

13. Elementary Problem Analysis, Idea Generation, and Solution Invention

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 2013-0.5, 13-10-31
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- 1) Good Questions
- 2) Problem Analysis and Idea Generation
- 3) GAP Analysis (Generation, Assessment, Prioritization)
- 4) Assessment and Prioritization Methods
 - 1) Qualitative and Quantitative Analysis for Olympic and Efficiency Criteria
- 5) Complete Solution Processes

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- 3)
 - ▶ Mark Sh. Lewin's web page on problem analysis and solving: <http://www.mslevin.iitp.ru/>
 - ▶ Ritchey's book on Wicked Problems and GMA: Tom Ritchey. Wicked Problems – Social Messes. Decision Support Modelling with Morphological Analysis. Series: Risk, Governance and Society, Vol. 17. 1st Edition., 2011, Springer.
 - <http://www.springer.com/business+%26+management/technology+management/book/978-3-642-19652-2>

Obwohl ich diese Unterscheidungen nur zum Hausgebrauch mir zurechtgelegt habe, zur eigenen Orientierung in den verwickelten Erscheinungen meines Beobachtungskreises, muß ich hier doch ausdrücklich auf sie hinweisen, um die Gesichtspunkte meiner Ausführungen genügend erkennbar zu machen.

Ernst Abbe in Gesammelte Abhandlungen III
 Vorträge, Reden und Schriften sozialpolitischen und verwandten Inhalts
 Editor: S. Czapski
<http://www.gutenberg.org/1/9/7/5/19755/>



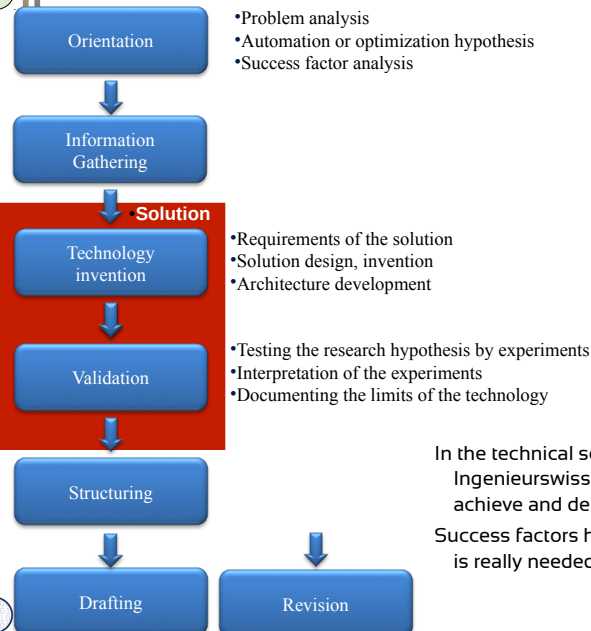
References

- 2)
 - ▶ [VanGundy-ProblemSolving] Arthur B. Van Grundy. Techniques of structured problem solving. Van Nostrand Reinhold Company, 2nd edition, 1988. The bible of problem solving techniques.
 - ▶ [Thiele] Albert Thiele. Die Kunst zu überzeugen. Faire und unfaire Dialektik. Springer.
 - ▶ [Leicher] R. Leicher. Verkaufen. TaschenGuide. Haufe-Verlag.
 - ▶ [Scherer] Hermann Scherer. 40 Minuten für eine gezielte Fragetechnik. Gabal Verlag
 - ▶ [deBono] Edward de Bono. de Bono's neue Denkschule. Kreativer denken, effektiver arbeiten, mehr erreichen. mvg-Verlag, München.
 - ▶ [Hill] Bernd Hill. Der Methodenbaukasten - Ein Kompendium von Methoden zur Erkennung und Lösung technischer Probleme. 2. erw. u. überarb. Aufl. [Taschenbuch bei amazon]
 - ▶ Rohrbach, Bernd: Kreativ nach Regeln – Methode 635, eine neue Technik zum Lösen von Problemen. Absatzwirtschaft 12 (1969) 73-76, Heft 19, 1. Oktober 1969.
 - ▶ Basili, V.R.; G. Caldiera, D. Rombach (1994). The Goal Question Metrics Approach. Encyclopedia of Software Engineering (Wiley).
 - ▶ O Nierstrasz. Identify the champion. Pattern Languages of Program Design, 2000. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.77.3459&rep=rep1&type=pdf>
 - ▶ Ziel-orientierte Projektplanung (ZOPP) from GTZ (Gesellschaft für technische Zusammenarbeit) www.gtz.de:
 - http://portals.wi.wur.nl/files/docs/ppme/ZOPP_project_planning.pdf
 - GTZ is a German society for development. ZOPP is a general-purpose project planning and requirements analysis method. Google for it....



Rept. The OIS-SDR Research Process for Technical Science Thesis

4) Phases of scientific text production, e.g., for technical papers or theses in a technical science.



How do I find a solution?
 How do I invent a technology?

In the technical sciences (engineering science, Ingenieurwissenschaften), a thesis must be technical, i.e., achieve and demonstrate a technical result. Success factors have to be analyzed to know whether a result is really needed

Eternal Problems While Inventing

- 5
- ▶ Edison tried more than 2000 different variants of the light bulb before he found a successful design in 1879
 - <http://www.shapell.org/btl.aspx?2718806>
 - ▶ You have written the literature review – but how to find a solution for your research problem?

Use systematic methods to speed up finding a solution

13.1 Good Questions

- [Thiele, Leicher, Scherer]

Invention and Problem-Solution Analysis

- 6
- ▶ Most often, such a problem-solution analysis will become part of the introduction of your report.
 - ▶ Inventing a technical solution for a problem, as required by technical science, is a difficult task.
 - ▶ Also, research should be relevant – how to find out?
 - ▶ Important is a problem solving method, such as
 - ZOPP (Ziel-orientierte Projektplanung)
 - B-POPP (problem-blocking-factor analysis)
 - GROW (goal analysis)
 - And several more.
 - ▶ These analyses help to focus the problem, develop goals for the work, find out success factors, and how to prove that the solution is working well.

... remember...

8 I keep six honest serving-men:

(They taught me all I knew)

Their names are What and Where and When

And How and Why and Who.

I send them over land and sea,

I send them east and west;

But after they have worked for me,

I give them all a rest.

I let them rest from nine till five.

For I am busy then,

As well as breakfast, lunch, and tea,

For they are hungry men:

But different folk have different views:

I know a person small--

She keeps ten million serving-men,

Who get no rest at all!

She sends 'em abroad on her own affairs,

From the second she opens her eyes--

One million Hows, two million Wheres,

And seven million Whys!

Rudyard Kipling „Just so stories“

<http://www.gutenberg.org/cache/epub/2781/pg2781.txt>

Instantiation of the The 6+1 Honest Men (7 W-Fragen) for specific Aspects or Problem Fields

- 9 ▶ [Thiele] shows that the 7-W questions must be instantiated for different purposes in form of checklists. E.g., for problem analysis, goal analysis different checklists result

| | Problems | Goals |
|-------------------------|---|---|
| Who? | Who is responsible to treat the problem? | Who has defined this Goal? Who benefits from achieving this goal? |
| What? | What is the real problem? What are the subproblems of the problem? | What are the subgoals of this goal? |
| How? | How does this problem affect us? How can we solve this problem? How can we delay the handling of the problem? | How will we achieve this goal? |
| Where? | Where did the problem occur? | |
| When? | In which situation did the problem arise? | When will we achieve this goal? |
| Why? | Why did the problem occur? | Why is it important? |
| What for? To which end? | What would a solution for the problem help us to achieve? What will happen if we don't solve the problem? | What will the achieved goal further enable? |

Different Types of Questions – Somewhat Critical for a Paper

- 11 ▶ **Mirroring questions** mirror the attitude of the dialogue partner.
- “So you think that this solution is not appropriate for your problem?”
 - “This means that you think that this is not your main problem?”
 - Mirroring questions transform statements into questions
 - “Our competitor is too expensive.” --> “Do you also feel that our competitor is too expensive?”
- ▶ **Suggestive questions** are rhetoric, that is, not real questions, but pseudo questions
- “Is it true that you are interested to simplify your production?”
 - Handle them with care, because they can create anger
 - Suggestive questions are dangerous, because they can make the reader angry
- ▶ **Positive questions:** try to avoid negative questions, make the dialogue partner answer “Yes”. They prepare other, open questions:
- “Are there any problems on your side?” --> “What happened?”

