

# 15 Years of SPALTEN Problem Solving Methodology in Product Development

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## Abstract

The brain has only limited ability to deal with complex Problems. Therefore, the developer must be supported to supplement his natural problem-solving behaviors. The SPALTEN-Methodology was described by Albers et al. and constantly developed further in the past 15 years. Furthermore, it was applied consistently in projects and education. SPALTEN is a German acronym and means “to split”, “to decompose”. In this contribution, the results of an extensive empirical study of the use of SPALTEN in the last 15 years is presented. The study consists of a qualitative preliminary study on basis of interviews (n=15) and a quantitative survey using a questionnaire (n=108) and has a focus on the application and the added value for the user. The results show, that SPALTEN is used in practice by over 80 % of former students and PhD-students, who learned the method in their education.

**Keywords:** SPALTEN, problem solving, methodology, method

## Motivation

Sudden component failure of a prototype in field tests results in development practice regularly to a problem situation. To ensure that the start of production is not jeopardized, the problem has to be solved in a short time. In these situations, a systematic problem solving must be given an increasingly higher priority. For a successful development management, it is therefore necessary to equip engineers with the right tools and provide a structured approach for the product development process. Many authors, including HUBKA (Hubka and Ernst Eder, 1992), EHRENSPIEL (Ehrlenspiel and Meerkamm H., 2013), PAHL AND BEITZ (Pahl and Beitz, 2013) regarding the technical problem solving process as the central task of engineering activity. However, in practice, the problem is tackled more common intuitive and seldom structured. In many cases, the reason is that the methods and processes are too complex, which leads to a high acceptance hurdles in real product development processes. In this paper, the problem-solving process SPALTEN is presented. This process defines a structured approach of general problem-solving and is based on the idea of Systems Engineering. Following, the results of an extensive empirical study of the use of SPALTEN in the last 15 years will be presented. Subsequently, based on the practice observations, appropriate

adjustments will be discussed. Key aspects of the SPALTEN problem solving process were included in the revision of the VDI guideline 2221 (Mantwill, 2014; VDI2221, 1993).

## **Problem solving**

In the following problem solving processes in general will be described from a cognitive (i.e. human-centered) perspective. Afterwards selected methods for problem solving will be presented in an overview.

### **Problem Solving as cognitive Process**

A problem is characterized by three components according to DÖRNER (Dörner, 1979):

- Undesirable initial state
- Desired final state
- Barrier, that prevents the transformation from initial to final state at the moment

This description basically matches the descriptions made by Ernst and Newell in 1969 (Ernst and Newell, 1969) about problem solving. Furthermore DÖRNER (Dörner, 1979) describes problem solving as transformation of specific circumstances with the help of specific operators. In detail there are five general demands on cognitive processes of problem solving persons (Samuel Greiff, 2010):

- Reduction of information: Reducing exuberant information to a workable extent
- Modelling: Designing adequate models for comprehension of the situation
- Prognosis: Predicting upcoming developments based on the current situation and in the context of measures taken
- Gathering and generating of information: Acquiring missing but crucial information for the problem solution
- Evaluation: Making value judgments and prioritizing for setting objectives and resolving conflicts of objectives

Solving a problem is also influenced by the present type of problem. As REITMANN already states back in 1966, problems can be characterized by the precision with which initial and final state are defined (Mayer, 1979). DÖRNER later depicted four underlying, recurring attributes of problems: Lack of transparency, complexity, dynamics and lack of knowledge (Dörner, 2000). WILD AND MÖLLER state connectedness of variables, intrinsic dynamics, lack of transparency about the underlying variables and their connections, irreversibility of decisions, flood of (also useless) information and side effects of decisions to be additional attributes of complex problems (Wild and Möller, 2015). MÜLLER (in (Glock, 1998)) defines the demands of engineering design problems as „cross-linked, partly qualitative and therefore only estimably evaluable, partly depending on each other or even contradicting“ (according to (Glock, 1998) p. 28; translated by the authors). According to DÖRNER, a problem is highly cross-linked, when „the variables or attributes strongly depend on each other, so that it is only limitedly possible to influence them in an isolated way“ (Dörner, 1979) p. 20; translated by the authors). Moreover PAHL attributes the „characteristic to be accompanied by complexity and indeterminacy“ to engineering problems (Pahl and Beitz, 2013)p. 58; translated by the authors). Complexity and interconnectedness require measures from the problem solver in the problem solving process: RUTZ delineates the problem solving process as a „continuous

change between the whole and details“ (Glock, 1998) p. 27; translated by the authors). Since „the number of distinguishable objects grows with increasing level of detail in the respective area of interest. This increases complexity of the area of interest and thus makes problem solving more complicated“ (Dörner, 1979). The problem solver hence switches between various degrees of detail in the mental problem representation to handle complexity and connectedness in an iterative way (Wynn et al., 2007). This concerns the process of generating knowledge and identifying options for solution procedures rather than simple repetition of activities (Costa and Sobek, 2003). Various methods of problem solving claim to provide support for the issues discussed above; an excerpt will be presented in the following.

