11. The ADED Research Process - From the Idea to the Text of a Paper or Thesis

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http://st.inf.tu-dresden.de/teaching/asics

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Literature

- **Hubert Österle, Boris Otto.** A Method For Consortial Research. Report No. BE HSG/ CC CDQ/ 6, University of St. Gallen
  - http://works.bepress.com/hubert_oesterle/196/
- **Helga Esselborn-Krumbiegel**. Von der Idee zum Text.
Eine Anleitung zum wissenschaftlichen Schreiben:

  3. überarbeitetete Auflage, 2008. http://schreibzentrum-koeln.de/
- **Joseph Novak.** The Theory Underlying Concept Maps and How To Construct Them. IHMC, Techreport, 2002.
  - http://cmap.ihmc.us/docs/theory-of-concept-maps
- **Alan Bundy**. How to Write an Informatics Paper. Web page:
  - http://homepages.inf.ed.ac.uk/bundy/how-tos/writingGuide.html
- **Matti Tedre.** Know your discipline: Teaching the philosophy of computer science. Journal of Information Technology Education (JITE), 6:105-122, 2007.
- **Prof. Mary Shaw** from CMU has a lot of good material on Software Engineering Research. http://spoke.compose.cs.cmu.edu/ser04/

Goals of this Chapter

- Give you an overview of the research process, e.g., of research paper or a Bachelor, Master's thesis, or PhD thesis
- Illustrate the process with some example methods.

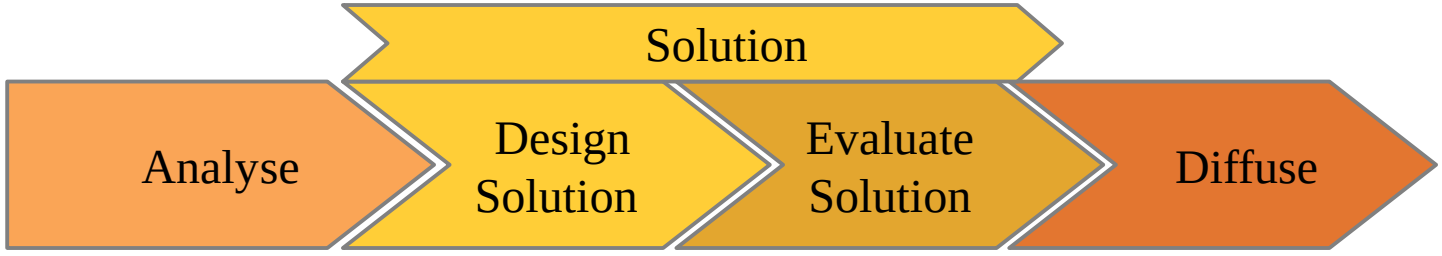
11.1. The ADED Research Processes

Inspired from [Österle/Otto] and [Esselborn-Krummbiegel]

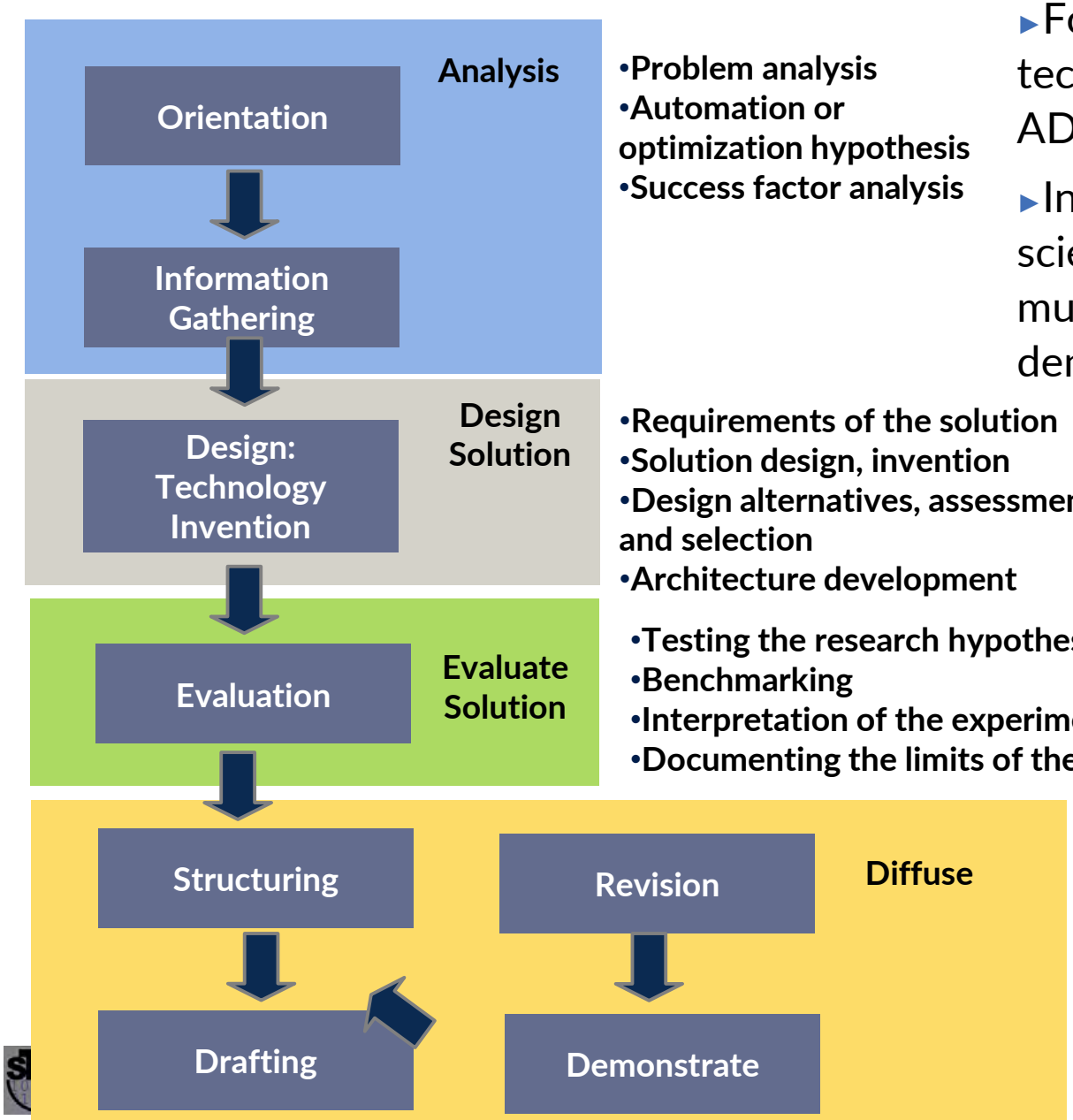
DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Standard Research Process ADED [Österle/Otto]

- [Hubert Österle, Boris Otto. A Method For Consortial Research. Report No. BE HSG/ CC CDQ/ 6, University of St. Gallen http://works.bepress.com/hubert_oesterle/196/]
- **Analyse** existing technologies, literature, background, problems
- **Design** new technologies (new solution)
  - Think, brainstorm, generate ideas
  - Research and develop
- **Evaluate** technologies (new solution)
  - Show why the new technology is superior; use success criteria
- **Diffuse (publish and demonstrate)**
  - Demonstration for creating vision
  - Popularize (position) your research results
  - „visible scientist“



The ADED Research Process for Technical Science Thesis



- Problem analysis
- Automation or optimization hypothesis
- Success factor analysis