Different Types of Questions

- 10 ▶ **Open questions:** begin with who, why, when, which (the 7 W)...
- Motivatory
 - The asked person can talk afterwards... (collect-information phase)
 - Good for papers
- ▶ **Closed questions:** ask for a boolean value
- “Do you?” “Don't you?”
 - These questions force decisions and are to be answered by yes/no (commitment or conclusion phase)
 - Use rarely in papers!
- ▶ **Alternative questions** are to be answered by one of two alternatives
- “Would you prefer alternative A or B?”
 - “is a red or blue car better?”
- ▶ **Manouvring questions (Rangierfragen):** change the “playground”, i.e. the field of discussion – do avoid further discussion on a certain subject
- “What do you think, shouldn't we first talk about the background/side condition/cause/effects of this problem?”
 - “What do you think, how is problem X related with your problem?”
 - For dialectic, pivot paragraphs

Problem Questions are Good for Introductions

- 12 ▶ A **problem question** analyzes together with the dialogue partner (reader, listener, customer, etc.) his problems.
- Problem questions clear the mind of the dialogue partner
 - Show him the situation more clear
 - Create interest
 - Problem questions lead to ZOPP-like development schemes
 - Examples
 - “Which functionality is your product lacking?”
 - “Which problems do you have with the tool you use these days?”
- ▶ A **blocking-factor (hindrance) question** analyzes why an objective of the dialogue partner cannot be reached
- „What is disturbing with your supplier?”
 - “What are the obstacles to automate this function?”

State Questions for Setting the Scene in Introductions

- 13
- ▶ A **state question** asks the dialogue partner (customer) about his/her state of affairs
 - „How can I help you?“
 - „Which functions are you interested in?“
 - „With which supplier do you work these days?“
 - „How large is your budget?“
 - „How is the decision process?“
 - ▶ State questions are asked first, to enter the discussion
 - ▶ **State paragraphs (setting-the-scene paragraphs)** discuss a state question in the introduction, for setting the scene
 - ▶ A **summarization question** summarizes the results of the analysis and attempts to get the agreement with the customer about the analysis
 - ▶ For your summary or intro

Effect Questions (Auswirkungsfragen)

- 14
- ▶ An **effect question** analyzes together with the dialogue partner the effect of his problems and the consequences of his decisions. It opens a cause-effect analysis (CEA)
 - ▶ Effect questions are extremely important for selling something
 - Visualize the effects of the current situation to the customer
 - Look into the future
 - Highlight trends and developments
 - Bring the customer the insight that he must solve his problem
 - ▶ Examples for positive effects
 - „What is the significance of this problem with your supplier?“
 - Which other problems would this cure?
 - What should be changed to increase the effectivity of this tool?
 - What does the solution of your problem mean to the win/balance of your company?
 - ▶ Examples for negative effects
 - „What is the significance if this problem is not solved?“
 - Which other problems would result if this is not solved?
 - Supposed you leave it like it is, what would result?

Benefit Questions

- 15
- ▶ A **benefit question (usefulness question)** is a special type of effect question, highlighting a benefit to the dialogue partner.
 - „Which additional space could you win buying this new machine?“
 - „Which advantages will you get from introducing this new technology?“
 - „which group of people will benefit from this new technology?“ (Who)
 - Benefit questions are very important to find a selling argument, USP, or technical science hypothesis
 - ▶ **Olympic questions:** faster, higher, farer
 - “what do you gain with this method?“ “How far do you come with this?“ “How much faster are you?“
 - „How would the win of your company rise, given you buy this machine?“
 - ▶ **Efficiency questions:** How much better will it be?
 - “when will you be able to achieve turnaround with this method“
 - “what do you think about this simplification?“

The 6 Honest Men (7 W-Questions) Instantiated for Benefit Questions

- 16
- ▶ For finding a controlling idea of a text or talk, the 7-W-Questions should be tried to expand into a checklist. This checklist can be used to create alternatives for a technical science hypothesis or a controlling idea.

| | Benefit | Success factors |
|-------------------------|--|--|
| Who? | Who will benefit from solving this problem? | Who has defined this success factor? |
| What? | What is the real benefit of this solution? What is the cost? | What are the success factors to measure the achievement of this benefit? |
| How? | How do we increase the benefit of this solution? How is this benefit achieved? | How will we measure the success of this? |
| Where? | Where did the problem occur? | Where will we measure the success of this? |
| When? | | |
| Why? | Why do we need the benefit? | |
| For what? To which end? | Why do we need the benefit? What will happen if we don't solve the problem? | |

Effect and Benefit questions are very important because they lead to controlling ideas of texts and talks.

Exercise: Instantiate the 6 Honest Men for

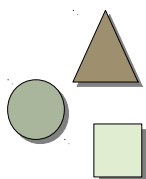
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- ▶ Summary Questions
- ▶ Olympic questions
- ▶ Efficiency questions



13.2 Problem-Objective Analysis (POA) for POPP (Problem-Objective-Oriented Project Planing) ZOPP (Ziel-orientierte Projektplanung)

Without problem-goal analysis no way to invention, to
technology nor to a scientific result.



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The Law of Paragraph Question and the Classes of Questions

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- ▶ Remember the Law of Paragraph Question
- ▶ Which class of question fits to your paragraph?
 - open? probably closed is hard to write about
 - Problem questions lead to problem description paragraphs
 - Summarizing questions to summaries
 - Alternative questions lead to a development scheme called comparison and contrast" (dialectic development)
 - Benefit questions are always nice
 - Effect questions lead to cause-effect development scheme

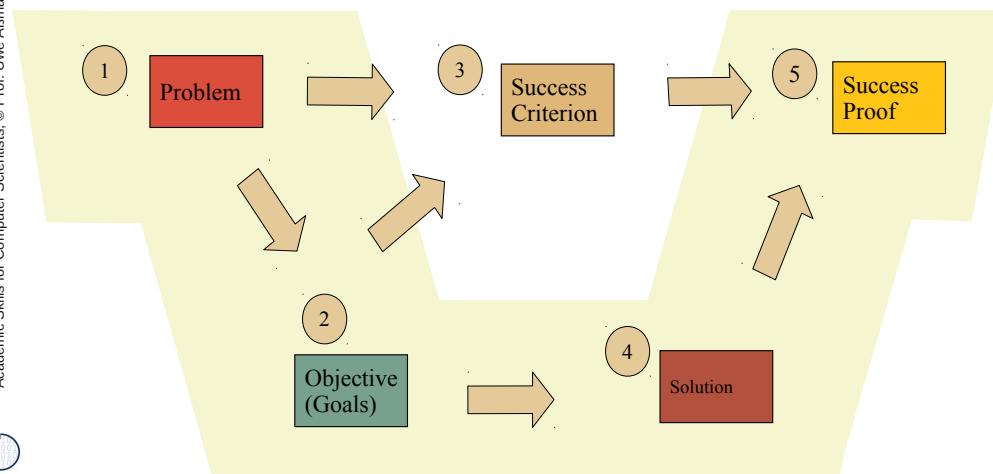


Law of Paragraph Question:
Never write a paragraph without an invisible question you answer in
the paragraph.