## Problem Solving Methods

The following chapter gives a brief overview of the relevant problem solving methods applied in research and practice. These are visualized in figure 1.

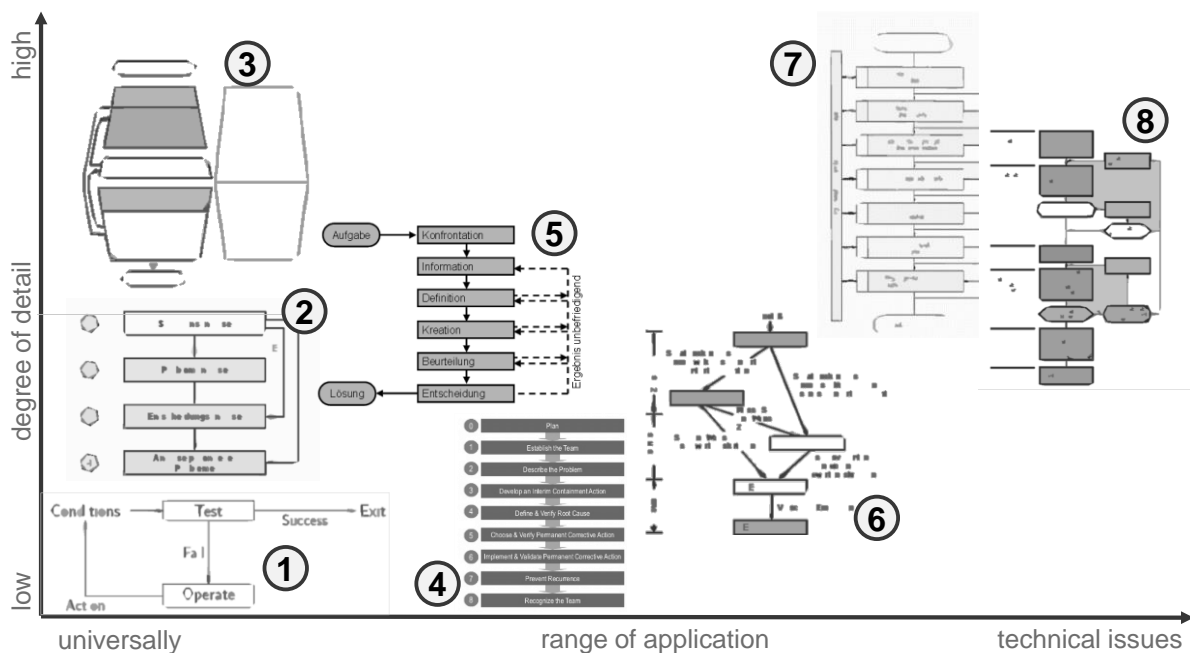


Figure 1: Problem solving methods

The **1) TOTE-scheme** (Miller, 1960) depicts an elementary sequence of activities. The scheme is intended to reach the desired state or objective, based on the actual state, by variations respectively operations of the given state. The loop can be divided into two process operations: the process of change (Operate) and the testing process (Test). Occurs the achievement of the target, the loop is exited (Exit). Further methods as the **2) problem-solving method by Kepner/Tregoe** (Kepner and Tregoe, 1992) or the **5) general solving process by Pahl/Beitz** (Pahl and Beitz, 2013) include a basic scheme which can be divided into individual working steps. These operations are executed sequentially and may be repeated depending on the need for further operation. The **3) procedure cycle by Ehrlenspiel** (Ehrlenspiel and Meerkamm H., 2013) is an extension of the systemic problem solving cycle. The process is aimed at finding a solution for a defined task or problem. Though the procedure cycle is split into three operations: task clarification, searching for solutions and selecting solutions. The **4) 8D-Method** (Schmitt and Pfeifer, 2015) represents a kind of checklist for problem solving. The method is intended to identify fundamental causes of