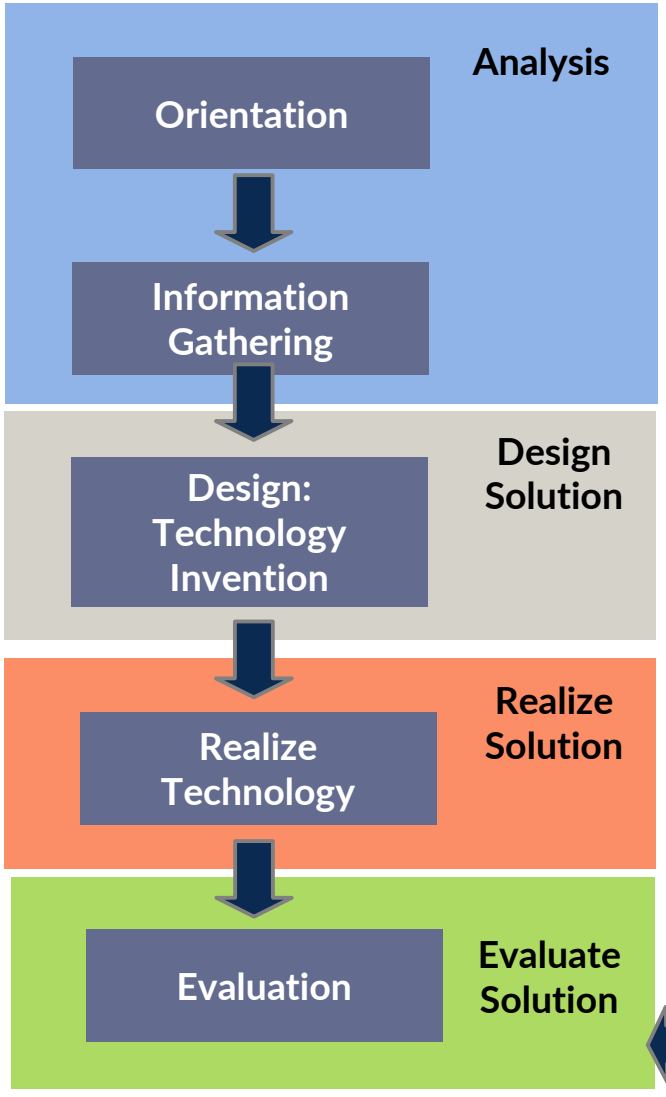
- Requirements of the solution
- Solution design, invention
- Design alternatives, assessment and selection
- Architecture development

- Testing the research hypothesis by experiments
- Benchmarking
- Interpretation of the experiments
- Documenting the limits of the technology

Diffusion of the technology by writing: a design pattern, a report by demonstrating a software prototype

- For a technical science thesis or for technical papers, an evaluation phase as in ADED is necessary.
- In the technical sciences (engineering science, Ingenieurswissenschaft), 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

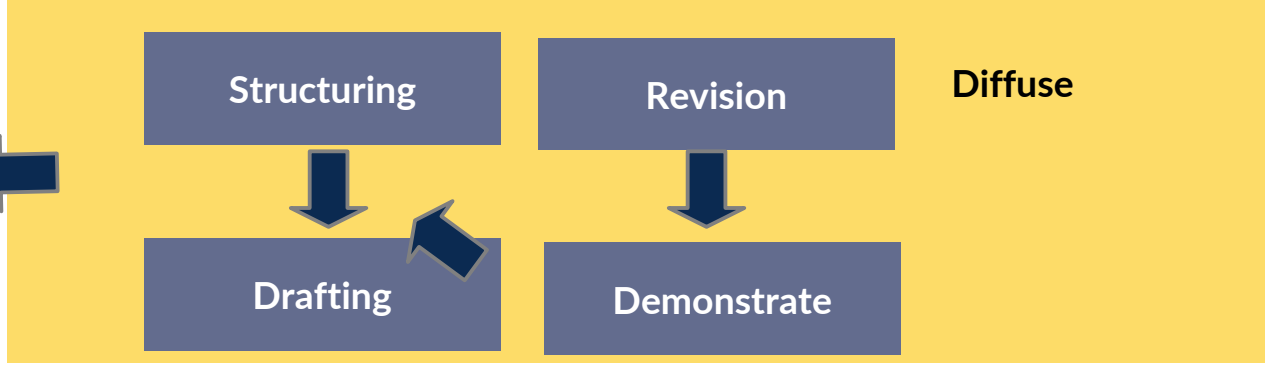
The AD-R-ED Research Process for Technical Science Thesis



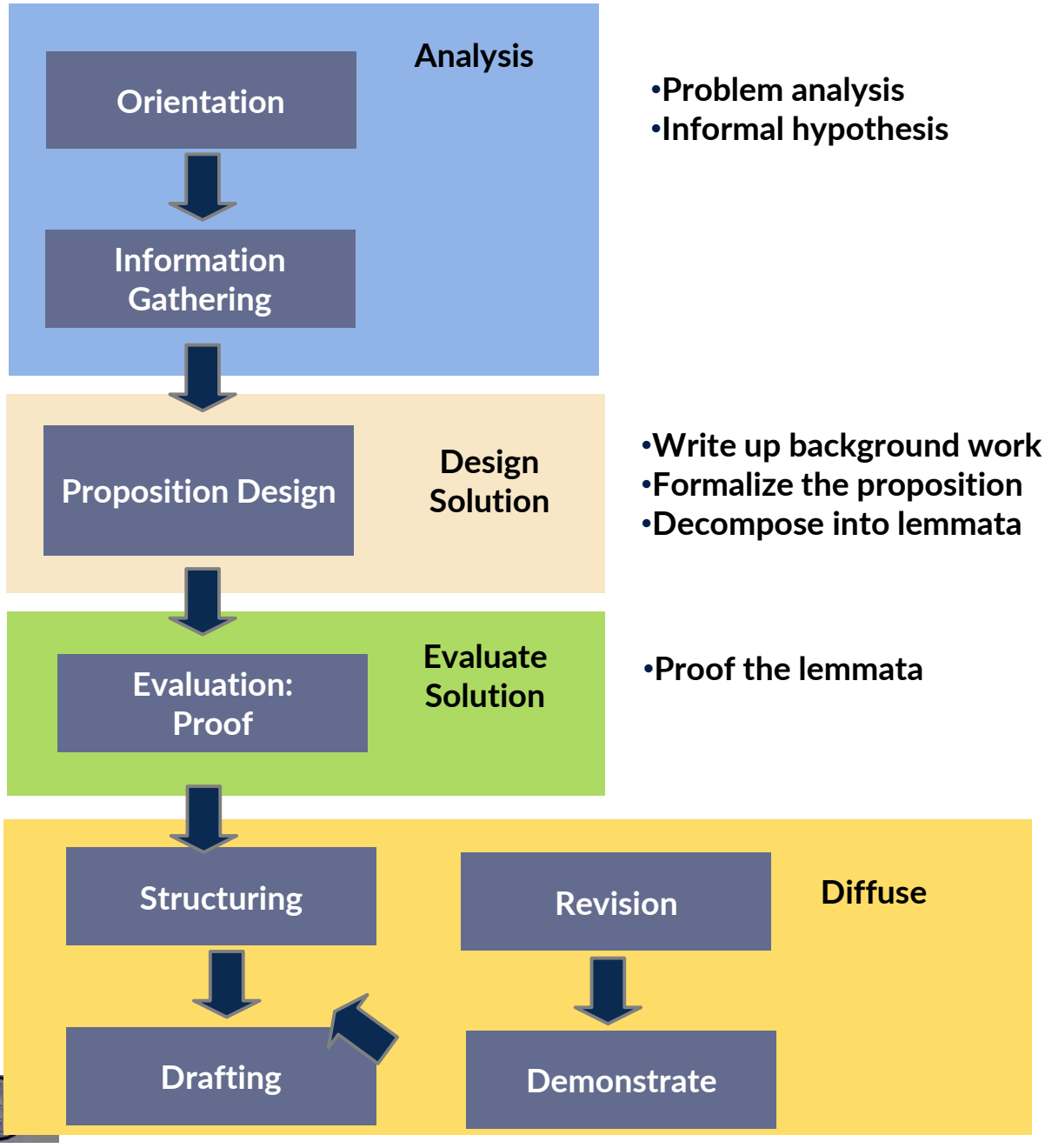
- For technical science, in particular software engineering, a ***realization phase*** is required so that evaluation can take place