The Swiss Knife of Solving Problems: Problem and Objective Analysis POA for POPP

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- ▶ POA/POPP is a **goal-oriented problem-solving analysis and planning method** with success proof:
 - With a set of success criteria, it is checked whether the solution solves the problem
- ▶ Ubiquitous like the V-model



Exc.: Solving Some Practical Problems

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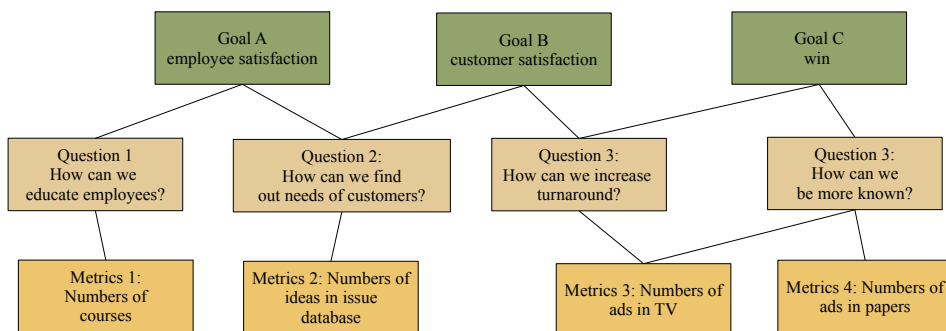
- ▶ "I am so lonely"
- ▶ "I am so hungry"
- ▶ "Germany has too many unemployed people"
- ▶ "Neonazis are a danger for democracy"



Goal-Question-Metric Approach (GQM)

23

- ▶ GQM [Basili/Rombach] is a special POPP method
- ▶ The original GQM approach uses a multi-bush (3-level multi-hierarchy) of goal level, question level and metric level.
 - Questions can be related to several goals
 - Metrics can be related to several questions
- ▶ Idea: Achieve the goals by answering questions with metrics
- ▶ Use the 6 honest serving men to generate questions



13.2.1 Goal-Question Metric



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Exc.: Solving Some Practical Problems with GQM

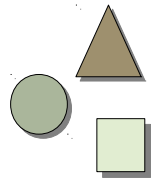
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- ▶ "I am so lonely"
 - Different goals may solve this problem, "have a beer in the evening", "marry in 12 months", "move into a Wohngemeinschaft"
 - Correspondingly, questions and metrics are different
- ▶ "I am so hungry"
- ▶ "Germany has too many unemployed people"
- ▶ "Neonazis are a danger for democracy"



13.2.2 Problem Analysis with Topic Fans (Themenfächer)

From [Esselborn-Krumbiegel]



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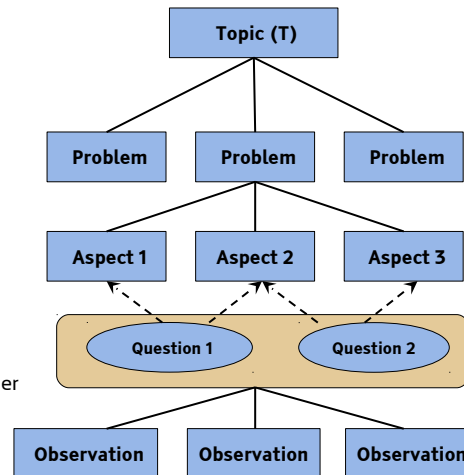
Find and Scope Topics with Topic Fans

- ▶ The topic fan method finds initial hypotheses for essays [Esselborn-Krumbiegel]
 - You may start the process of a paper with Topic Fans
 - It combines analyses the problems of a problem area, by asking problems about the problems.
- ▶ Objective:
 - Finding hypotheses for essays by a problem-aspect-question analysis of a topic (ToPAQO)
 - Analyzing texts and their topics
- ▶ Collection of aspects of the problem and related questions

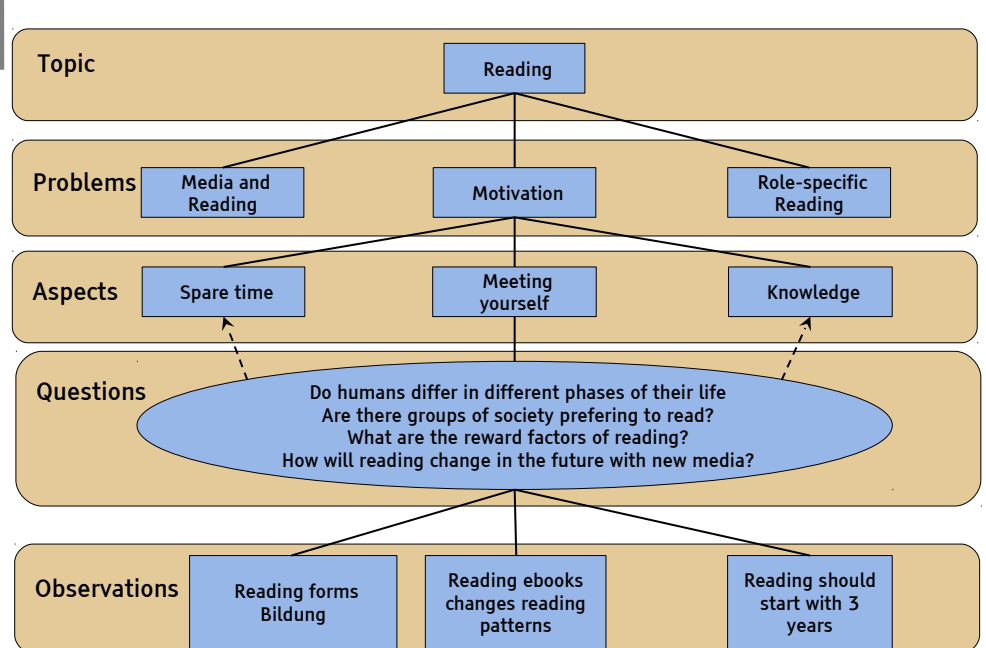
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Topic Fans with Problem-Aspect-Question-Observation Levels (ToPAQO)

- ▶ Topic (T)
 - related to the topic
- ▶ Problems (P)
 - related to the problems
 - related to the context of the investigation
- ▶ Problem-related Aspects (A)
 - related to the problems
 - related to the context of the investigation
- ▶ Questions (?)
 - Questions to one or several aspects
 - Interacting aspects
- ▶ Observations (O) as initial hypotheses
 - Potential answers to questions
 - Observations to questions
 - Initial assumptions or hypotheses for further research



Example: ToPAQO Topic Fan "Hypotheses about Reading"



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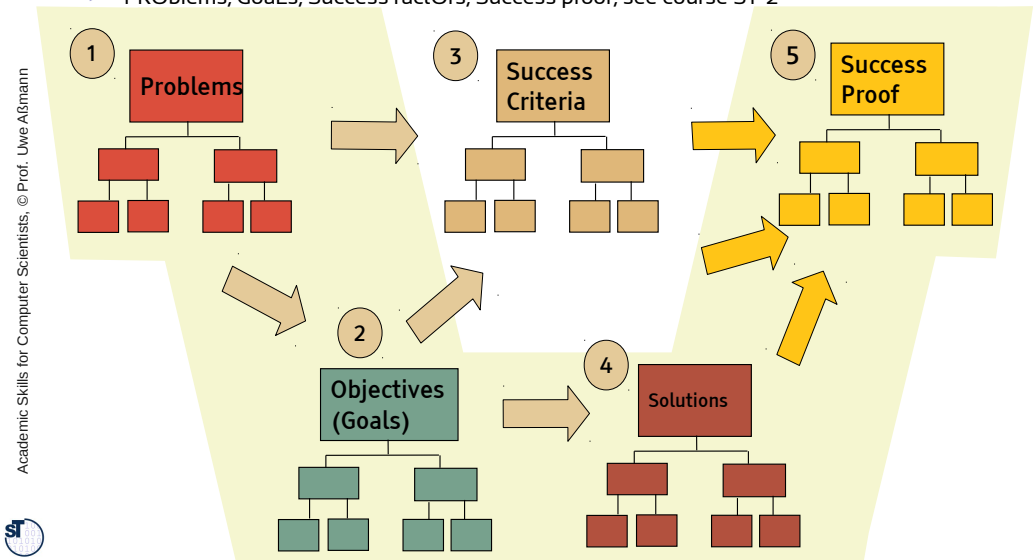


