

Martin Fritz

Contribution to the design of a matrix to
analyse and classify problem solving
methods according to performance criteria

Diploma Thesis

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**Contribution to the design of a matrix to analyse and classify
Problem Solving Methods according to performance criteria**

**- How to choose the fitting Problem Solving Method for a
specific problem -**

**Contribution à l'élaboration d'une matrice d'analyse et de classification dédiée aux
méthodes de résolution de problèmes selon des critères de performance**

**Beitrag zur Erstellung einer Matrix zur Analyse und Klassifizierung von
Problemlösungsmethoden nach Leistungskriterien**

Diplomarbeit von Martin Fritz

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Recommendations for the fast reader:

For an overview on the thesis the fast reader is recommended to glance over chapters 1 and 3 and to read chapters 4.3, 6.2 and 6.3.

List of abbreviations

ACM	Analysis and Classification Matrix
AC-matrix	Analysis and Classification Matrix
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAX	entirety of computer aided methodologies
CE	Concurrent Engineering
CSE	Concurrent Simultaneous Engineering
DFM	Design for Manufacturing
DP	Design Parameter
ECAM	Ecole Catholique d'Arts et Métiers
FR	Functional Requirement
HOQ	House of Quality
IP	Innovation Principle
IT	Information Technology
MIT	Massachusetts Institute of Technology
NOIS	Naturorientierte Innovationsstrategie Nature Oriented Innovation Strategy
P&B	Systematic Approach of Pahl and Beitz
PERT	Program Evaluation and Review Technique
PIM	Powder Injection Moulding
PSM	Problem Solving Method
PV	Process Variable
QFD	Quality Function Design
S/N	Signal-noise ratio
SAPB	Systematic Approach of Pahl and Beitz
SE	Simultaneous Engineering
S-field	Substance-field
Su-field	Substance-field
TQM	Total Quality Management
TRIZ	Theory of Inventive Problem Solving
VA	Value Analysis
VDI	Verein Deutscher Ingenieure
VE	Value Engineering
VM	Value Management

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Beitrag zur Erstellung einer Matrix zur Analyse und Klassifizierung von Problemlösungsmethoden nach Leistungskriterien

1. Framework and context of the work

Cadre et contexte du travail

Rahmen und Kontext der Arbeit

1.1. *Objective and structure of the work*

Nowadays products get more and more complex, product life cycles tend to become shorter, knowledge within a company is huge, but distributed...– Facing this industrial background ways and means have to be found and described to master the situation and to stay competitive.

When it comes to idea creation, solution of design problems and creation of innovations a broad range of methods exists: Axiomatic Design, Quality Function Deployment, Robust Design, Systematic Engineering Design, TRIZ, Value Engineering, etc.

Problem in this context has to be differentiated from a mere task where a standard solution approach is known and applied.

In this work the most frequently used methods are to be identified, described and evaluated. Special attention is paid to the method TRIZ (Theory of Inventive Problem Solving).

For method analysis and comparison and to facilitate the problem-driven choice between the methods, criteria have to be described to position the method within the innovation process, to evaluate the performance of the applied method and to characterize the problem. Different example problems have to be solved by the use of the methods in order to evaluate their performance.

In this work the new approach to assess problem-specific method performance is stressed.

Finally the consistent assessment has to provide a matrix showing the methods' strengths and weaknesses. Thereby hints for integrating and combining ideas of single methods might be gained. The concept of a comparison and analysis matrix has to be justified by a final case.

The outline of this report is as follows: In chapter 1 the necessity of an analysis and classification matrix is explained and central notions are presented. In chapter 2.1 the most currently used methods are introduced. The different stages of an innovation or problem solving process are presented in chapter 2.2 and methods positioned within this process, followed by a description of possible criteria to classify methods in chapter 3. Example problems are solved in chapter 4. Based on literature research and the gained insights when working on example problems, the Problem Solving Methods are classified according to their characteristics and evaluated according to their performance to solve specific problems. This chapter is summarized by a matrix displaying the findings. One exemplary problem follows in chapter 5 allowing some conclusions on validity of the findings. A summary and outlook in chapter 6 conclude this work.

Objectif et structure du travail

De nos jours on peut constater que les produits deviennent de plus en plus complexes, que le cycle de vie produits diminue, que la connaissance dans une entreprise est immense mais dispersée... - Pour maîtriser cette situation et pour rester compétitif, des méthodologies doivent être trouvées, décrites et appliquées.

