



6-1 Design Science Research

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Design Science Research Guidelines

1	Design as an Artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation
2	Problem relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems
3	Design evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods
4	Research contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies
5	Research rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact
6	Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem Environment
7	Communication of research	Design science research must be presented effectively to both technology-oriented and management-oriented audiences

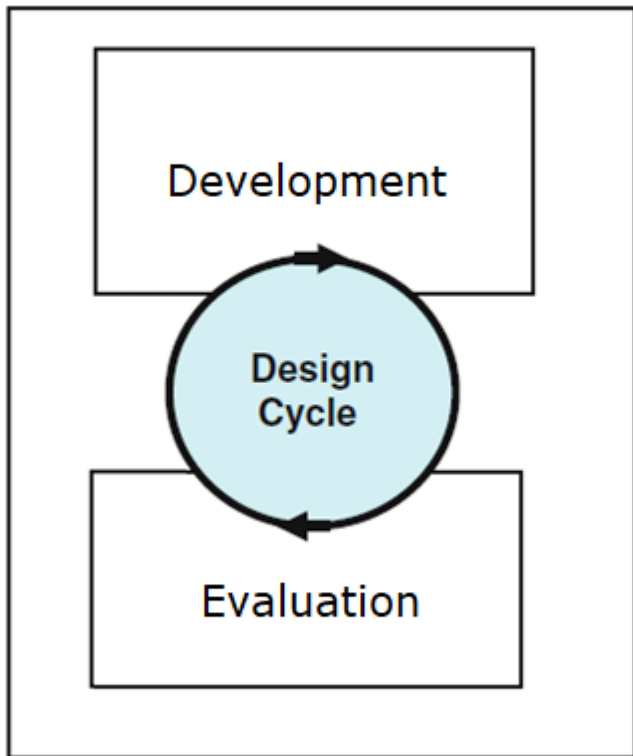
(Hevner & Chatterjee 2010)

- Design research involves the design of an **artefact** with the aim of better understanding or improving a theory
- Artefacts can be
 - ◆ **constructs** (e.g. formal languages, mathematical constructs like Petri nets)
 - ◆ **models** (representations of existing or possible real-world systems)
 - ◆ **methods** (processes, procedures, algorithms)
 - ◆ **instantiations** (implementation examples of constructs, models, or methods, e.g. in computer programs)

“Knowledge through making”

Design Science Research Cycle

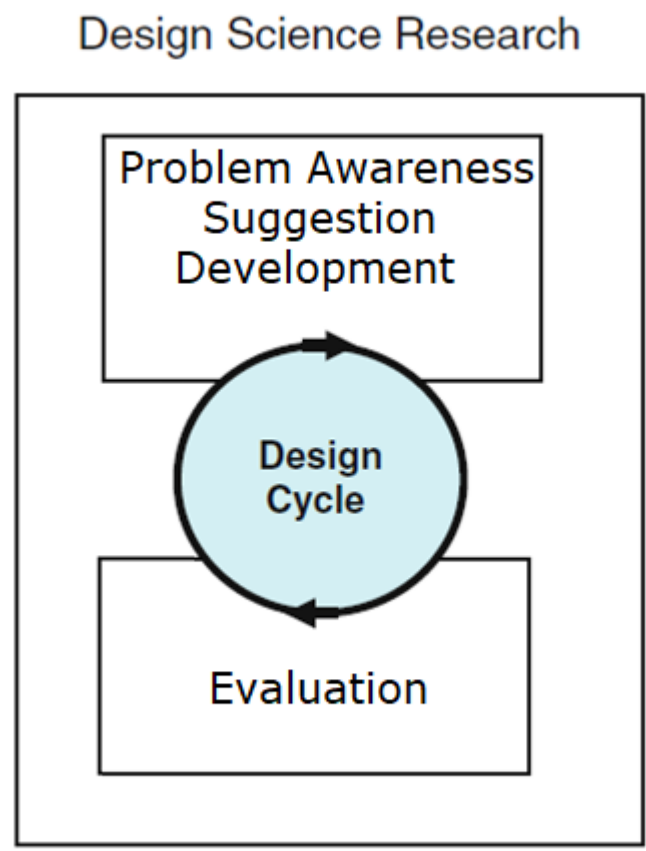
Design Science Research



- The design science research combines
 - ◆ Development of an artefact
 - ◆ Evaluation of the artefact
- There can be several iterations of Development and Evaluation
- This is what is called the Design Cycle