13.2.3 ZOPP and Others

Hierarchical Problem and Goal Analysis ZOPP

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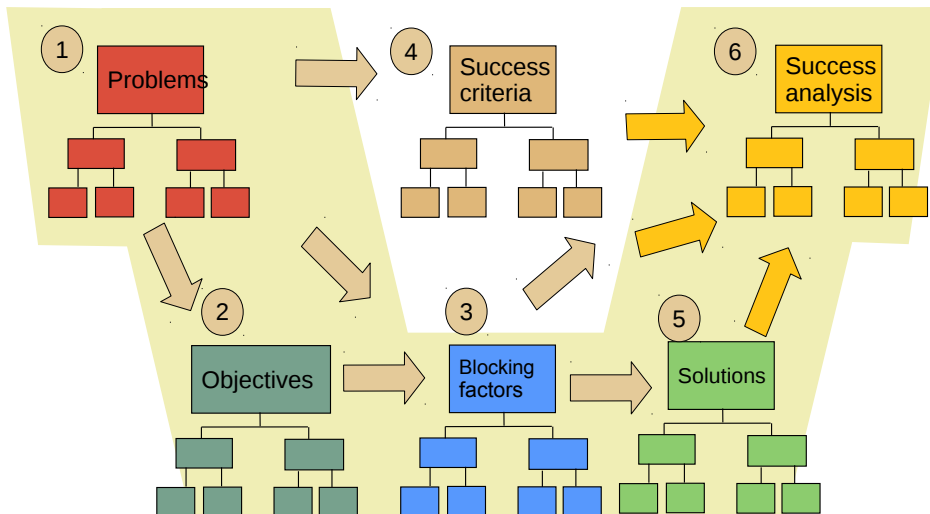
- ▶ ZOPP ("Ziel-orientierte Projektplanung") is a hierarchical goal-oriented problem-solving method with success proof, more general than GQM. Developed by GTZ, ubiquitous like the V-model
- ▶ PROblems, GoAls, Success factOrs, Success proof, see course ST-2



Hierarchical Problem and Goal Analysis B-POPP

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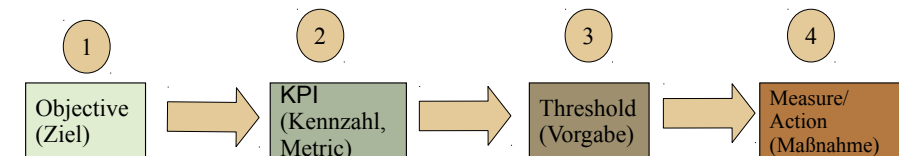
- ▶ Sometimes, it is possible to determine **blocking factors** preventing that the objectives are reached.
- ▶ B-POPP is a ZOPP-like problem and efficiency analysis that checks blocking factors preventing that objectives are reached.



KPI-POPP: Objective-Action Analysis with KPI (Kaplan/Norton)

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- ▶ KPI-POPP uses metric values (key performance indicators) to measure the quality of a solution
 - and tests with a threshold whether the goal is reached
- ▶ KPI-POPP automatically fulfils the SMART-criterion "Measurable"
- ▶ According to Kaplan/Norton it consists of 4 steps: [Objective → KPI (Kennzahl) → Threshold (Vorgabe) → Measure (Maßnahme)]
 - The steps can be hierarcally structured



POPP For Your Research

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- ▶ For all kinds of research: Bachelor, Master, PhD thesis, Research paper, Essay, Analysis study
 - ▶ Do a QQM, ZOPP, KPI-POPP, or a variant of B-POPP and refine it over all the duration of the research
 - ▶ Benefits:
 - If you do not solve a real problem, your research is not relevant
 - Goal analysis helps to think
 - Hierarchical goal analysis helps to focus on the more important issues
 - If your decomposition of the problem is good, you may say something about the *solution's coverage of the problem*:
 - Did I forget to solve a subproblem or are all problems solved? How complete is the solution?
 - Benefits for your reports
 - Usually a good ZOPP or B-POPP gives you an introduction for free: just write a paragraph or a section on each of the steps
 - In particular, the *research contributions (research results)* become very clear.
 - An entire report can be structured like ZOPP or B-POPP

Exercise:

- 34
- ▶ Repeat the paper "Zähmt den Kapitalismus" of Schmidt, and look at his arguments again.
 - ▶ Do a B-POPP with his article.
 - ▶ Did Schmidt really treat all problems?
 - ▶ Which of his problems are blocking factors?
 - ▶ Did he distinguish problems and goals?
 - ▶ Did he mention success factors?
- ▶ Rewrite the paper starting from your own B-POPP.
 - ▶ Write an introduction by writing a sequence of paragraphs:
 - background problem → technical problems
 - goals
 - blocking factors
 - success factors
 - solution, approach
 - success validation

Exercise with LaTeX

- 35
- ▶ a) Put B-POPP into a LaTeX template with comments marking up the parts

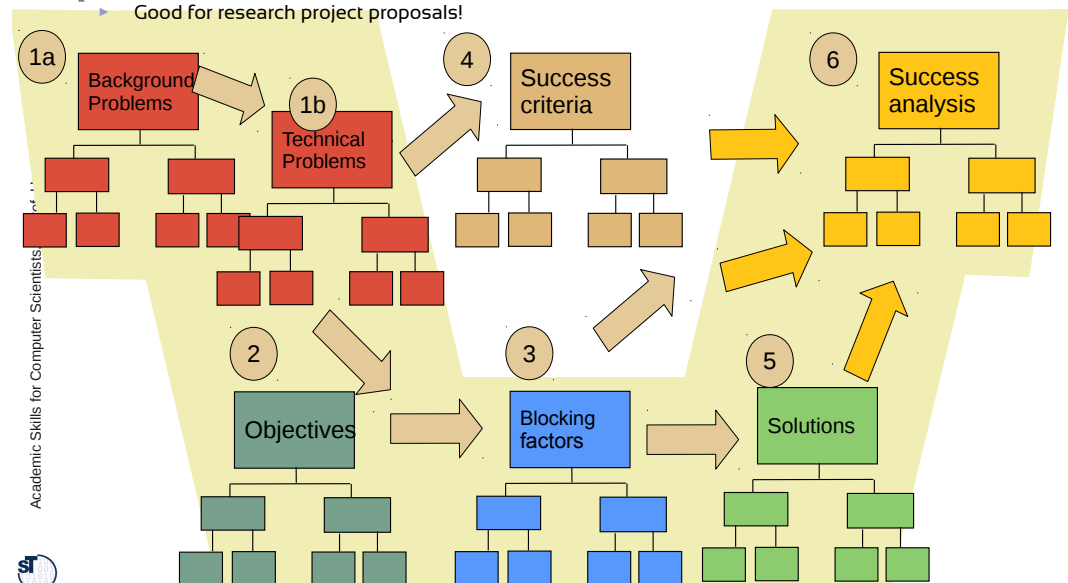

```
% problems
% objectives
...
% success analysis
```
 - ▶ b) Put B-POPP into a LaTeX style file, defining commands for your documents:


```
\def\problem#1{#1}
\def\objective#1{#1}
\def\blockingFactor#1{#1}
...
\def\successAnalysis#1{#1}
```
 - ▶ c) do the same defining LaTeX environments


```
\newenvironment\problemEnv{ }{ }
```

Improved BATE-POPP

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- ▶ For technology research, it is useful to split problems into **background** and **technical problems**
 - ▶ Background problems show economic, societal, ethical importance
 - ▶ Good for research project proposals!



Exercise

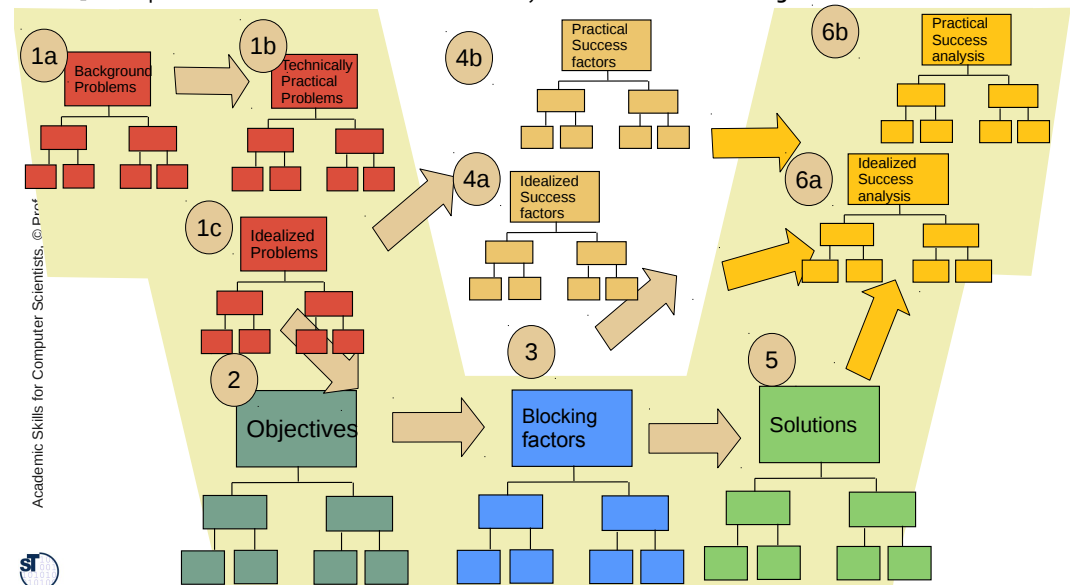
- 37
- ▶ a) Reanalyze Churchill's "Finest hour" speech, in particular the last concluding paragraph, with BATE-POPP.
 - Which goals does Churchill have?
 - Which questions does he derive from the goals?
 - What's the background, what's the technical problems?
 - What is the success factor? Is he giving a metrics?
 - ▶ b) Write a exposé for a Bachelor oder Master's or PhD Thesis with BATE-B-POPP.

