable structure.
According to Roth [13], question lists or checklists can be used as "short analyses" of a task and to formulate a task description. They have a tree-like form, as they contain structured levels of elements that inherit properties from higher levels, as depicted in Figure 1 [17].

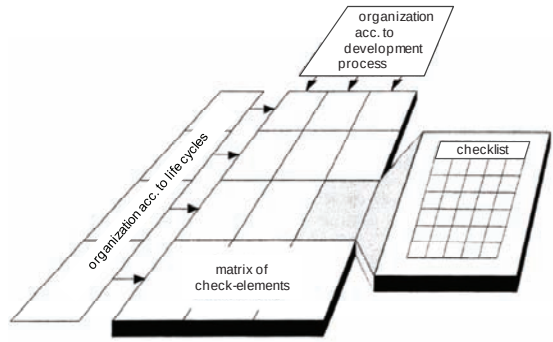


*Figure 1. Generation of checklists from catalogs [17]*

Subordinate elements in a hypothetical checklist section »concept phase« could be for example "analysis of solutions" or "generation of solutions", both inheriting the properties of the category »concept phase«. Checklist items fitting this example would thus refer to abstract and immature “concepts-only” and not to fully elaborated solutions.

Another practical, general and recurrent method to reflect one's actions is the method of "targeted questioning" [9]. Focusing on own or other ones' questions stimulates cognition and intuition, and a catalog of questions supports discursive procedure. These structured questions can more or less be formatted as checklists.

Further, checklists that help to reflect and to evaluate should generally be formulated like questionnaires asking the user questions [3]. These questions should follow some basic guidelines:

- short, understandable and precise
- proper language (no dialect or colloquial language)
- no double negations
- disjunctive, sufficient and precise answer-categories resp. -possibilities
- no judgmental terms or terms associated with moral values (like freedom, justice, crime, etc.)
- no multi-dimensional questions (no questions that combine more than one topic or question)
- no indirect questions
- no suggestive questions
- no excessive demands (cognitive overload, excessive calculations)

Diekmann [3] also says: No rule without exception – when designing checklists these rules possibly cannot all be applied sometimes.

### 3.2. Usage of checklists

With the checklist the designer must rate and thus describe a situation. Therefore the checklist must contain items or elements corresponding to the product, the design process and the design context (the situational factors). Although verbal descriptions of a designer (without rating) may have some advantages (like the replacement of documentation or the better understanding of the situation by thinking it through and writing it down), we think a rating is more feasible, as it is shorter and avoids some disadvantages of making descriptions (e.g. designers dislike documenting and are usually not accustomed to describe their situation; see also [10]).

Various existing checklists with rating scales can give an idea of how an appropriate checklist can look like and work. They are structured in categories with elements that can be rated. Existing rating systems like the »University Of Texas Behavioral Markers Rating Scale« or the »NOTECHS Rating Scale« use rating scales from zero to four or from very poor (=0) to very good (=4) [7].

Along the lines of these tools, the items on our checklist can be assessed with numbers on a scale from zero to four (as is recommended by e.g. the VDI 2225 [20]). In our opinion this scale is comprehensible and easy to use, so that a quick and feasible use of such a reflection checklist is possible.

Our checklist can be used by individuals AND by teams. It is important to create an atmosphere of openness and trust, when the checklist is filled out by teams, and it should be guaranteed that no disadvantages result from honest processing of the checklist.

As Reymen [10] describes, the end of each session is the natural starting point for the description of the design situation. So she recommends her checklist for the beginning and/or the end of design sessions. The time required for the processing of her tool (max. 10 min), is much too long in our opinion. Assuming three or more design sessions a day, a designer could possibly reflect more than one hour a day with such a tool, which is in sum far too long and would be impracticable. We want our checklist to be practicable and thus much shorter to process and additionally provide a rating that supports designers in a quick assessment.
As the checklist is for self reflection, statistic statements regarding these assessments cannot be deduced. Objectivity and reliability (see e.g. Nolting [8]) cannot be guaranteed, nor can validity. But self-reflection is always somehow subjective and our checklist is just a support tool to achieve a methodical and complete self-reflection on methodical procedure of individuals and/or teams. Therefore we think that our checklist is an appropriate tool to support designers in methodically reflecting on their work.