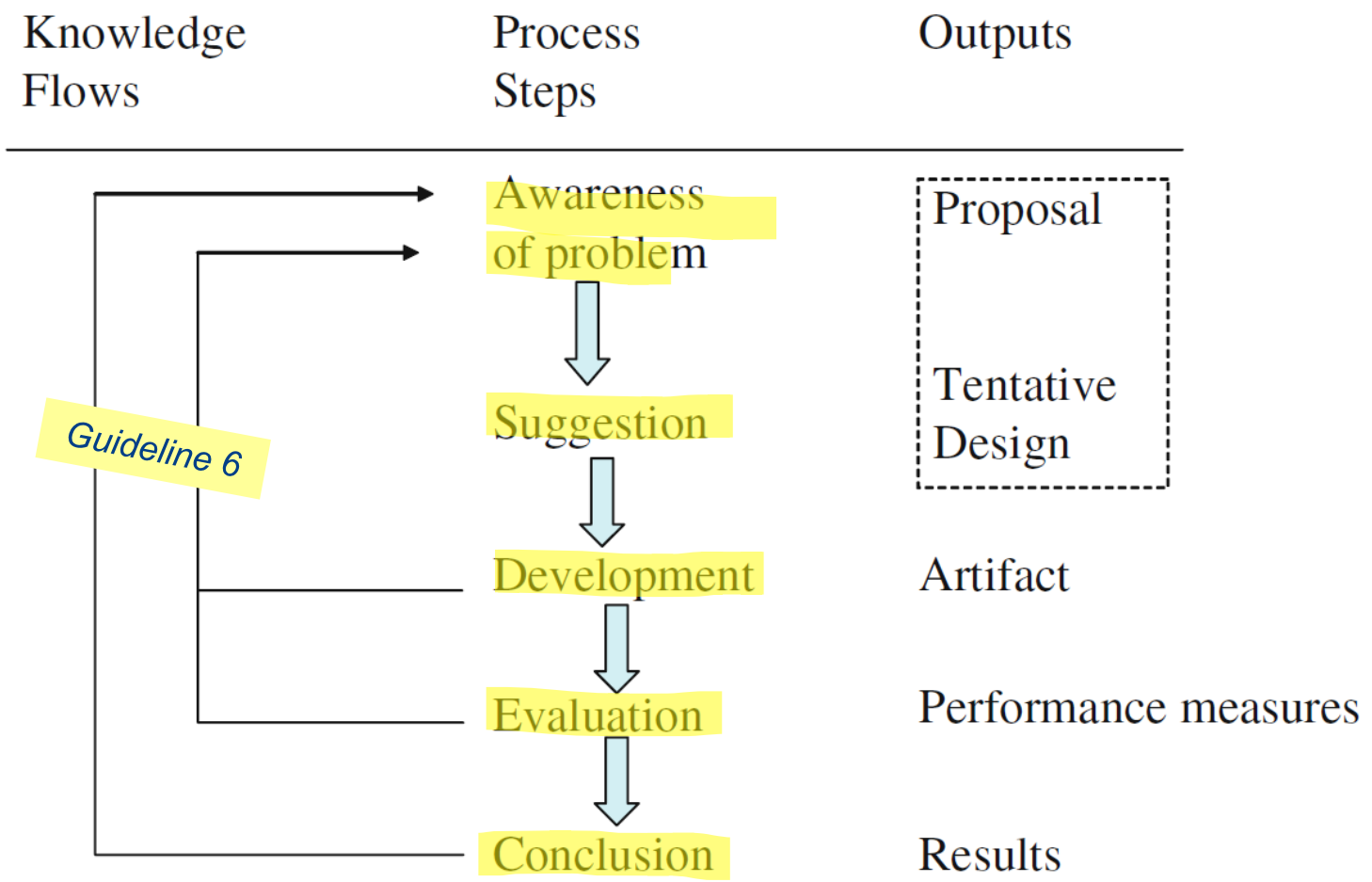
Process Steps in Design Research (1)