Theorem Paper Outline of [Aßmann00] – How I Would Write It Today – with BATEID-POPP

- 39
- ▶ [Uwe Aßmann. Graph rewrite systems for program optimization. ACM Transactions on Programming Languages and Systems (TOPLAS), 22(4):583-637, June 2000.]
 - ▶ **General Background:** Inefficient software is costly for society.
 - ▶ **IT Background:** Construction of program optimizers is hard and costly, at least 1-3 person years are necessary. (economic problem)
 - ▶ **Technical problem:** Optimizers cannot be generated, there are diverse theories for single steps, but none is used for generation
 - ▶ **Goal:** generate optimizers from specifications to speed up development
 - ▶ **Blocking factors:** no uniform theory for model-driven development of program analyzers and transformers is available.
 - No theory can make it possible to shift analyses into transformations and vice versa
 - ▶ **Solution:** Use graph rewriting to specify optimizers
 - Definition: Use *edge-addition rewrite systems* to specify program analysis for reachability
 - Definition: Use *exhaustive graph rewrite systems* to specify transformation
 - Uniformity because everything is graph rewriting
 - Theorem: Use stratification to order complex rewrite systems, based on a rule dependency graph which allows for moving rules to other rule systems
 - Theorem on implementation: show that a specific algorithm avoids inefficient redex search (order algorithm)
 - ▶ **Success factors:** show the specification of several analyses and transformations
 - show the uniformity; show how the optimizer works; show how fast it is running; show optimization effectiveness
 - ▶ **Success proof:**
 - Mathematical proof of the theorems
 - Case studies of the implementation of the optimizer generator OPTIMIX

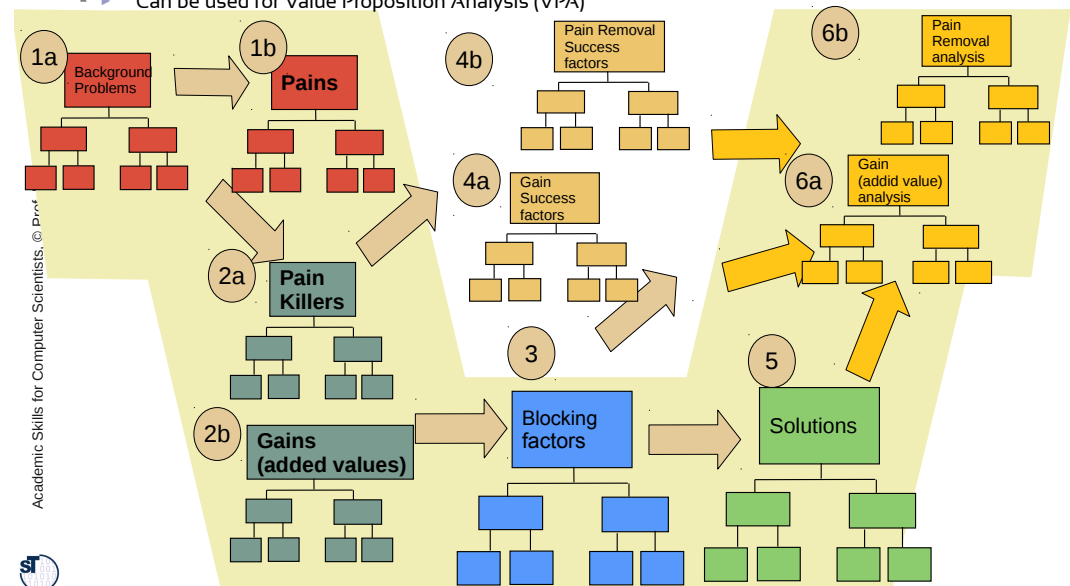
Improved BATEID-POPP for Theorem Papers

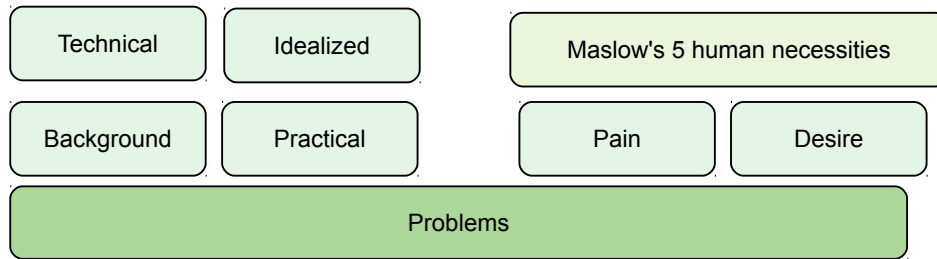
- 38
- ▶ For idealized research, it is useful to split problems into **background** and **technically practical**, and **idealized (model) problems**
 - ▶ Split also success factors and success analysis: This is called **funneling**



PainGain-POPP for Customer Analysis and Practical Research Papers

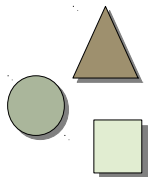
- 40
- ▶ Distinguish special hurting problems (**pains**) and special desired objectives (**gains**)
 - ▶ Distinguish objectives in **pain killers** and **gains (added values)**
 - ▶ Can be used for Value Proposition Analysis (VPA)





13.3 Generation of Ideas, Alternative Analysis, and Prioritization (GAP Analysis)

- [VanGundy-ProblemSolving]

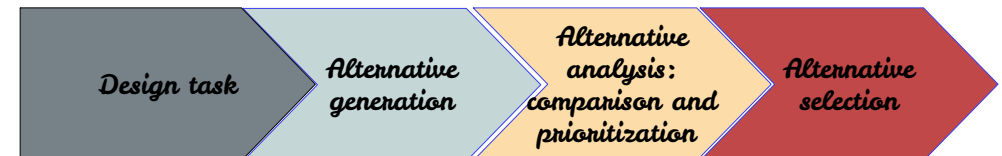


- ▶ 1) Write the introduction section of a
 - "Why adaptive software architecture can help to solve the German SmartGrid problem"
 - Use BATE-POPP
- ▶ 2) Write the introduction section of a theorem paper on
 - "Composition of finite real-time automata for driving trains in time"
 - see www.railcab.de and the research of Prof. Schäfer's group in Paderborn as inspiration
 - Use BATEID-B-POPP for idealized research
- ▶ 3) Write the outline of a research project proposal for a funding agency, such as EU or DFG, with BATE-POPP
 - "Service robots for helping elderly people in their home"



Motivation: How to Develop Your Chapter on "Design" or "Architecture" in your Bachelor/Master Thesis

- ▶ In a **design phase** of a thesis, not only one design should be investigated, but several alternatives
 - They should be compared, assessed and documented in the report (alternative analysis)
- ▶ Technical science motivates the selection of a best technology according to assessment criteria
- ▶ Your work is not scientific if you just choose the first solution and do it



Generation of Prioritized Lists with GAP

- 45
- ▶ For assessments and analyses of ideas, problems, solutions, risks, etc
 - ▶ For alternatives if difficult decisions have to be taken
 - ▶ For example: What do I do if I have a research goal, but no research problem?