problems and prevent the renewed appearance of mistakes. The **6) Systems Engineering** (Daenzer and Huber, 2004) is a problem solving methodology for handling complex problems. The problem solving process is divided into five working steps: Situation analysis, formulation of goals, synthesis-analysis, evaluation and deciding. Unlike previously considered problem-solving processes, the systems engineering allows a certain dynamic. The **7) problem solving process described in VDI 2221** (VDI2221, 1993) is derived from the systems engineering. Compared to the systems engineering, however it differs in the restriction on the development and design of products in the mechanical and plant engineering. The **8) REFA-Method** (REFA, 1985) can be considered as a method, which is adapted to very specific problem situations. Divided into six stages it deals in particular with the process of fulfilling economic targets.

## **The SPALTEN Problem Solving Method**

The SPALTEN method describes an universal approach which is not limited to special problems which can be adapted according to edge condition and complexity degree to the problem formulation. The method is suited therefore equally for emergency situations and planning situations. SPALTEN became first-time published by ALBERS (Albers et al., 2002). Since then the methodology was applied in projects and education and continuously developed during the past 15 years. SPALTEN was developed, on this occasion, as an acronym which helps the problem solver to notice the steps in a logical sequence. Through this initial hurdles should be diminished (Albers et al., 2005). The single activities form a breathing process in which steadily information is generated and is condensed afterwards (Albers et al., 2010),(Albers et al., 2002). This happens with the generation and refinement of situation information, as well as concerning solutions and their possible results. Thus the SPALTEN method should help to divide big problems into smaller manageable problems. The method gives a firm and returning order of sub-activities for the solution of problems. With it a red thread is given to the developer to which he can keep. Because SPALTEN is universal and can be used in different abstraction levels, it is possible to apply it during the entire product development process just as well as during the several phases of the product development process and during the several activities which are operated during these phases (Saak, 2007). This characteristic is defined as a fractal structure (Albers and Braun, 2011) and is equivalent to the fact that every working step of the SPALTEN process can depict an own SPALTEN process (Figure 2 left).