The Development Phase can be split in several steps



Process Steps in Design Research (1)

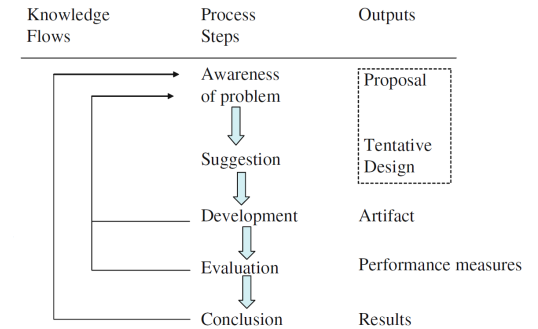
Guideline 1



Guideline 2

Guideline 3

Guideline 4



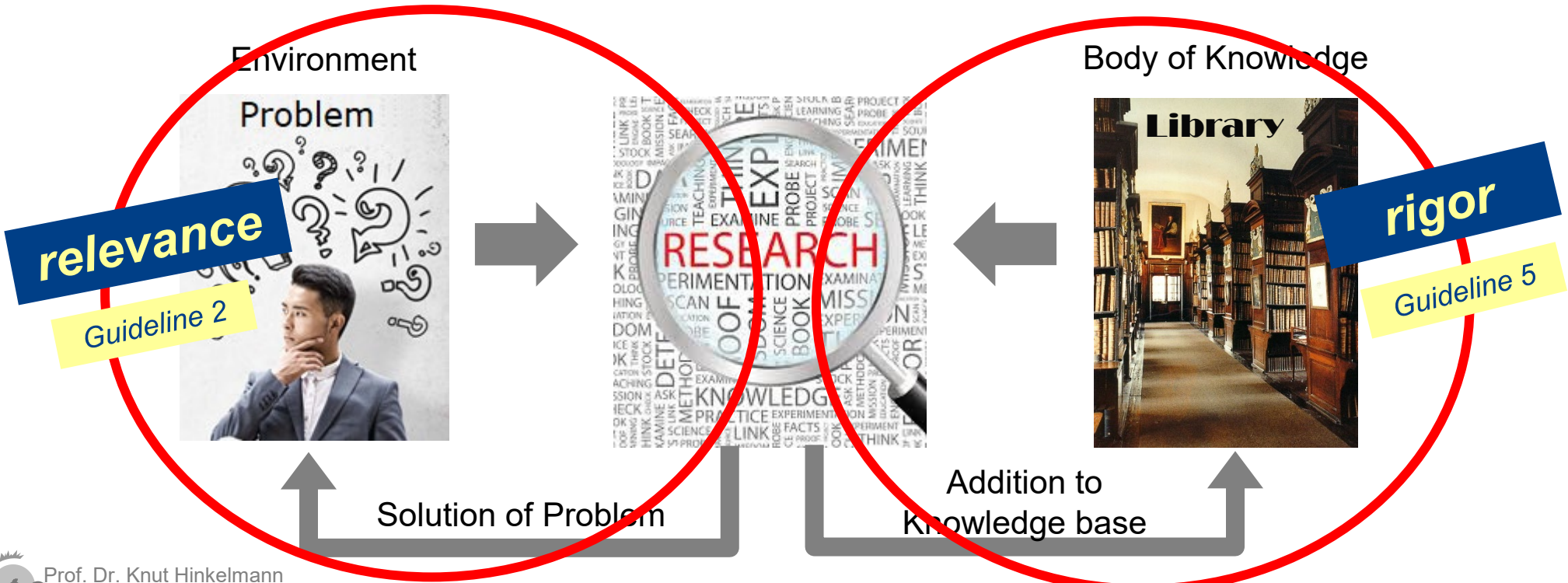
Phases of Design Science Research:

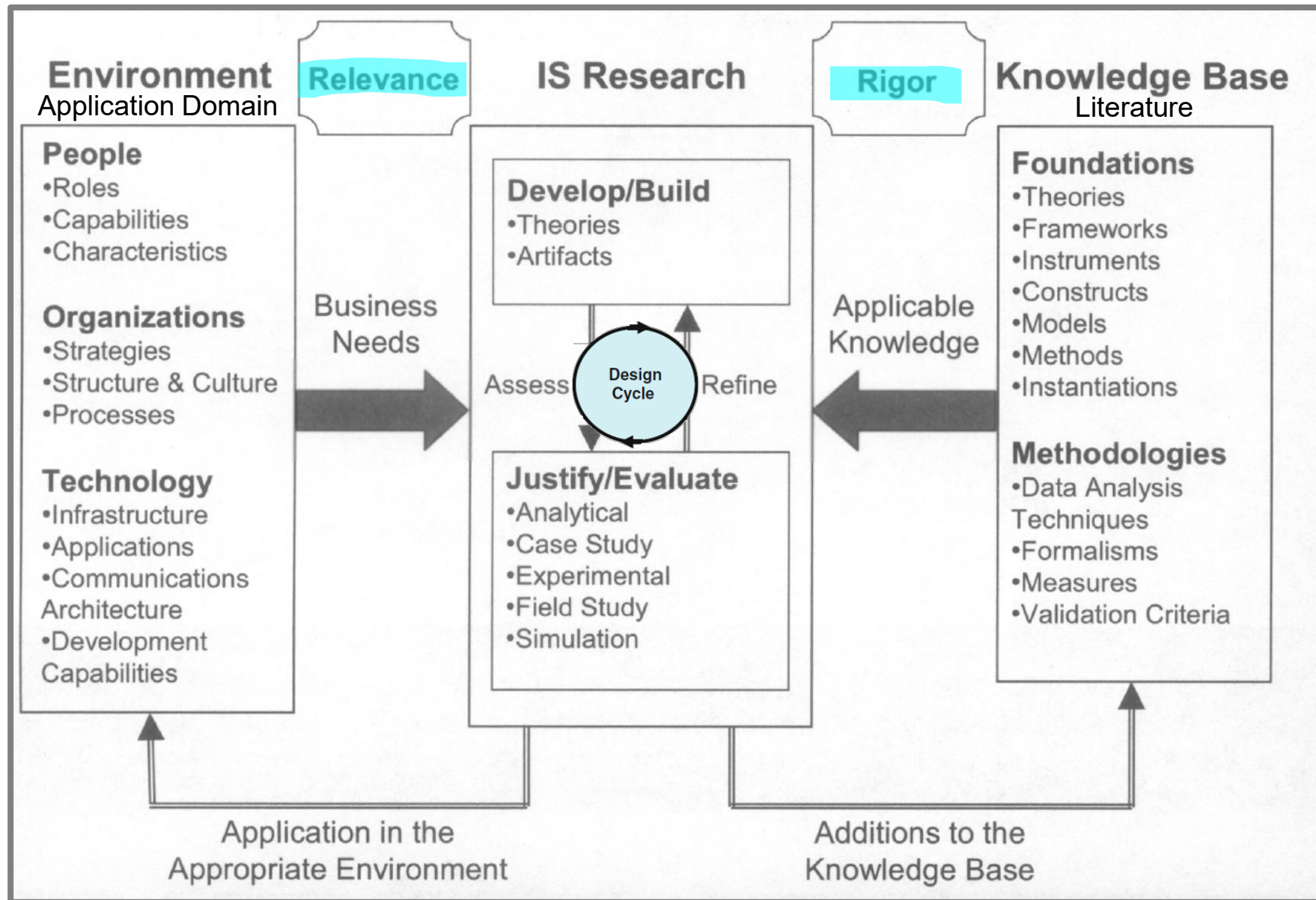
- Awareness of problem
 - ◆ recognition of a problem which can be solved by or using new artifacts
- Suggestion
 - ◆ discussing what kind of artifact might solve the problem
- Development
 - ◆ designing and creating the artifact
- Evaluation
 - ◆ checking whether the artifact solves the problem, analyzing its strengths and weaknesses
- Conclusion
 - ◆ compilation of results and future aspects such as open questions or plans for further development