Generation
(Identification,
Elicitation)

Assessment
(Rating, Scoring,
Grading)

Prioritization
(Ordering,
Selection)

Thinking
Clustering
7-W questions
Structure Trees
Brainwriting
Brainstorming
Delphi-Studies
Checklists

Isolated Assessment
and Grading

Metrics (on scales)
onedimensional
multidimensional

Comparative Assessment
and Selection

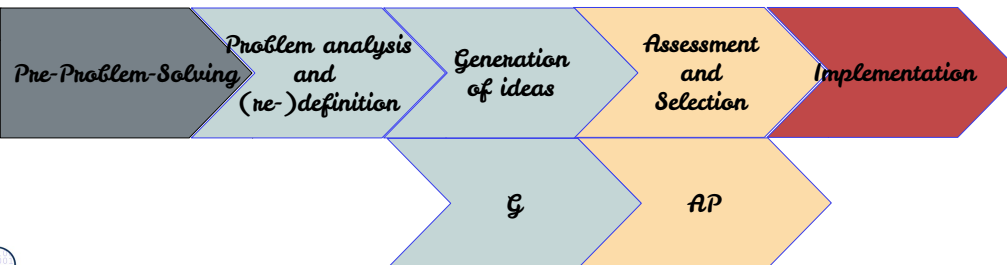
single-criteria analysis
multi-criteria analysis
and optimization

Scientific Aspect of GAP for Design Chapters of Final Theses

- 46
- ▶ For a problem of technical science, usually, several designs exist (tool and software architectures, etc)
 - ▶ Though one design must be selected, the alternatives should be
 - G: generated (invented, developed, documented)
 - A: assessed (evaluated individually)
 - P: prioritized (evaluated individually), ordered and selected
 - ▶ A good design chapter discusses several alternatives and why the chosen design is the best!

Embedding of GAP in the VanGundy Problem-Solving Process

- 47
- ▶ [VanGundy, Kap.2] shows how to combine GAP with problem analysis
 - ▶ This book has *many* techniques, both for individual and group processes



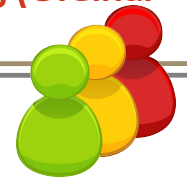
Variation and Extension Method for GAP Analysis

- 48
- ▶ **Variation Method about Variability Analysis** [Hill, Zwicky]
 - In a basic solution, try to **find variables (variation points)** which might be changed. In specifications or designs, the variables are called *variation points*
 - Analyze their range: which values may they take?
 - Change the variables
 - Build variant solutions
 - ▶ **Extension Method, Extensibility analysis**
 - In a basic solution, try to find *variables* which might be *extended*. In specifications or designs, the variables are called *extension points*
 - Analyze their range
 - Extend the variables
 - Build variant solutions

13.4 Assessment and Prioritization Methods

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Prioritization with Simple Numeric Grading (Ordinal Scales)



50

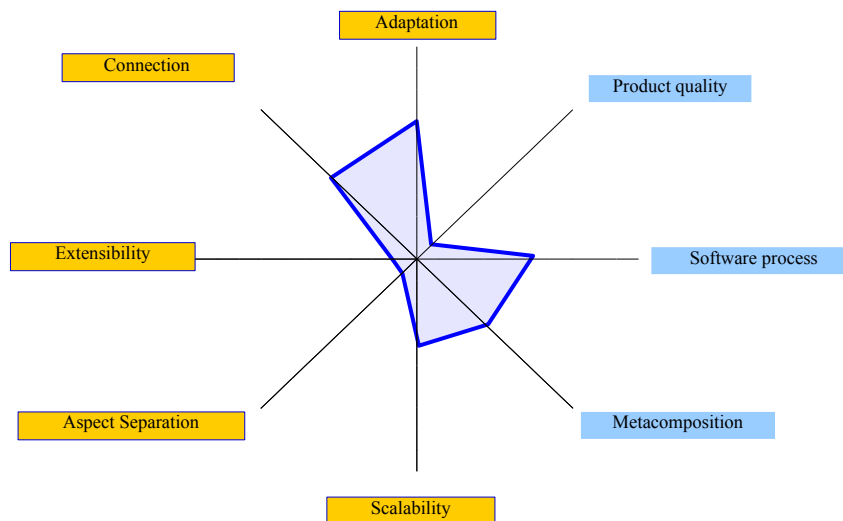
- ▶ **Traffic lights:** Valuate with red, green, blue
- ▶ **School grades:** Assessment with 5 points
- ▶ **"American Women" Method:** Assessment with 10 points
 - Advantage: multiply school grades by 2 => American Women Method
- ▶ **"Abi-grading":** Assessment with 15 points
 - Advantage: multiply school grades by 3 => Abi-grading
- ▶ **"Percent grading":** express the adequateness as a quotient of value and whole (20%, 81%, 2/3, 1/3, etc)
- ▶ **"Factor scaling":** express the adequateness by a real number between 0 and 1 (e.g., stochastic or probabilistic grading)
- ▶ **"Identify the Champion"** for taking an explicit standpoint and forcing of decisions (Oscar Nierstrasz)
 - A: I will fight for it
 - B: I am in favor, but I will not fight for it
 - C: I am against, but I will not fight against it
 - D: I will fight against it

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[Hill]

Multi-Criteria Attribute Analysis with Kiviat-Graphs

- 51
- ▶ A **Kiviat-Graph** draws a vector from an n-dimensional space into the plane.
 - ▶ It visualizes a multi-criteria analysis



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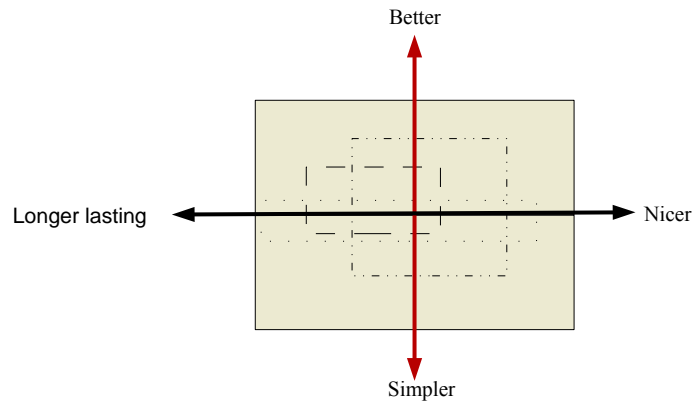
Olympic Evaluation Questions and Efficiency Evaluation Questions

- 52
- ▶ Approaches, ideas, and solutions can be evaluated with regard to
 - Olympic criteria (faster, higher, farer) or
 - Efficiency criteria (cost vs utility)
 - (see types of questions)

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Olympic Assessment with BeNeSiLo – Which Progress are we interested in?

- 53
- ▶ **BeNeSiLo** is a 4-D attribute analysis (olympic), measuring progress qualitatively or quantitatively (Better, Nicer, Simpler, LongerLasting)
 - ▶ Enter your own technology and competitors into BeNeSiLo for qualitative or quantitative olympic analysis
 - ▶ **Qualitative comparison:** without scales
 - ▶ **Quantitative comparison:** with scales (e.g., ordinal)



Exercise: Comparing Sort Algorithms with Kiviat

- 55
- ▶ Take up your olympic BeNeSiLo analysis for comparison of sort algorithms
 - ▶ Construct a Kiviat graph with the dimensions:
 - Speed (complexity)
 - Average speed (average complexity)
 - Memory consumption
 - Energy consumption
 - ▶ Draw several sorting algorithms into the axes of the Kiviat graph

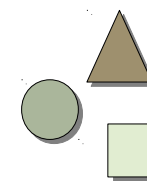


Exercise: Comparing Sort Algorithms

- 54
- ▶ Sorting is a well researched field of algorithmics
 - ▶ Do a BeNeSiLo analysis for comparison of sort algorithms
 - ▶ Look for comparing papers of sort algorithms
 - ▶ Compare according to the criteria:
 - Speed (complexity)
 - Average speed (average complexity)
 - Memory consumption
 - Energy consumption
 - ▶ Draw several BeNeSiLo cross diagram and comment it with a text



13.4.1 Quantitative and Qualitative Comparisons for Olympic and Efficiency Success Criteria



"Magic Rectangle" of Objectives

- 57
- ▶ Many research problems in technical science deal with **benefit (utility) or cost (resource consumption)**
 - ▶ An **olympic research problem** is about increasing benefit or reducing cost
 - ▶ Others are **efficiency problems**: increase benefit while reducing cost
 - ▶ These are related to **olympic or efficiency goals**