- **Requirements of the solution**
- **Solution design, invention**
- **Design alternatives, assessment and selection**
- **Architecture development**

- **Realize the architecture (implement components)**
- **Tune the system**
- **Stabilize the system for better quality (non-functional requirements)**



The Variant A-PP-ED Research Process for Mathematical/Structural Science Thesis



- **Problem analysis**
- **Informal hypothesis**

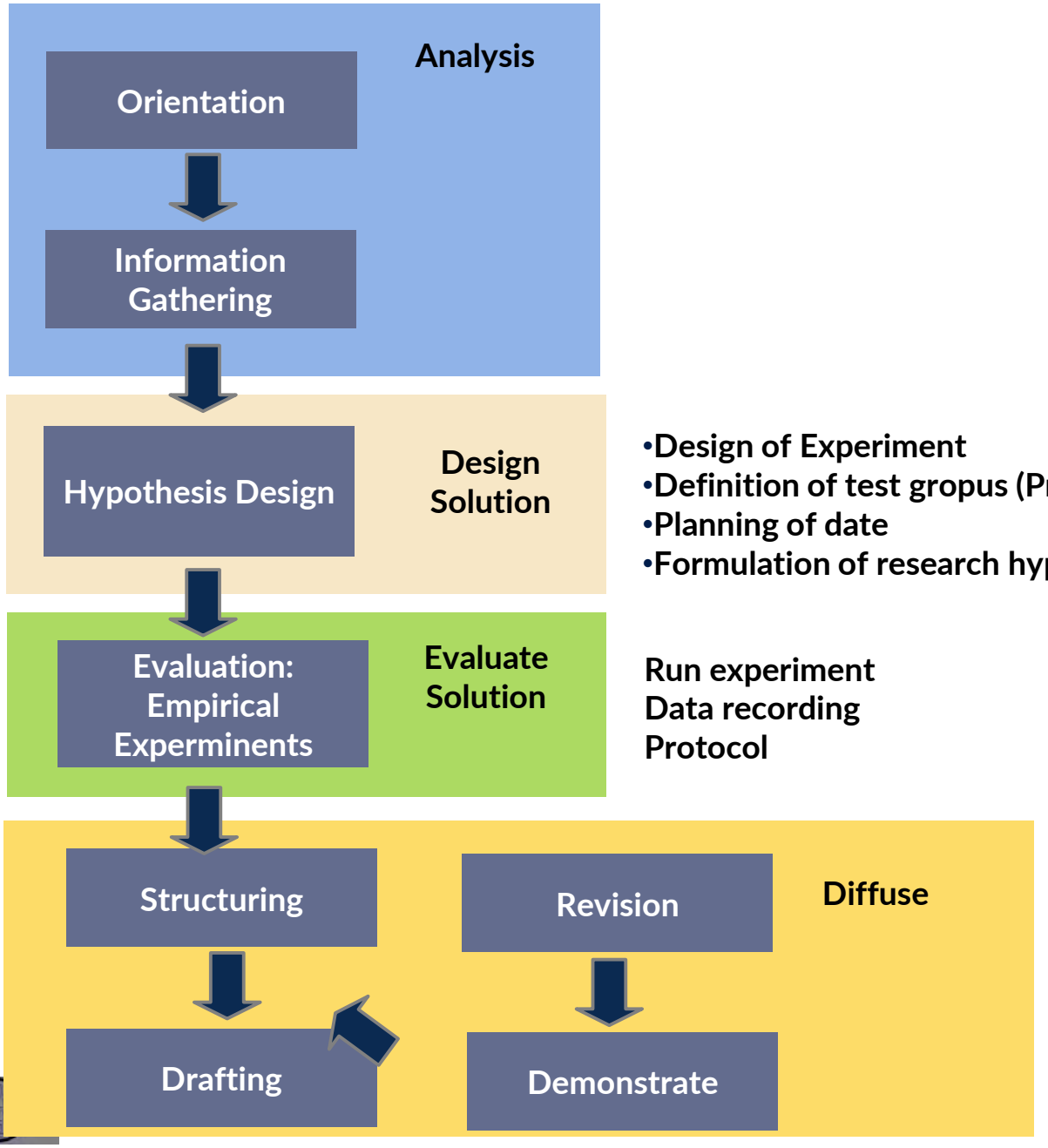
- **Write up background work**
- **Formalize the proposition**
- **Decompose into lemmata**

- **Proof the lemmata**

Phases of scientific text production, e.g., for mathematical papers or papers in theoretical computer science.

In the structural sciences (mathematics, theoretical computer science), a thesis must prove a **proposition** (thesis), i.e., demonstrate a result in mathematical language and logic.

The Variant A-HE-D Research Process for Empirical Science Thesis



Phases of scientific text production for empirical papers, e.g., in usability engineering.

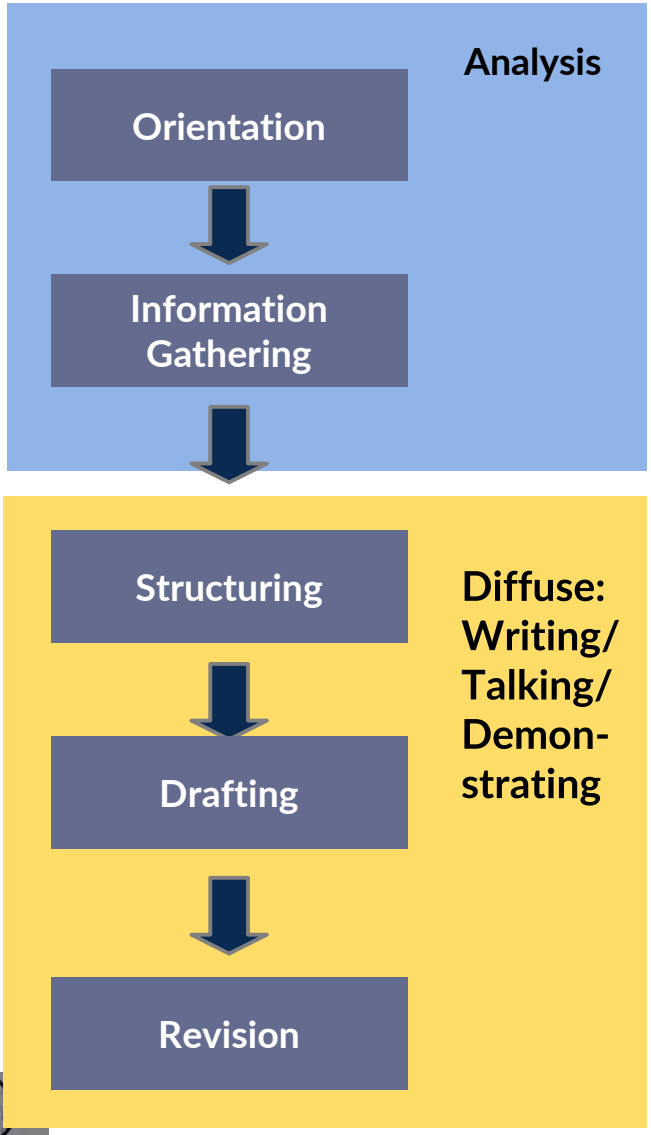
- **Design of Experiment**
- **Definition of test gropus (Probanden)**
- **Planning of date**
- **Formulation of research hypotheses**

Run experiment
Data recording
Protocol

The A-D Process for General Scientific Topics and Overviews **(without Solution Design and Evaluation)**

Here, we look at a simple variant of ADED, OI-SDR [Esselborn-Krummbiegel].