## 4 CHECKLIST FOR SELF REFLECTION

We already defined a model of methodical competence that describes ideal methodical procedure of designers [6]. This model was the result of literature research and a comprehensive Behavioral Marker system that describes ideal methodical behavior of designers. This system was developed by the BEMAP group and is the result of additional literature research and an extensive interview study with 46 interviewees from 15 companies.

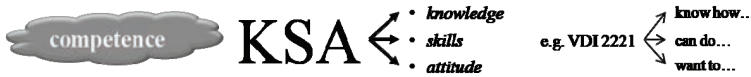


*Figure 2. KSA-model*

The KSA-model (see Figure 2: competence = Knowledge + Skills + Attitude; see also Cannon-Bowers et al. [1] or Richter et al. [12]), shows that for methodical competence in teams reflection during the process is an essential factor, so that ideal and real methodical procedure can be combined and thus better designing can take place.

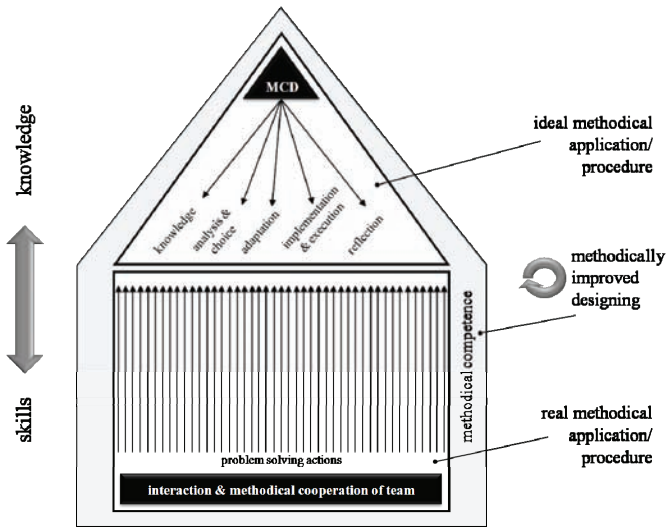


*Figure 3. New model of methodical competence of design teams*

Therefore, the competence model was slightly altered and supplemented with team characteristics (such as interaction and parallel problem solving) regarding the contrast of theory and practice (see Figure 3.). This model now includes the combination of theoretical and practical knowledge.

Our checklist intends to support designers and their teams in reflection and is a tool to ensure the quality of this reflection. It includes a “meta-reflection”, a reflection on the reflection, as another quality management tool. This checklist helps to compare one's actions (problem solving or real methodical procedure) to the ideal procedure, what helps designers to raise appropriate measures and to improve their designing. Therefore, we use the above described model for an ideal methodical procedure with its five categories including their elements (as described by Geis et al. [6]). These categories do not merely reflect tasks and problem solving actions described by e.g. the VDI 2221 [19], Pahl [9] or other design methodologists. They were explicitly designated as important and necessary actions by experienced designers in the interview study of the BEMAP project. These actions thus can be found in the BEMAP Behavioral Marker system that describes successful actions of designers and design teams.