Benefit dimension: Utility

Quality

Quantity

Cost dimension: Resources and Time

Time: Deadlines, being early

Cost: Resource consumption
Money consumption

Eternal Questions in Solution Assessment

58

Cost dimension:
Resources and Time

Time: Dates, Duration

Cost: Money, Resources

Benefit dimension:
Quality and Quantity

Quality

Quantity

Legende:

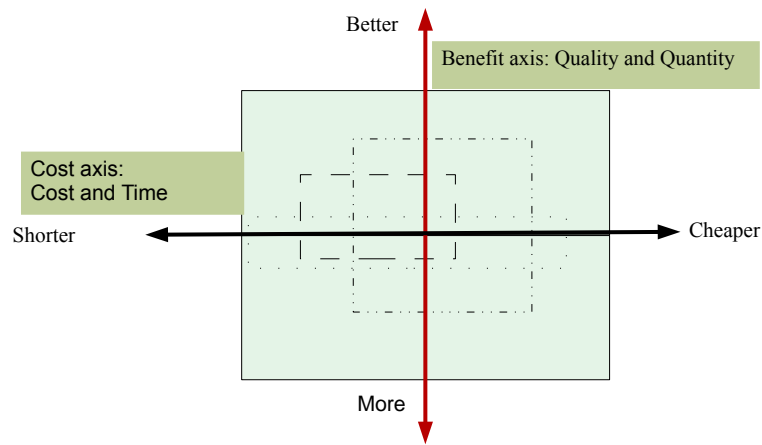
⊕ = Verbesserung

⊖ = Verschlechterung

Quelle: [Jenny, Projektmanagement S. 292]

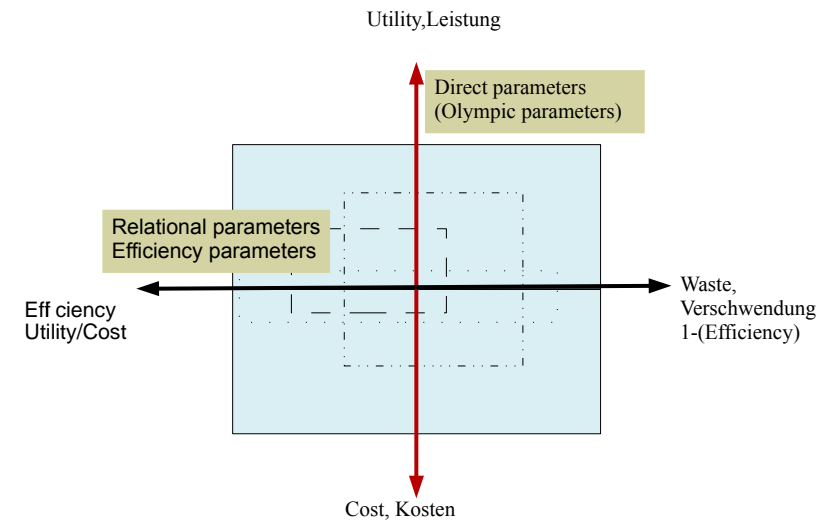
Efficiency Analysis (Cost-Benefit Analysis) with CoBit How Efficient is our Technology?

- 59
- ▶ **CoBit (Cost-Benefit Analysis on Cost, Time, Quantity, Quality)** is a special 4-D analysis on cost and benefit axis, comparing different technologies for *efficiency*
 - Larger areas mean *better efficiency*
 - ▶ Enter your own technology and competitors into CoBit for qualitative or quantitative analysis



Olympic and Efficiency Analysis Combined with UCEW: How Olympic and Efficient is our Technology?

- 60
- ▶ **UCEW** is a 4-dimensional attribute analysis comparing *efficiency* of a product, process, service, research result, technique, method
 - ▶ based on *olympic, direct* parameters (utility, cost) and indirect relations (efficiency, waste)



13.4.4 Advance Analysis - Comparisons for Approaches with Regard to Success Criteria

- Advance analysis compares a set of approaches in the literature with regard to some success attributes/criteria/factors.
 - These criteria may stem from a literature analysis or classification.
 - The comparison is usually multi-criteria.
 - Display with tables, riviati, or portfolios.
 - Qualitative (boolean) or quantitative (scales)

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Ex.: Boolean Advance Analysis

- Boolean values in the multi-criterion analysis

| | Approach 1 | Tool 2 | Technology 3 | My approach |
|---------------|------------|---------|--------------|-------------|
| Criterion 1 | no | no | no | yes |
| Criterion 1.2 | may be | yes | no | yes |
| Criterion 1.3 | no | unclear | yes | yes |
| Criterion 2 | yes | yes | no | yes |
| Criterion 3 | yes | no | no | yes |

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Ex.: American Woman Advance Analysis

- A "American Woman Comparison table" lists several approaches with grades 1-10 in the multi-criterion analysis, indicating the best approach
- For an advance analysis, you have to compare your own approach with all others
- Ex. Scientific evaluation of Papers: Papers are often evaluated with American Woman Analysis according to multiple criteria, e.g., Innovation depth

| | Approach 1 | Tool 2 | Technology 3 | My approach |
|--------------------------|------------|--------|--------------|-------------|
| Technical quality | 5 | 3 | 9 | 7 |
| Innovation depth | 3 | 3 | 7 | 8 |
| Presentation quality | 6 | 4 | 8 | 7 |
| Validation quality | 7 | 2 | 7 | 9 |
| Practicality | 8 | 3 | 10 | 7 |
| Expert level of Reviewer | 10 | 7 | 8 | 9 |

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Ex.: School Grade Analysis for Student's Theses

- German Grades 1-5 in the multi-criterion analysis, with 1/3 steps, or equivalently Abi-School grades:
- 0.7 (15 – not handed out), 1.0 (best, 14), 1.3 (13), 1.7 (12), 2.0 (11), 2.3 (10), 2.7 (9), 3.0 (8), 3.3 (7), 3.7 (6), 4.0 (5), 5.0 (4, 3, 2, 1, 0)
- For theses in Assmann's group, 3 Groups of Criteria exist: technical, presentation, and process quality

| | Approach 1 | Tool 2 | Technology 3 | My approach |
|----------------------|------------|--------|--------------|-------------|
| Technical quality | 12 | 4 | 3 | 12 |
| Presentation quality | 14 | 5 | 10 | 12 |
| Process quality | 12 | 8 | 8 | 11 |

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Ex.: Weighted School Grade Analysis for Student's Theses

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- ▶ Weight factors scale the absolute grades in ordinal scale

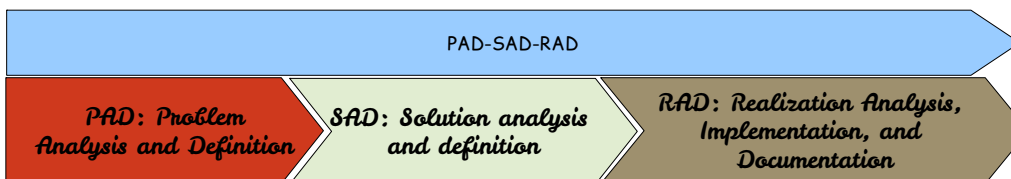
| | | Approach 1 | | Tool 2 | | Technology 3 | | My approach | |
|----------------------|------|------------|-----|--------|-----|--------------|-----|-------------|-----|
| Technical quality | 0.45 | 12 | 5.5 | 4 | 1.8 | 3 | 1.4 | 12 | 5.5 |
| Presentation quality | 0.2 | 14 | 2.8 | 5 | 1 | 10 | 2 | 12 | 2.2 |
| Process quality | 0.25 | 12 | 3 | 8 | 2 | 8 | 2 | 11 | 2.8 |



Complete Solution Processes

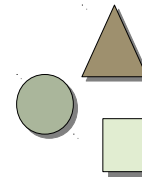
67

- ▶ For your Master's thesis, you need a complete solution process
- ▶ In general, there are three steps
 - PAD: Problem analysis and definition
 - SAD: Solution analysis and design
 - RAI: Realization Analysis, Implementation, and Documentation
- ▶ ARGESI, SPALTEN, and DesignThinking are fantastic solution processes for your Master's thesis
- ▶ For a PhD thesis, they have to be iterated several times