Phases of scientific text production, e.g., for overview papers on a subject or essays



- **Collect ideas, generate ideas**
- **Find the scope (limits) of the topic**
- **Analyze problems**
- **Orientation in literature: First overview on literature**
- **Planning: Expose + project plan**
- **Market need, relevance analysis: identify your readers and stakeholders [Ashby]**

Informing: Information Gathering: Primary texts, evaluate sources. Check relevance of Literature

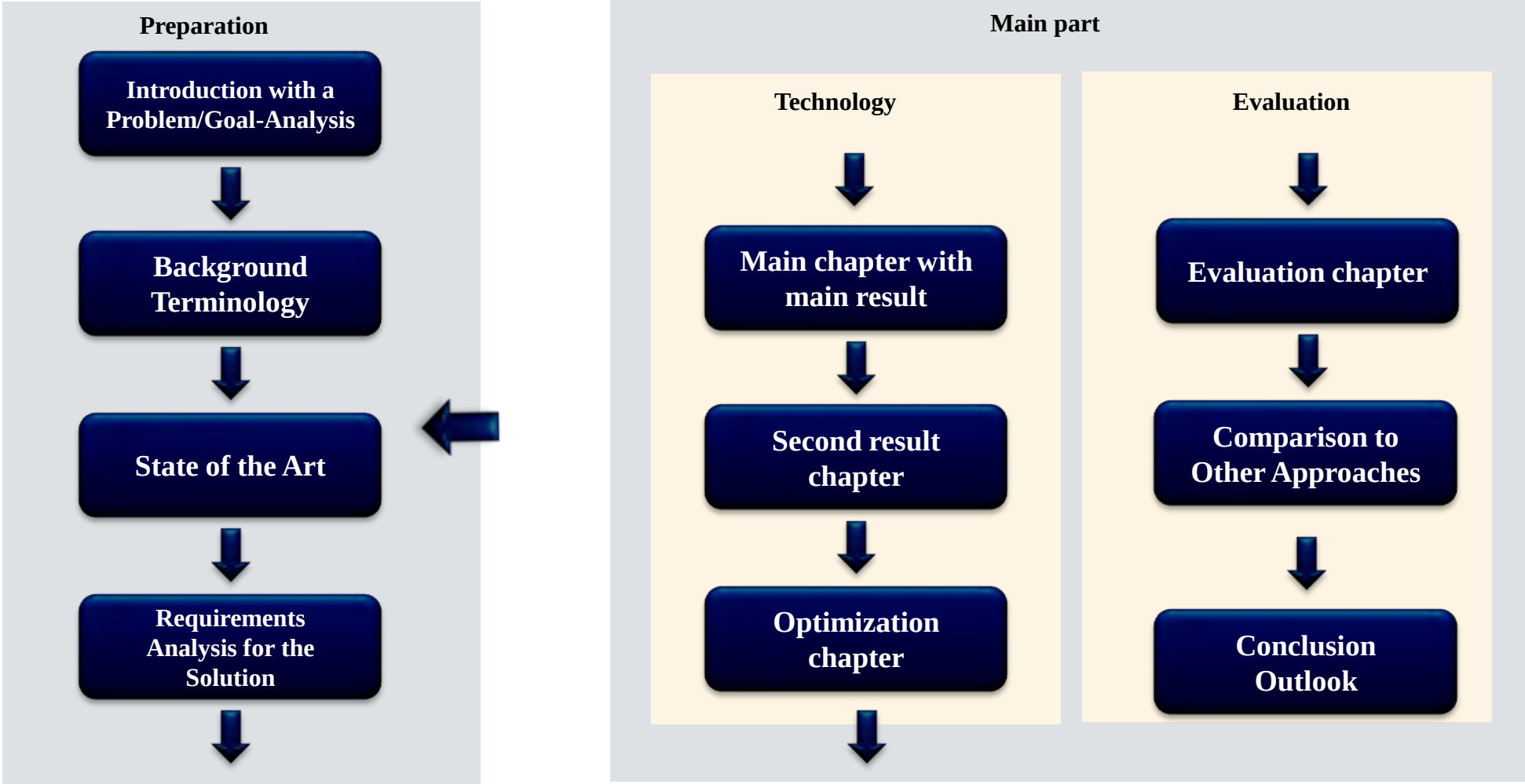
- **Order Material**
- **Find Hypotheses by applying problem and solution analysis**
- **Outlining**
- **Design Controlling Ideas, Points, Skeletons**

- **Write main part of work**
- **Write Introduction and Conclusion**

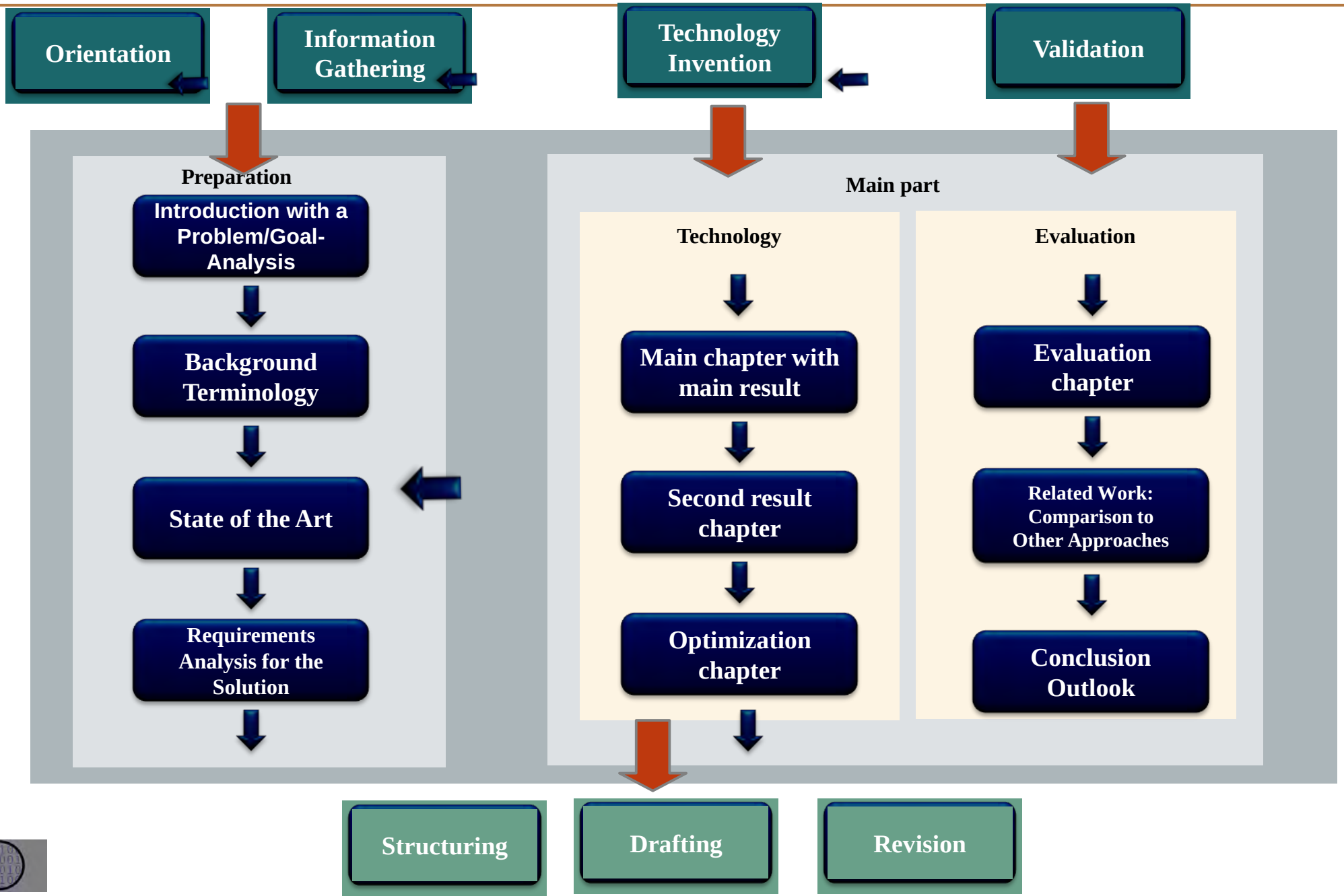
- **Mature controlling ideas**
- **Mature skeleton**
- **Mature to final document**

Standard Structure of a Technical Science Thesis

- A scientific thesis work should clear demarcate the part that is from you from the part that is not from you (background).
- The main part is divided in technology and evaluation part.
  - Some chapters can be folded or distributed.