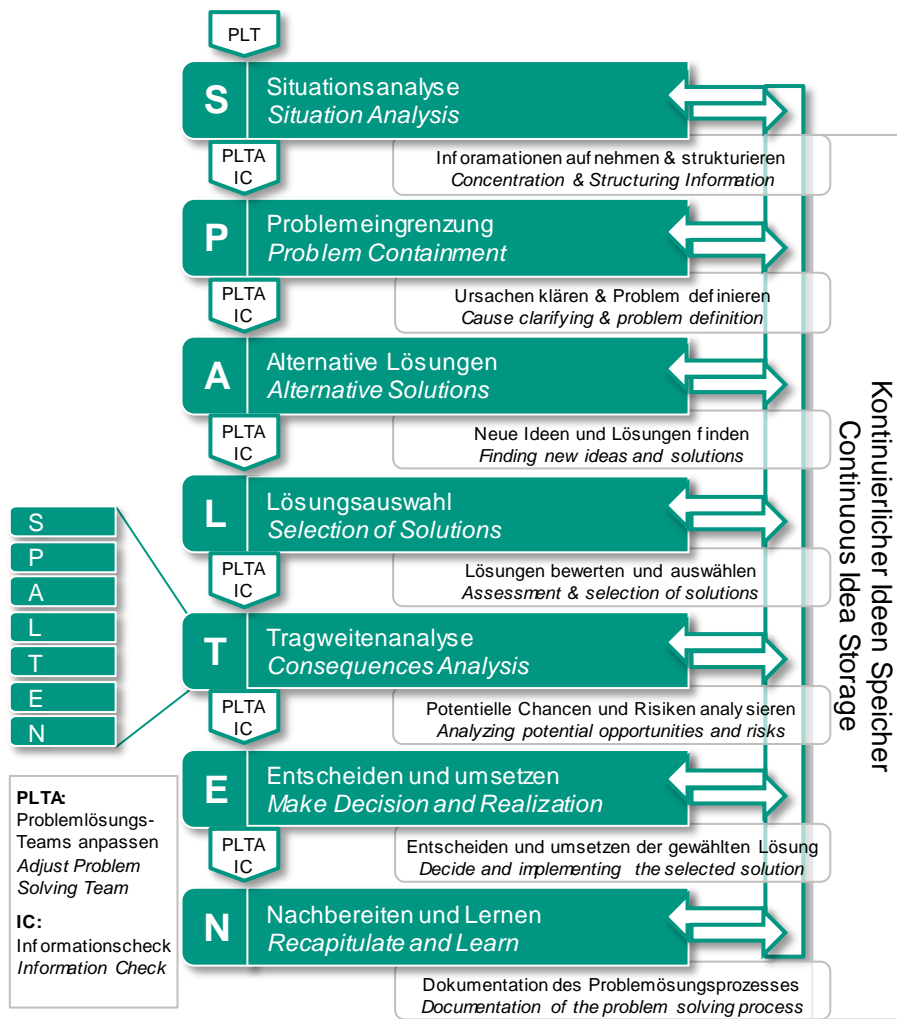


Figure 2: The SPALTEN problem solving method

The SPALTEN problem solution method consists, on this occasion, of the seven working steps shown in figure 2. **Situation analysis:** In the situation analysis all relevant information about the situation is collected, structured and documented. The information serves as a basis for the further problem solution process. **Problem containment:** The aim of this activity is to describe the present problem on the basis of the before accumulated information. Typical problem connections should be recognized. In addition, the variety of information should be specified. Among other things, these data form the basis for the target/performance comparison. **Alternative solutions:** In this step solution variations are generated for the before described problem. For support different creativity methods can be applied. To cover the solution space complete and accurate, a high quantity in solutions should be aimed. **Selection of solutions:** On this occasion, the before generated solution alternatives are compared with each other and valued by means of defined criteria. The choice of the criteria is to be defined specifically according to the problem situation. **Consequences Analysis:** In the Consequences Analysis risks and chances for the chosen solution are determined. **Make decision and Realization:** The aim of this activity is the translation of the mental solutions in reality. With the conversion measure plans are generated and realized. The identified risk and chances are considered especially. **Recapitulate and learn:** Recapitulate and learn there is the final step in the problem solution method SPALTEN and offers the chance to protect the resulted knowledge with lasting effect. The activity describes the reflection of the problem

solving process and the documentation of knowledge for future processes. This separates SPALTEN from existing problem solving techniques which neglect this step mostly.

Beside the SPALTEN activities other elements of the methodology are the steady adjustment of the problem solving team (**PST**), the **continuous idea pool** as well as the mandatory check of information (**IC**).

In general, the process starts with the definition of the PST which is continuously checked and adapted. Since the different activities also need different competence, the consideration of the problem solving team plays a crucial role in the process. Thus creative people can make a valuable contribution in the activity of generating alternative solutions. If these people value their own ideas, an objective statement is seldom guaranteed. In this manner it is checked continuously whether the composition of the PST is adapted to the respective demands of the topical activity, or whether additional experts are needed.

During the problem solving process, ideas are continuously collected. So that these do not get lost, they are held on in the continuous idea pool. He serves to generate and store solution ideas of the problem solution team systematically. Thus every participant can access any time the entire solution space.

Another element is the check of information. During the analysis it is checked whether the present information is sufficient to move the upcoming step. With the check of information, it is checked, to what extent the base of information was used enough and whether additional information is needed for the implementation of the next activity

## **Aim of Research and Research Method**

First of all, the research objective is presented and after that, the achievement of this objective by operating with the research method is declared.

### **Aim of Research**

The problem solving method SPALTEN was developed 15 years ago and until now is propagated by various publications and university courses. Although the authors have received lots of good feedback on the value of SPALTEN, there hasn't been any empirical study concerning the value of the problem solving method. Thus, the aim of this contribution is to identify the way how SPALTEN applied in development practice and its benefit.

### **Research Method**

For data acquisition a qualitative interview study with N=10 participants was made. Based on the interview results a quantitative survey among N=636 recipients was designed with the online survey tool LimeSurvey. The survey was accessible for 3 weeks. During this time, N=108 alumni of the IPEK from various branches of industry and higher education completed the survey. Calculating the overall population as about 600 former students of integrated Product Development (15 years of each about 40 graduates) and about 100 former IPEK staff members results in a sample size of about 17% of the population. The sampling process can be regarded as self-selected sampling, since the participants volunteered and the researchers had no control over whether or not the members of the population participated in the survey. Based on Cochran's formula this means a sample interval width of +/- 6.5%, which states that with 95% confidence any other sample of the population would vary with a maximum +/- 6.5% in answer distribution; the survey data is thus of good quality and is regarded as representative for the population. However, bias is likely to result from the self-selecting process and limits comparability with other populations.