| ***checklist for self-reflection of methodical procedure*** | | ***very poor*** | ***poor*** | ***acceptable*** | ***good*** | ***very good*** | ***↓ value*** |
|---|---|---|---|---|---|---|---|
| ***Category*** | ***Element*** | **0** | **1** | **2** | **3** | **4** | |
| ***expert knowledge*** | Gathering, acquirement and documentation (mental & written) of product-specific knowledge | □ | □ | □ | □ | □ | |
| | Gathering, acquirement and documentation (mental & written) of product design methodology knowledge and generic problem-solving knowledge | □ | □ | □ | □ | □ | |
| ***selection of methods*** | Analysis and assessment of task and situation | □ | □ | □ | □ | □ | |
| | Analysis and assessment of available resources and methods | □ | □ | □ | □ | □ | |
| | Choice of appropriate method(s) and/or development of procedure | □ | □ | □ | □ | □ | |
| ***adaptation of methods*** | Analysis and assessment of method(s) & procedure | □ | □ | □ | □ | □ | |
| | Change and adaptation of method(s) and/or procedure | □ | □ | □ | □ | □ | |
| | Allocation of resources & responsibilities | □ | □ | □ | □ | □ | |
| ***execution of methods*** | Development of solutions | □ | □ | □ | □ | □ | |
| | Evaluation and discussion of solutions | □ | □ | □ | □ | □ | |
| | Execution of problem solving actions and/or quality of procedure | □ | □ | □ | □ | □ | |
| ***reflection-on-action*** | Initiation and organization of reflective action | □ | □ | □ | □ | □ | |
| | Recapitulation and analysis of reasons of procedure and actions | □ | □ | □ | □ | □ | |
| | Assessment of effectiveness of procedure, actions and outcome | □ | □ | □ | □ | □ | |
| | Derivation, documentation, implementation and control of measures | □ | □ | □ | □ | □ | |
| | | | | | | ***Total*** | |

*Figure 4. Checklist for self-reflection of methodical procedure*

The checklist as depicted in Figure 4. adheres to the more or less chronological structure of ideal methodical procedure with ratable elements that describe necessary actions when methodically designing and will be described below. The categories and elements of the checklist were slightly changed and formulated in an "action-like" form, so that a user can easily understand and rate these items/elements on a scale from zero to four.

### Expert knowledge

Before a method can be executed and the process can be started, missing or essential information has to be collected or newly acquired and documented. This information can concern the product or the process.

1. Product-specific knowledge:
   The checklist user (the terms "user" and "users" will be used synonymously below; the same applies for "designer" and "designers") has to assess how well he collected the requirements and necessary information regarding the product and its competitors. For example, existing CAD-models or prototypes can be reviewed or the designer can conduct a heuristic analysis of the forerunner products.
2. Design methodology and problem-solving knowledge:
   Designers require knowledge of existing applicable methods and their scope. Knowledge and experience regarding problem solving actions (such as dealing with uncertainty and abstractness or the procedure in designing) is also essential for the application of a method and needs to be acquired if not present. The designer and/or his team has to rate how well he/they collected or acquired this information or knowledge respectively.

### Selection of methods

Before a method can be applied, the design situation and a possible method deployment need to be thoroughly analyzed.

1. Analysis and assessment of task and situation:
   The design situation (state of product, state of design process and design context) needs to be described to be able to choose appropriate methods and/or procedures. The user has to rate how well this analysis and assessment of the task and situation took place.
2. Analysis and assessment of available resources and methods:
   The user has to rate how well he analyzed and assessed available and feasible methods in regard to whether they fit the task.
3. Choice of appropriate method(s) and/or development of procedure(s):
   In the design process an appropriate method or a set of methods is chosen and a strategy is built for mastering the design task. The user must rate how efficient and sound he acted in this respect.

### Adaptation of methods

After a method (or a set of methods) is selected and a procedure is developed, the methods must be adapted to the actual design situation.

1. Analysis and assessment of method(s) & procedure:
   After having analyzed the design situation and the interrelations between the constraints, the chosen methods have to be analyzed as to whether they fit and/or correspond to the actual needs. The user of the checklist must rate the quality of such analyzing and assessing actions.
2. Change and adaptation of method(s) and/or procedure:
   Depending on resources, capacities, competences, and time restrictions or similar, the procedure and/or the methods may have to be altered and slightly adapted to the situation. The user has to assess whether he adapted methods and/or procedures at all and how well he succeeded at that task.
3. Allocation of resources & responsibilities:
   In this adaptive step it is important to organize and allocate human resources, equipment, capacities, etc. to allow for a successful method deployment. The person or team working with the checklist must assess whether and how well all necessary preconditions and requirements were fulfilled.

### Execution of methods

When procedure and methods are selected and adapted, the execution or the methodical designing must take place and methods must be carried out to move forward in the process.