The Standard Structure of a Master Thesis in Technical Science is Related to the ADED Research Process



Chapters and Process

- Because the structure of a scientific thesis is related to the chapters, write chapter by chapter
  - Start with (a draft of) the “background” and “literature/state of the art” chapters from the orientation phase
  - Then develop the technical solution and write it up in a main technical contribution chapter
  - Validate with an evaluation (experimental, proof, empiric) in parallel.
  - Draft, revise, revise,...
- If you clearly put your technical contributions into 3-4 main chapters, your main slide at your defense will be:

Scientific Results / Contributions:

1. Result of Main Chapter 1
2. Result of Main Chapter 2
3. Result of Main Chapter 3

- And this will also form your introduction of your thesis.

Practical Hints

- Meet your supervisor biweekly or weekly.
  - Produce protocols of the meetings
- Write up everything in scratchpads. Material can be used in the end, and you don't forget important discussions or decisions
  - Starting to write after 2/3 of the time is a fatal error (start early)
- Reserve 1/3 of your time for writing
  - 3 months Bachelor → 1 month writing
  - 6 months Masters → 8 weeks, at least 7 weeks, writing
  - 4 years PhD thesis → 1 year writing PhD thesis, 0.5 year writing papers
- Your thesis may be written in English or German.
  - English gets a broader, world-wide audience.

11.2. Analysis – From the Problem to the Research Question

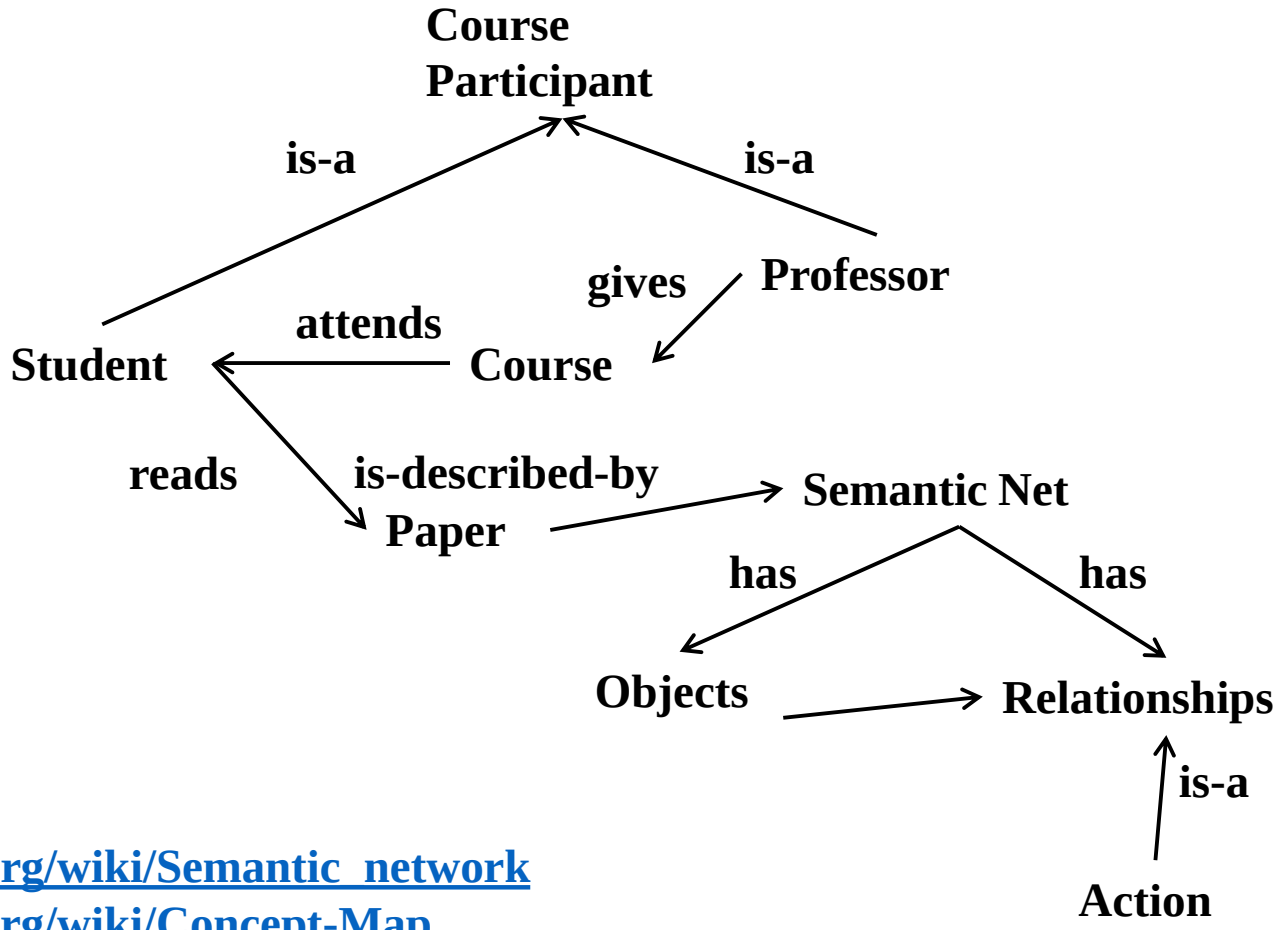
- When I don't know what to do yet (Overview)
- This orientation process is from [Esselborn-Krummbiegel]

11.2.1 Orientation
Analysis and Idea Generation with Semantic Nets, Concept Maps, Clusters, Mindmaps, Row Hierarchies, Honest Serving Men, and other Techniques

- Concept maps by [Novak]
- Clustering was invented by [Rico] [Esselborn-Krummbiegel]
- Mindmaps by [Buzan]

Semantic Nets (Simple Concept Maps)