Quant à la génération d'idées, la résolution des problèmes de construction et l'innovation, des méthodes diverses existent : Axiomatic Design, Quality Function Deployment, Robust Design, Systematic Approach of Pahl and Beitz, TRIZ, Analyse de Valeur, etc.

Dans ce travail des méthodes usitées et courantes sont identifiées, décrites et évaluées, avec une attention particulière par la méthode TRIZ (Théorie de la Résolution des Problèmes d'Innovation).

Pour rendre possible une comparaison et pour faciliter le choix entre les méthodes, des critères doivent être décrits. Cela sert à positionner la méthode dans le processus d'innovation, à évaluer la performance de la méthode générale et la performance liée au caractère du problème. Des problèmes exemplaires doivent être résolus par les méthodes pour juger leur performance.

La nouveauté de ce travail, évaluer la performance des méthodes liées au caractère du problème, est soulignée.

Finalement les évaluations des méthodes doivent être rassemblées dans une matrice qui présente les points forts et faibles des méthodes.

Le concept de la matrice d'analyse et de classification doit être validé par un problème exemplaire final.

Description de la structure du rapport:

Dans le chapitre 1 la nécessité d'avoir une matrice d'analyse et de comparaison et des notions centrales sont expliquées. Les méthodes les plus fréquemment utilisées sont présentées dans le chapitre 2.1. Dans le chapitre 2.2 les étapes différentes des processus d'innovation ou de résolution de problèmes sont présentées et les méthodes sont positionnées selon ces étapes. Dans le chapitre 3 des critères pour classier et évaluer les méthodes sont décrits. Des problèmes exemplaires sont résolus dans le chapitre 4.1. La classification et l'évaluation des méthodes de résolution de problèmes (chapitre 4.2) sont basées sur une étude bibliographique et des connaissances gagnées pendant la résolution des problèmes. Le chapitre est résumé par la matrice d'analyse et de classification. Dans le chapitre 5 un problème final permet de conclure sur la validité du concept. En vue du travail effectué, un résumé et une ouverture sur ce thème est proposé en conclusion dans le chapitre 6.

Zielsetzung und Struktur der Arbeit

Heutzutage werden Produkte immer komplexer, Produktlebenszyklen immer kürzer, das Wissen im Unternehmen ist immens, aber verstreut... - Um wettbewerbsfähig zu bleiben und die Herausforderungen des Marktes anzunehmen, müssen Methoden gefunden, beschrieben und angewandt werden.

Um Ideen zu finden, Konstruktionsprobleme zu lösen oder Innovationen zu schaffen gibt es zahlreiche Methoden: Axiomatic Design, Quality Function Deployment, Robust Design, Methodisches Konstruieren, TRIZ, Value Engineering, etc.

In dieser Arbeit werden die gebräuchlichsten Methoden identifiziert, beschrieben und bewertet. Besondere Aufmerksamkeit kommt dabei der TRIZ-Methode zu (Theorie des erfinderischen Problemlösens).

Im Rahmen dieser Arbeit muss dabei ein Problem von einer bloßen Aufgabe unterschieden werden. Bei einer Aufgabe ist der Lösungsweg standardisiert und vorgegeben.

Um einen Methodenvergleich und eine Methodenauswahl in Abhängigkeit vom Problem zu ermöglichen, müssen Kriterien definiert werden: Diese Kriterien dienen dazu, die Methode den verschiedenen Phasen des Problemlösungsprozesses zuzuordnen und die Methodenleistung zu bewerten. Um die Methodenleistung auch problem-spezifisch bewerten zu können, müssen auch Kriterien zur Charakterisierung des Problems bestimmt werden.

In dieser Arbeit werden verschiedene Beispielp Probleme mit den Methoden gelöst, und dadurch die Methoden-Leistungsfähigkeit bewertet. Betont wird dabei der neue Ansatz, die Methodenleistung ausgehend von den Problemeigenschaften zu bewerten. Am Ende soll dem Konstrukteur eine Matrix zur Verfügung gestellt werden, welche die Stärken und Schwächen der Methoden veranschaulicht und eine gezielte Methodenauswahl ermöglicht.

Dadurch können auch neue Ideen für die Kombination verschiedener Methoden gewonnen werden.