13.5 Complete Problem Solving Processes (PAD-SAD-RAD)

- A **problem solving process PSP** is a structured process to solve problems
 - Problem analysis and definition (PAD)
 - Solution design: generation, evaluation and selection (SAD)
 - Realization analysis, Implementation, and Documentation (RAD)

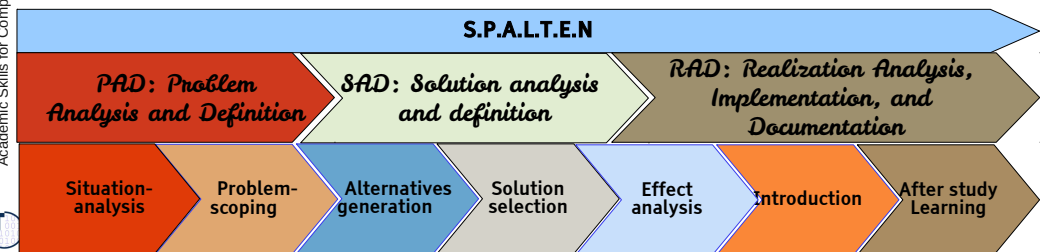


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S.P.A.L.T.E.N. is a Solution Process with Assessment of Multiple Solutions

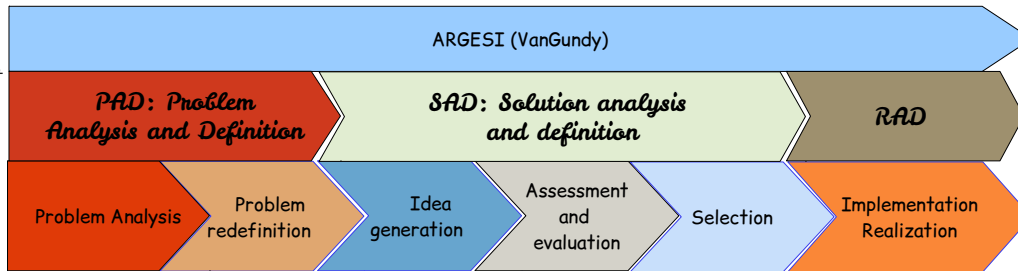
68

- ▶ SPALTEN is a problem solving process combining a GAP with a realization process
Steps: [Wikipedia/Problemlösen]
 - PAD: Problem analysis and definition:
 - Situation analysis (Ist-Analyse)
 - Problem analysis (demarcation, scoping, identification)
 - SAD: Solution analysis and design with idea generation, evaluation and selection:
 - Alternative generation (ideation, solution identification and generation)
 - Evaluation (Assessment)
 - Selection (Prioritization)
 - RAD: Realization Analysis, Implementation, and Documentation
 - Effect, risk and consequence analysis
 - Introduction (measures and processes)
 - After study and learning, documentation



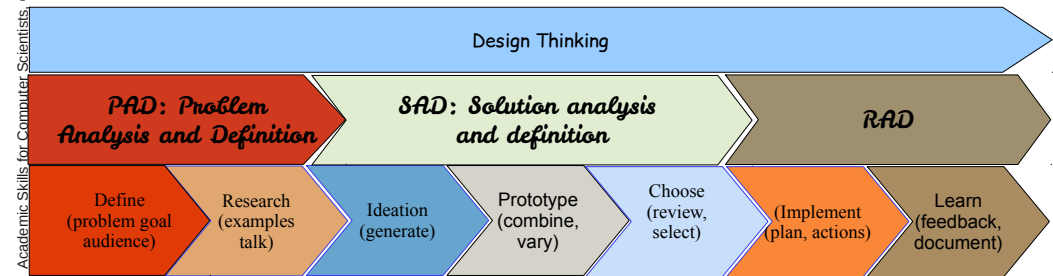
Problem Solving with VanGundy Problem Solving Method

- 69
- ▶ [VanGundy-ProblemSolving] contains a structured, very general process to solve structure problems: ARGESI
 - Problem analysis and Redefinition
 - Generating Ideas
 - Assessment and Evaluation of Ideas
 - Selection of ideas
 - Implementation and Realization



"Design Thinking" is a Solution Process with Assessment of Multiple Solutions

- 70
- ▶ http://en.wikipedia.org/wiki/Design_thinking
 - ▶ Similar to SPALTEN



Write a Project Plan (GANTT) for the Solution Process of Your Next Project

- 71
- ▶ ARGESI, SPALTEN, DesignThinking are fantastic solution processes for your Master's thesis
 - Write a project GANTT chart
 - Estimate weeks for every phase
 - What would you prefer for your Master's thesis?
 - ▶ For a PhD thesis, they have to be iterated several times

Why Do We Need Problem and Solution Analysis

- 72
- ▶ Solution processes organize your work systematically
 - make you much faster!
 - ▶ ZOPP and other POPP methods are extremely valuable
 - to organize your thoughts
 - to write introductions
 - to guide a reader the work, or your defense talk
 - ▶ GAP is important for finding solution ideas
 - ▶ Olympic and efficiency comparisons are very important for
 - comparing your work to others
 - selecting the *best* ideas
 - showing other people why they are best

Exercises

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Homework – The Weekly Schmidt

74

- ▶ Read the essay - "Innovationen sichern den ökonomischen Erfolg". (1996)
- ▶ Analyze the problem-goal analysis of Schmidt by trying to relate all points to a BATE-POPP.
 - Which problems does Schmidt identify? Which super-, which subproblems?
 - Which problems are background problems? Which ones are technical problems (problems economical politics can influence)?
- ▶ Write from the BATE-POPP an outline of a new essay, your own analysis.

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Homework – The Weekly Churchill

- 75 ▶ Read first Winston Churchill's speech "Never despair".
 - <https://www.winstonchurchill.org/learn/speeches/speeches-of-winston-churchill/1946-1963-elder-statesman/102-never-despair>
- ▶ Analyze the problem-goal analysis Churchill presents to the house of commons about the atomic and the hydrogen bomb.
- ▶ Do a BATE-POPP yourself, ordering the problems and goals by decomposition and subordination. Find out blocking factors and success factors.

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A.1 Association-Based Generation

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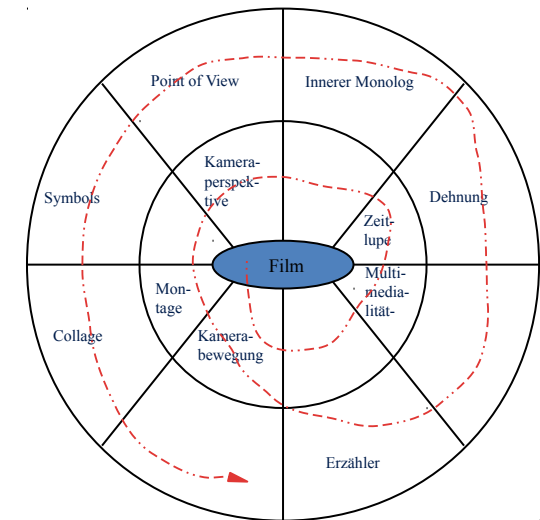
Analogy Spiral (Analogierad)

- 77
- ▶ **Objective:** Find relations and connections between aspects of a concept
 - ▶ **How To:**
 - Order associations in a set of *rings* or spirals
 - Find similar associations to the already fixed concepts
 - ▶ **Advantage:**
 - Every ring has a certain abstraction level
 - All entries of a ring are associated again with corresponding concepts on another ring, i.e., abstraction level

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Example: Analogy Spiral "Film"

- 78
- ▶ Find out structural features (Merkmale) of film and novel
 - ▶ Recognize and associate similar and typical features
 - ▶ Go round in a spiral from inside to outside
 - ▶ Associate concepts and features more and more concrete and detailed



Ex. Analogy Spiral

- 79
- ▶ Analyzing features of concept "control flow graph"
 - ▶ Mario Friske. Strukturelle Testabdeckung funktionaler Spezifikationen subs.emis.de/LNI/Proceedings/Proceedings133/gi-proc-133-036.pdf



Abbildung 3: Übertragung struktureller Merkmale von Kontrollflussgraphen auf funktionale Spezifikationen mithilfe eines Analogierades