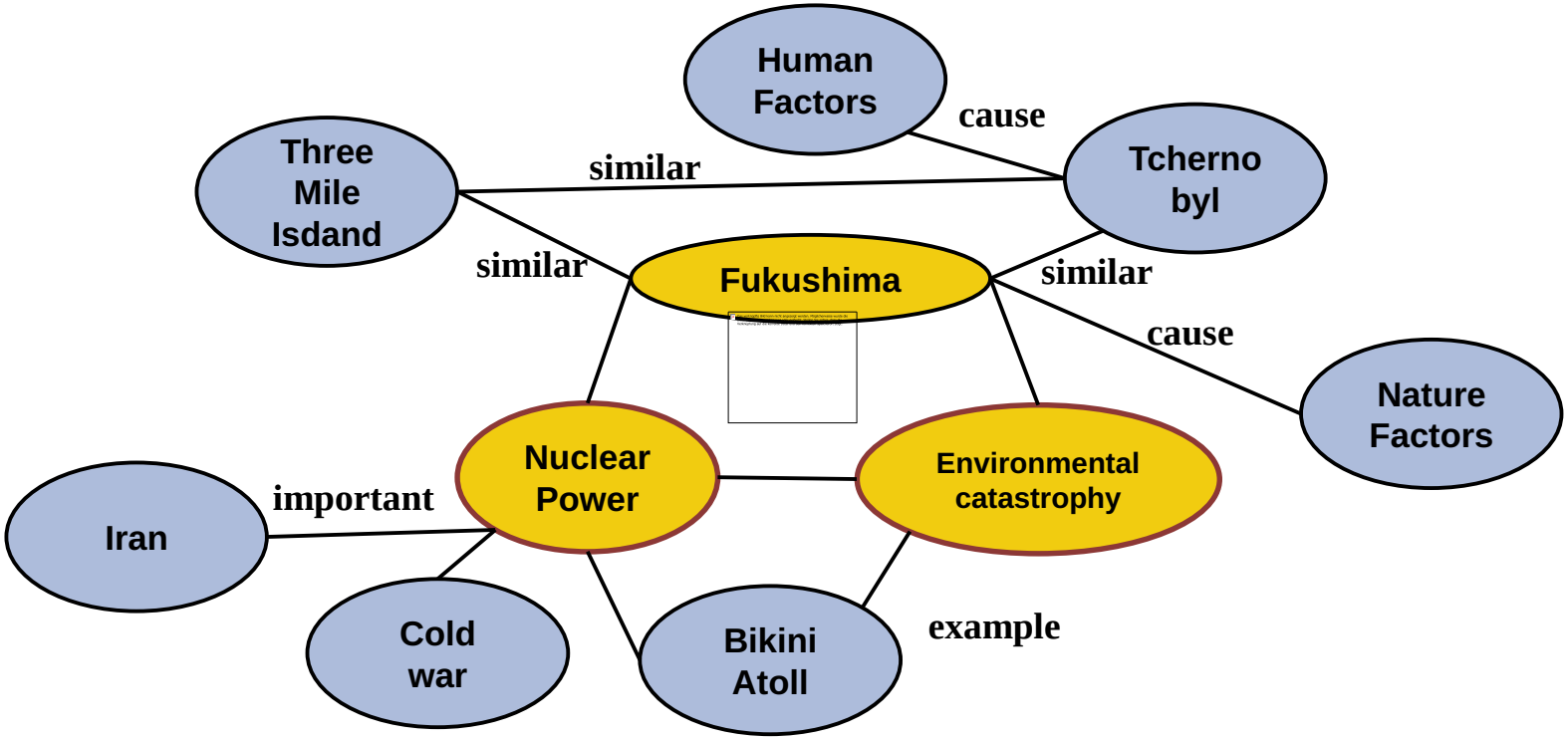
- To record what you understand, draw a **semantic net (simple concept map)** while reading
- A **semantic net** draws objects and their relationships and actions into a graph
  - Distinguished relationships: is-a, has-a, owns-a, ...



http://en.wikipedia.org/wiki/Semantic_network
http://de.wikipedia.org/wiki/Concept-Map

Concept Maps

- http://de.wikipedia.org/wiki/Concept-Map
- A **concept map (Begriffslandkarte)** shows several concepts and their relations
  - usually, one starts with several central concepts in the middle of a page and collects associations
- Concept mapping is a method for analysis, idea generation and structuring.
  - Other forms: Clustering, Mindmapping [Buzan], Structure Trees, Cause-Effect diagrams
- Depending on the purpose, a concept map is a **model** of problems, knowledge, goals, solution ideas



Concept Maps (Strukturbilder, Textbilder)

- The **concept map** enriches a Semantic Net with pictures and figures (Strukturbilder) [Novak]
  - http://www.teachsam.de/arb/visua/visua_3_2_6.htm
- Development
  - Always start the development with a focus question
  - Use a discriminating question to decompose (e.g., the Honest Men)
  - Grouping is important: group into phases, layers, regions, skeleton trees
  - Specific relations such as <implies>, <causes>, <abstracts>
- Concept maps are the basis of paper writing and book reading
- Software: http://cmap.ihmc.us/documentation-support/
- Alberto J. Canas, Greg Hill, James Lott. Support for Constructing Knowledge Models in CmapTools. Introduction. Technical Report IHMC CmapTools 93-02. Institute for Human and Machine Cognition (IHMC)
- http://cmap.ihmc.us/Publications/WhitePapers/Support%20for%20Constructing%20Knowledge%20Models%20in%20CmapTools.pdf

http://commons.wikimedia.org/wiki/Category:Concept_maps?uselang=de

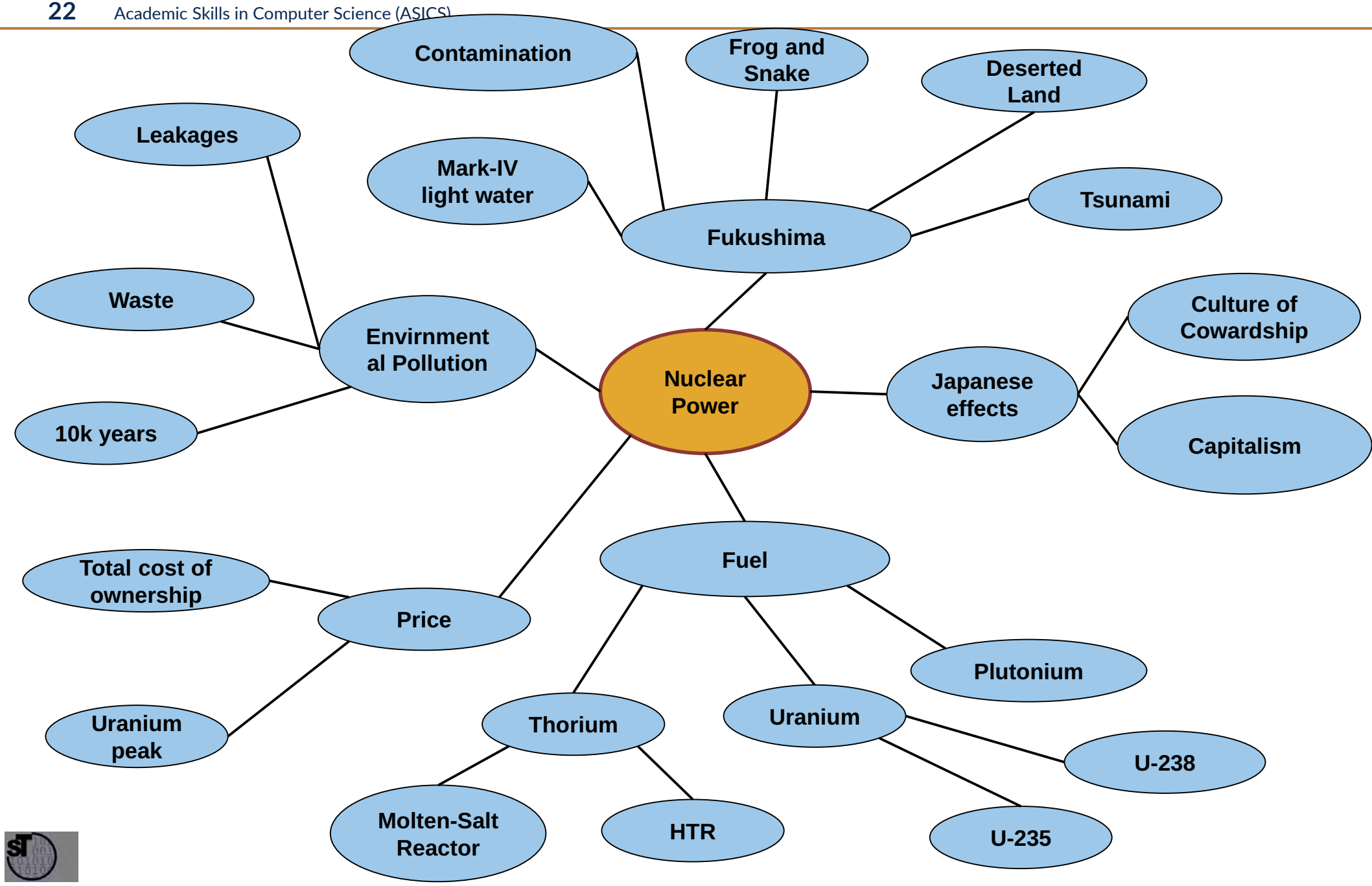
Clustering Helps to Develop Hierarchic, Logical Structures of Your Work