## Results and Interpretation

In this chapter, the results of the interview study are presented. Based on these results the output of the quantitative study is exposed.

### Interviews as preliminary study

In the present Paper the potentials of the SPALTEN method will be examined for problem solving. Interviews with 9 practitioners are forming the basis for the first investigation. The added value-bringing factors are specified with the help of a case study in the industry by interviews and a questioning. The questions addressed the categories; area of application, frequency of the use, added value, potentials and improvement possibilities.

All participations specified the circumstances of finding themselves in problem solving situations both in technical and other sectors several times a week. In this connection there was a differentiation between problems, which can be solved by a pragmatic/intuitive way (especially minor problems) and problems, which are solved by an approach of a complex sequence of partial steps. The survey focusses the last-mentioned kind of problems.

The following statements give an overview about the use of the SPALTEN methodology in practice:

*“SPALTEN is an **essential guideline** which reminds you not to go forward impulsively. It reminds you proceed systematically.”*

This assumption was named by the respondents in large part. In addition to that there was a hint which mentioned, that the approach in short-term isn't faster, but in long-term is more successful. The SPALTEN process was named frequently as problem-oriented approach, which is suitable for both the daily life and technical problems:

*“The SPALTEN Method can help me in the **structuring of all my thought processes.**”*

In situations of incertitude a great significance was attached to SPALTEN. The added value is particularly evident if - for example - no one is able to identify a reason for too high costs or which reasons cause a problem.

*“If you have such a Framework like SPALTEN, you can use this to find the **way on unknown terrain.**”*

*“SPALTEN is also usable at home and dealing with **technical and non-technical problems**”*

As an additional benefit the structure of SPALTEN for an orientation during a process and as regulatory scheme for a decision of methods was named.

*“[...] for example, if I have to find Alternative Solutions, I am able **to choose the methods, which support me** exactly on this step, purposefully. “*

Additionally, to that, there is the fact, that the respondents remember the importance and the sequence of the activities 10 years after learning the method.

*“I think, the characteristic of the process is, that it is relatively easy to remember because of **the acronym and its structure.** “*

To secure these statements also in the width, the hypotheses were examined within the scope of an empiric study with more than 100 Engineers.

## Survey results

Of the survey sample of N=108 participants, 74% stated, that over 50% of their daily work can be seen as problem solving activities. To cope with the demands of problem solving, only 24% stated to use problem solving methods! The method stated to be the one by far most frequently applied is SPALTEN with 76 participants stating to know the method and 40 stating to actually apply the SPALTEN method frequently (more than three times a week) or often (one to two times per week). This means a rate of application of over 50%. For comparison, the next frequently known method is the W-Question-Technique with 50 statements and an application rate of only 18%. The other well-known methods VDI 2221 and problem solving process according to Pahl / Beitz are stated known in 44 respectively 41 cases with an application rate of each 5%. SPALTEN can thus be considered very relevant for industrial problem solving based on this survey sample.

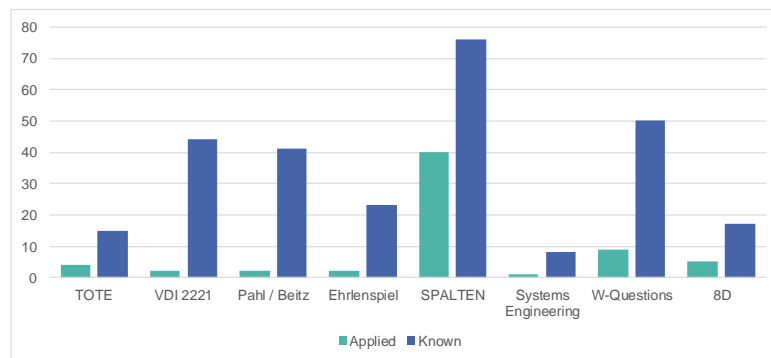


Figure 3: Knowledge and usage of problem solving methods

The following analysis (Fig. 4) considers the relative frequency of the methods application depending on the individual task.