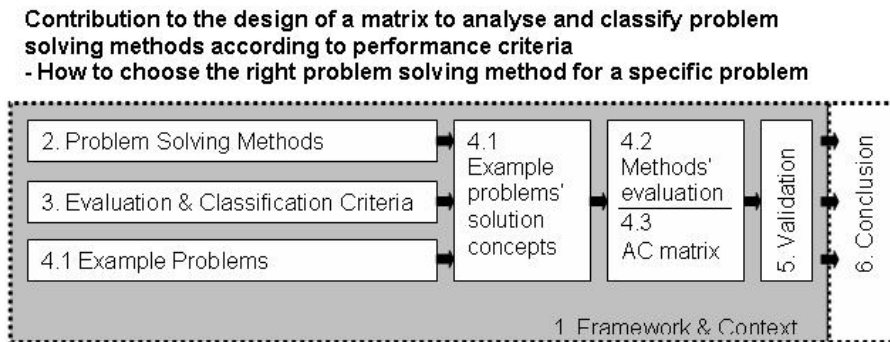
Das Konzept der Vergleichs- und Analysematrix wird zum Schluss durch ein Fallbeispiel bestätigt.

Dieser Bericht ist wie folgt strukturiert:

Nachfolgend wird in diesem Kapitel der Kontext dieser Arbeit präsentiert und es werden zentrale Begriffe erklärt. In Kapitel 2.1 werden die am häufigsten verwendeten Problemlösungsmethoden vorgestellt. Diese werden in Kapitel 2.2 den verschiedenen Phasen eines Innovations- oder Problemlösungsprozesses zugeordnet. In Kapitel 3 werden Kriterien zur Klassifizierung der Methoden vorgeschlagen. In Kapitel 4 wird die Vergleichs- und Analysematrix entwickelt. Dazu werden zuerst Beispielp Probleme gelöst. Die dabei gewonnenen Erkenntnisse führen - ergänzt durch eine Literaturrecherche - zur Klassifizierung der Methoden und zur Bewertung ihrer Eignung, ein bestimmtes Problem zu lösen. Den Abschluss des Kapitels bildet eine Darstellung der Matrix mit allen Ergebnissen.

Betrachtungen zur Gültigkeit des Konzeptes werden in Kapitel 5 an hand eines Validierungsbeispiels entwickelt.

Eine kurze Zusammenfassung und ein Ausblick beschließen in Kapitel 6 diese Arbeit.



1.2. **Keywords:**

innovation, problem solving methods, TRIZ, evaluation criteria, method comparison

innovation, méthodes à résoudre des problèmes, TRIZ, critères d'évaluation, comparaison des méthodes

Innovation, Problemlösungsmethoden, TRIZ, Bewertungskriterien, Methodenvergleich

1.3. ***On the necessity of an analysis and classification matrix – context of the work***

Sur la nécessité d'une matrice d'analyse et de classification – contexte du projet

Über die Notwendigkeit einer Analyse- und Klassifizierungsmatrix – Kontext der Arbeit

Enormous numbers of books have been written on hundredsⁱ of Problem Solving Methods (PSM), numerous conferences have been hold as well. But still application in industry to promote innovations and tackle intricate problems lacks.

Consultants may be hired to advice on innovation and problem solving techniques, see **Figure 1**, not necessarily leading to better problem solving performance or a better method choice.

ⁱ According to /102/ from the 1930s to the 1980s more than 300 innovation methods have appeared.



Figure 1: Consultancy wisdom /54/

So, what is the challenge when it comes to Problem Solving Methods? To answer this question, the elements involved in the problem solving process shall be regarded first.

■ Elements:

Knowledge: Knowledge, experience and know-how in a company or in a business sector are immense. To give good solution support, this knowledge has to be made accessible via methodology.

Method: A PSM is composed of various tools and suggests a course of action, i.e. a systematic approach in steps to develop a solution. To cover the whole process of problem solving in product development it is common practice to combine methods.

Tools: The tools to handle and treat the problem are in direct contact with the problem.

Men: Finally there are men acting as problem solver and the problem itself.

Each element and the interfaces in-between have some critical aspects. Those aspects determine current research activities on PSMs and the way to improve problem solving.

■ Ways of improvement:

Knowledge: The access to knowledge is incomplete. Even though it is impossible to give access to all existing knowledge, it can be improved, e.g. by the application of databases and knowledge management.

Methodⁱ: The method might be not powerful or unsuitable to solve a specific problem. Therefore either new methods are created, two existing methods combined or superⁱⁱ-methods developed, containing tools of various methods.

Tools: Tools lack solution strength. So tools are improved e.g. by adapting them to new economic demands or by integrating computer support.

ⁱ Definition of «method» according to www.webster.com: a way, technique, or process of or for doing something

ⁱⁱ "super" is meant in the sense of "hyper", without any intent to judge the method [German: Übermethode]