- A **Cluster** is a node-labeled concept map with *one* root in the middle of the page
  - If the cluster is a tree, it is called a *mindmap*
  - http://de.wikipedia.org/wiki/Cluster_(Kreatives_Schreiben)
- Clustering finds associations to one central term:
  - Develop, structure, find ideas by association
  - Start from a central term, concept, or idea (a spider-map)
  - Use the blackboard's space to find association
  - Use landscape to get a broader view and more space in breadth
- Develop: Note the **central concept** in the middle
  - Start to note associated terms or relations
  - Note relations or discriminators on the edges (optional)
  - Iterate
- Restructure: Redraw on new sheet
  - Find relations between the branches; Group

11.2.1.1 Mindmaps

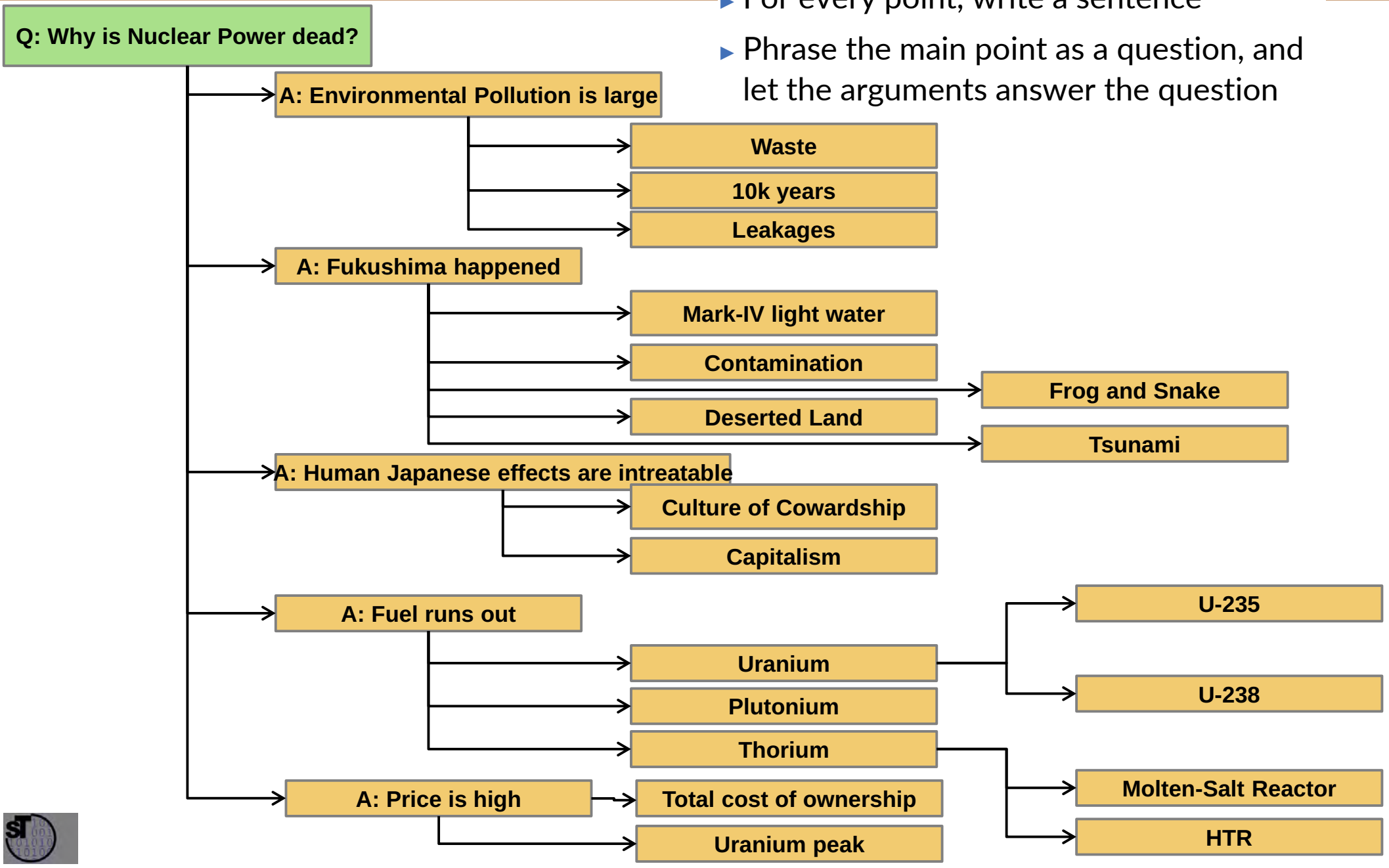
- Mindmaps are similar to structure trees
- A **Mindmap** is an node- or edge-labled association tree

Node-Labelled Mindmap of Associations to “Nuclear Power”



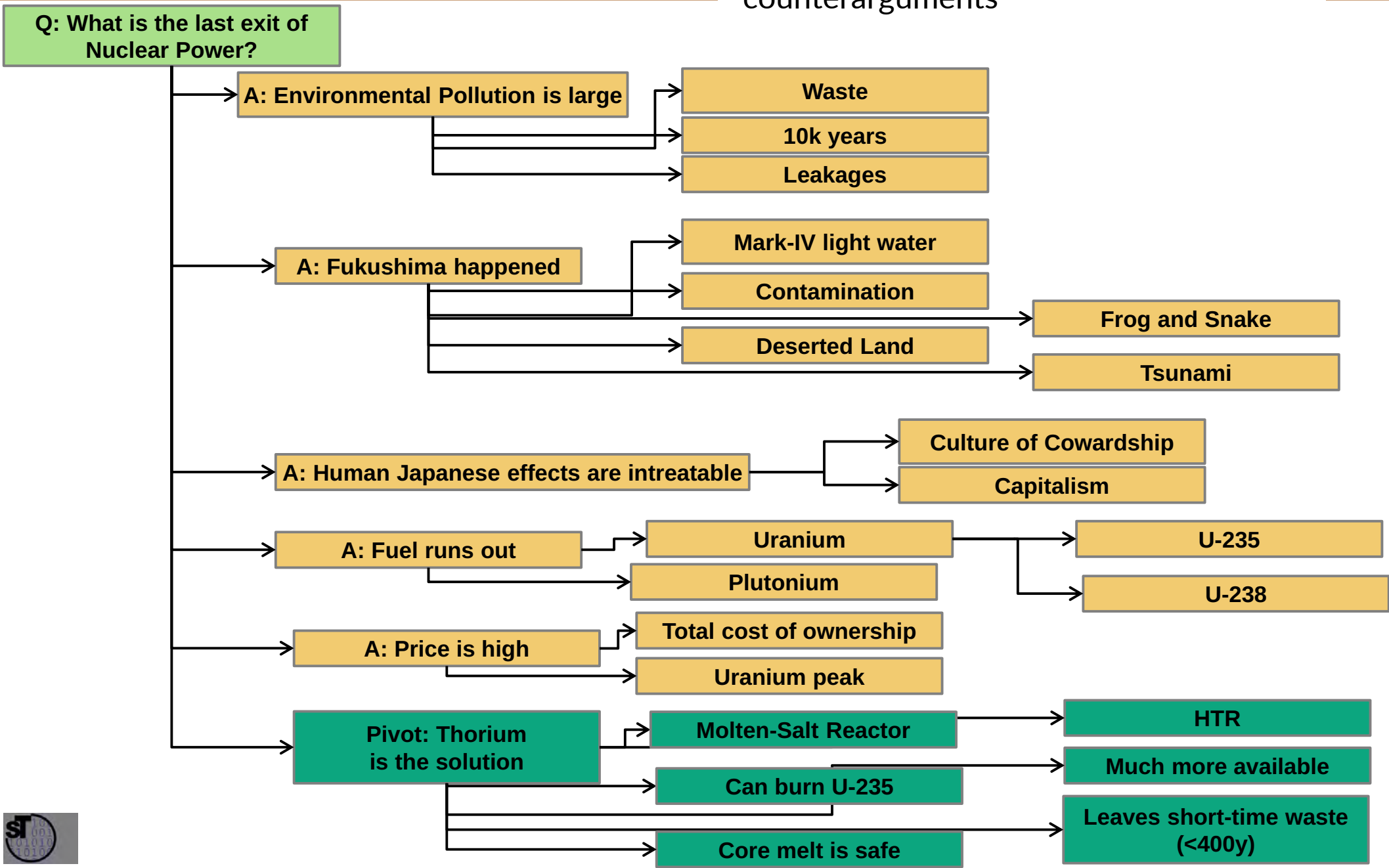
11.2.1.2 Line / Row Hierarchy (Q-A-Hierarchy)