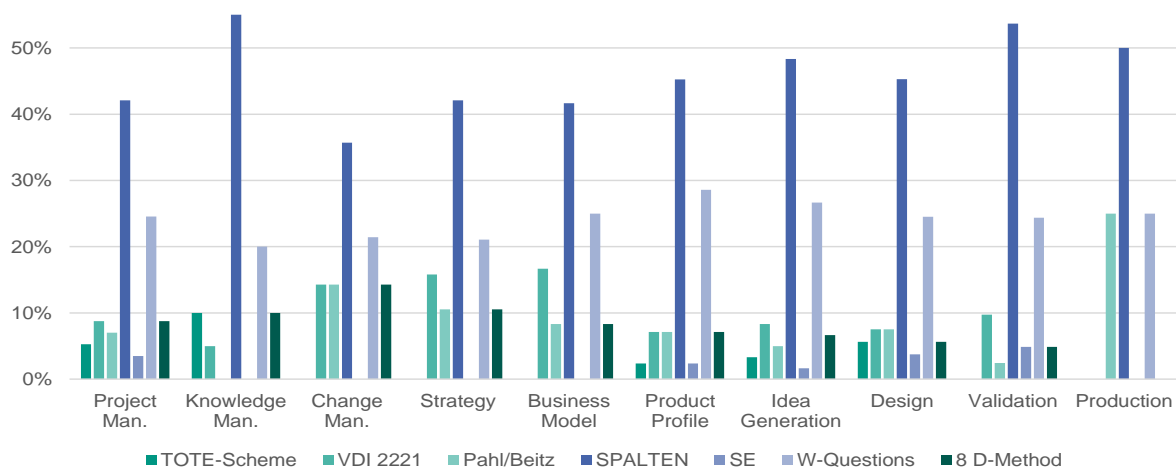


Figure 4: frequency of the methods application depending on the individual task

It can be seen that the SPALTEN method is applied independent by the individual task, while other methods are used in special situations. The most helpful aspects of SPALTEN are said to be the following (summarized over strong agreement and agreement; in order of descending degree of agreement):

- The acronym is helpful to recall the steps in order (over 90%)
- SPALTEN helps to follow the “red trail”/ not to get lost (over 80%)

These statements comply to the cognitive restrictions of working memory: The more information pieces (“chunks”) are to be remembered, the less capacity is left for other mental



activities (e.g. problem solving). An acronym is remembered as one single chunk and thus reduces mental workload necessary for structuring the problem solving process.

- SPALTEN helps to divide a problem into sub problems (about 75%)

Because of its fractal structure, SPALTEN supports divide and conquer heuristics, which are common in complex problem solving.

- SPALTEN helps to solve problems in a more focused way (about 75%)

By supporting a structured procedure, SPALTEN reduces the effort resulting from randomly skipping forward and backward over several problem solving steps. The continuous information pool and information check activities provide focus on the objectives of the respective problem solving process.

- SPALTEN helps to act in a rational, non-impulsive way (about 75%)
- The SPALTEN-methodology does not restrict my problem solving abilities (over 70%)

The first two steps of the SPALTEN process (Situation Analysis and Problem Containment) prohibit impulsive, solution-driven decision-making. The rather problem-driven approach results in well-founded problem descriptions and traceable solutions and activities. Nevertheless, SPALTEN leaves room for interpretation, which means that during problem solving some steps may be skipped purposefully resulting in a non-restrictive but guiding process.

- SPALTEN is suitable for non-technical problems (about 70%)

Being oriented on the mental activities of problem solving and typical steps in problem solving processes, SPALTEN can be applied to virtually any kind of problem.

Only regarding the criterion “SPALTEN helps to solve problems faster” the results were the majority of participants (about 45%) stated, that SPALTEN is of neither positive nor negative impact. Nevertheless 30% stated a positive influence of SPALTEN on problem solving speed, whereas 25% stated a negative influence.

## **Conclusion and Outlook**

The SPALTEN methodology describes a universal approach to the treatment of problems with different framework conditions and different complexity degrees. With SPALTEN a minimization time and effort as well as a solution optimization can be reached. The problem solving becomes supported with the SPALTEN methodology by the integration of a huge number of methods. The approach is not dogmatic, on this occasion but to apply pragmatically in dependence of the framework conditions. The study illustrated the added value of the method in the practice application. Furthermore, the results indicate, that the particular steps of SPALTEN remain in memory well by learning the acronym. The red thread, the fragmentation into sub problems and the more focused approach exhibit the support of systematic approaches by using the problem solving method. The positive results of the study prove that further papers should forward a continuing dissemination of the method. For this purpose, currently a training concept is generated to enable the systematic acquisition of the method for further participants. By one-day training the several steps of the method are learned by executing a cooperative game with a following reflection. As future work the methodical support of the single process steps as well as the diffusion the practice can be seen.

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