1. Development of solutions:
   Development of solutions in this context means that several possible solutions are developed and elaborated to cover a broad range of possible solutions. Hereby it can be ensured that promising concepts or solutions are not neglected a priori. The user thus has to rate the quality and thoroughness of his solution generation.
2. Evaluation and discussion of solutions:
   Generated concepts, solutions, ideas or calculations need to be evaluated whether they meet the requirements of the product and further advantages and disadvantages of the solutions need to be discussed. Possibly partial solutions need to be improved or can be replaced by better ones. In the checklist the user must assess his procedure in regard to analysis, evaluation and discussion of solutions, concepts, ideas, etc.
3. Execution of problem solving actions and/or quality of procedure:
   To control one's own behavior, one must ask himself whether all necessary steps were carried out properly and whether the designing went according to general rules (such as abstraction and concretion, appropriate dealing with uncertainty and fuzzy data, etc. – for more qualifications of problem solvers see Pahl et al. [9]). So with this element, the user must rate his own problem solving and quality of procedure.

### Reflection-on-action

As the last element of the checklist for a quality management measure, the user or users must assess the quality of their own reflection as a kind of meta-reflection (reflection on the reflection). Proper reflection on the process and the outcome of the execution of methods guarantees better quality in both problem-solving and future processes.

1. Initiation and organization of reflective action:
   The user must ask himself whether the reflection took place at the right point in the process and must rate whether it was conducted in a proper way.
2. Recapitulation and analysis of reasons of procedure and actions:
   When a designer designs, he must make decisions at various points in the process and most actions are influenced by earlier steps and decisions. Therefore, one has to ask himself about the motivation and reasons for procedures and actions. The checklist user must assess the quality of this recapitulation and analysis with this element.
3. Assessment of effectiveness of procedure, actions and outcome:
   It is important to analyze the effectiveness of procedure, actions and the outcome to see what potentials still exist, where improvements have to be made or to have the self-assurance that the design session proceeded in the right direction. The user must rate whether and how well he analyzed and evaluated his procedure and actions.
4. Derivation, documentation, implementation and control of measures:
   The user of the checklist must assess whether and how well appropriate measures (such as iterative loops, new generation of solutions, adding of new methods, etc.) were derived, documented and implemented. If the effectiveness of the procedure, actions and outcome was deemed imperfect, taking new measures (and their implementation) is inevitable.

All these elements of the checklist have to be rated according to the self-assessment of the individual or the team on how good or bad he/they estimate their behavior or design actions. The median throughout the categories shows what categories might have deficits and/or potentials. Additionally, one has an overview over the entire reflected design session. Based on this, the designer or team can specifically take measures, such as the initiation of iterative loops, collection of more information or a new analysis of the concept, to improve the procedure.

First usability tests with designers show that the categories and elements are easily understood and that the processing of the checklists takes considerably less than five minutes. In future training in the industry, designers will be trained to use the checklist which will hopefully lead to suggestions of improvement and further optimization of our tool.

## 5 CONCLUSION

When successfully designing, designers (individuals as well as teams) must carefully analyze and respond to current situations. These situations include the state of product, the state of the process and the design context (or situational characteristics). By reflection-on-action, designers can assess a situation and take measures for better performance in design situations in the future. To support this reflection, we developed a checklist that helps to evaluate the methodical procedure of the designer and/or his team. By processing the checklist, weak spots, problems and potentials of the design process can be identified so that measures can be taken. These measures could be for example the initiation of iterative loops or incorporating another solution generation phase for partial solutions and thus ensure a better integration of the two design-aspects »content« and »process«. In our checklist the user (or his team) must systematically rate relevant elements in the categories »expert knowledge«, »selection of methods«, »adaptation of methods«, »execution of methods« and »reflection-on-action«. The average values deduced show which aspects of the methodical procedure contain deficits and thus aid the designer in locating problems and improving the design process by taking measures. First tests indicate that the usage of this checklist takes considerably less than five minutes time, which will probably decrease even further when used more often. Further, it is a feasible and easily understandable tool. Therefore, we are confident that our checklist will help designers to methodically improve their work and thus achieve better solutions.

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