- From a mindmap or structure tree, a row hierarchy can be formed with main thesis and arguments
- For every point, write a sentence
- Phrase the main point as a question, and let the arguments answer the question



Alternative Row Hierarchy

- Also alternative row hierarchies can be built, with other messages.
- Then, the solution must answer all counterarguments

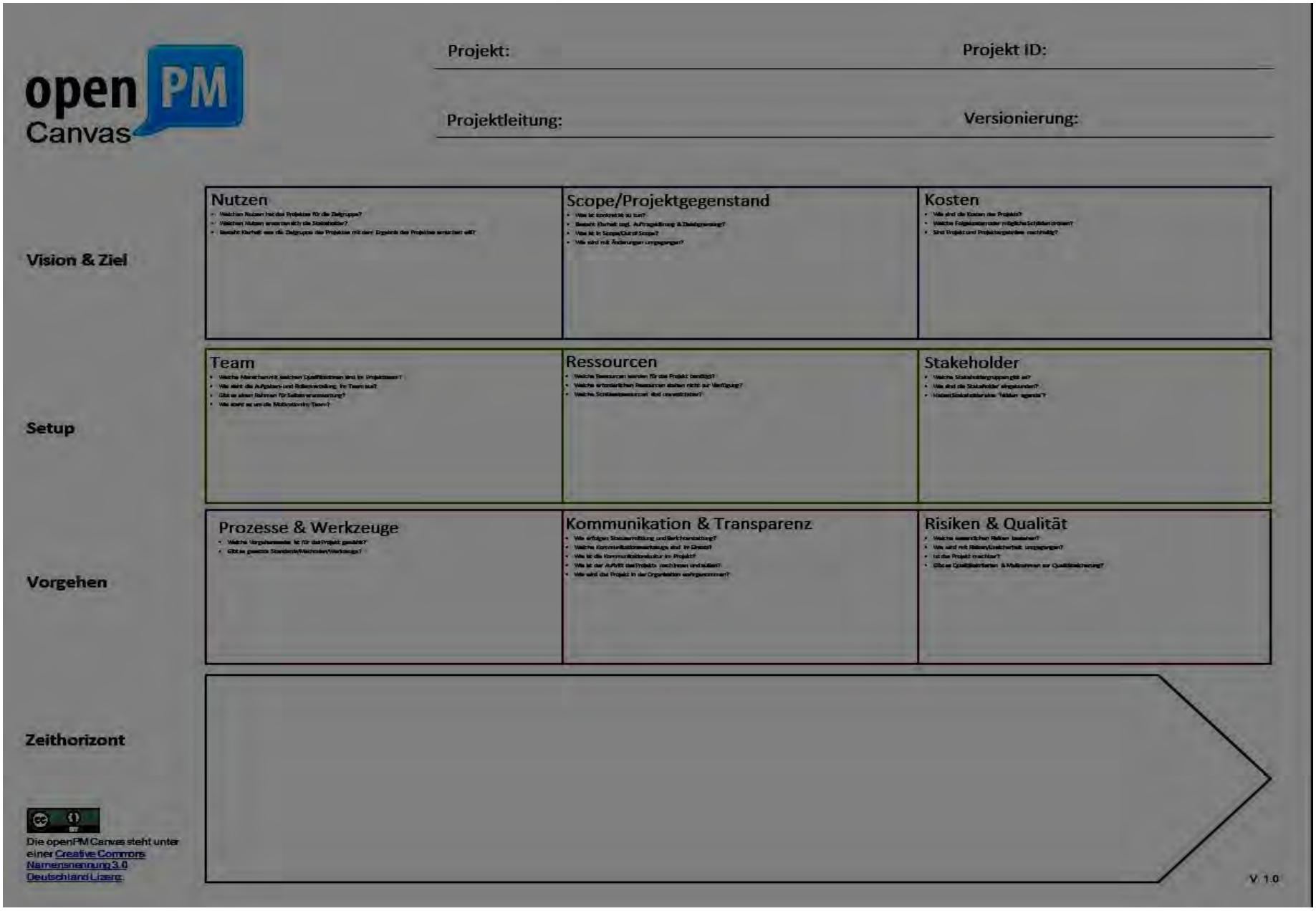


11.2.1.3 Canvases

- A Canvas is a structured **collaborative** form, to be printed on a BIG poster
  - It has a **fill order**, in which the fields should be filled
  - Every field has standardized questions
  - Fields are filled by sticky notes
- Canvases are very structured – Mindmaps and Concept Maps are unstructured
- Canvases are **mind maps with normalized discriminators**

Open Project Management Canvas

https://www.openpm.info/display/openPM/Canvas



11.2.2 Problem Analysis with Questions

Problem Analysis asks the questions:

- Why?
- To which end?

The Honest Serving Men
7 Basic Questions (7 W-Fragen)

The 6 honest serving men (R. Kipling, Just So Stories)

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!

The 7 Basic Questions (7 W-Fragen) used for Topical Questions

- For finding topics of research, a text or talk, the 6 honest men (7-W-Questions) should be attempted to expand into a checklist.
- This checklist can be used to create alternatives for the topic (idea generation for topic).

	Ideas for Topic; Limits and Implications	Aspects
Who?	Who is interested in the topic? Who benefits?	
What?	What do I want to find out? What may change in my topic, problem or question? What is fix?	**Results, Solutions**
How?	**How similar is my topic to another work? How different is it? What is its research advance? research contribution?**	**Implementation, Realization**
Where?	Where is my research located in the research landscape?	
When?	**When did somebody else research on something similar?**	
Why?	**causal; Why do we need the topic?**	**Motivation; Problem**
For what? To which end?	**final; What will happen if we don't solve the problem?**	**Goal**

Problem Analysis

- Most idea generation techniques (concept maps, clusters, mindmaps, Honest Men) can be used to analyze problems
  - Ask the questions “why” and “to which end”?
- But they can also be used to generate solution ideas
  - Ask the question “how to achieve”?
- and to structure the available knowledge and literature:
  - Ask the question “What do we know?”

The End

- Why are concept maps so important?
- Explain the difference of a semantic net, a concept map and a mindmap
- Lay out the ADED research process
- What is the role of evaluation (validation)?
- Explain the 7-W-questions
- How would you use the 7 honest serving men as discriminators in a mindmap?

- Several slides are courtesy to Sebastian Cech