(Hevner & Chatterjee 2010, p. 27), (Oates 2006, p. 111f)

Rigor and Relevance

- The intent of DSR is to create an artefact through a balanced process that combines
 - ◆ the highest standards of *rigor*
 - ◆ with a high level of *relevance*

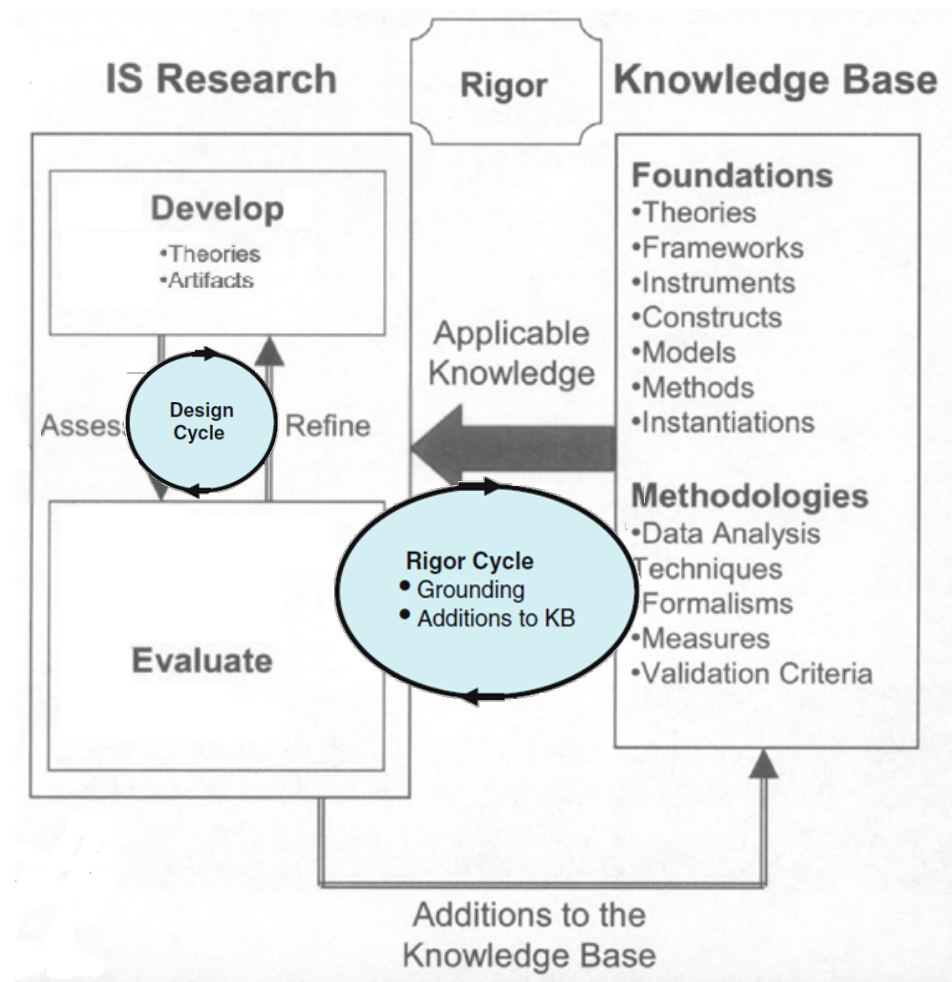




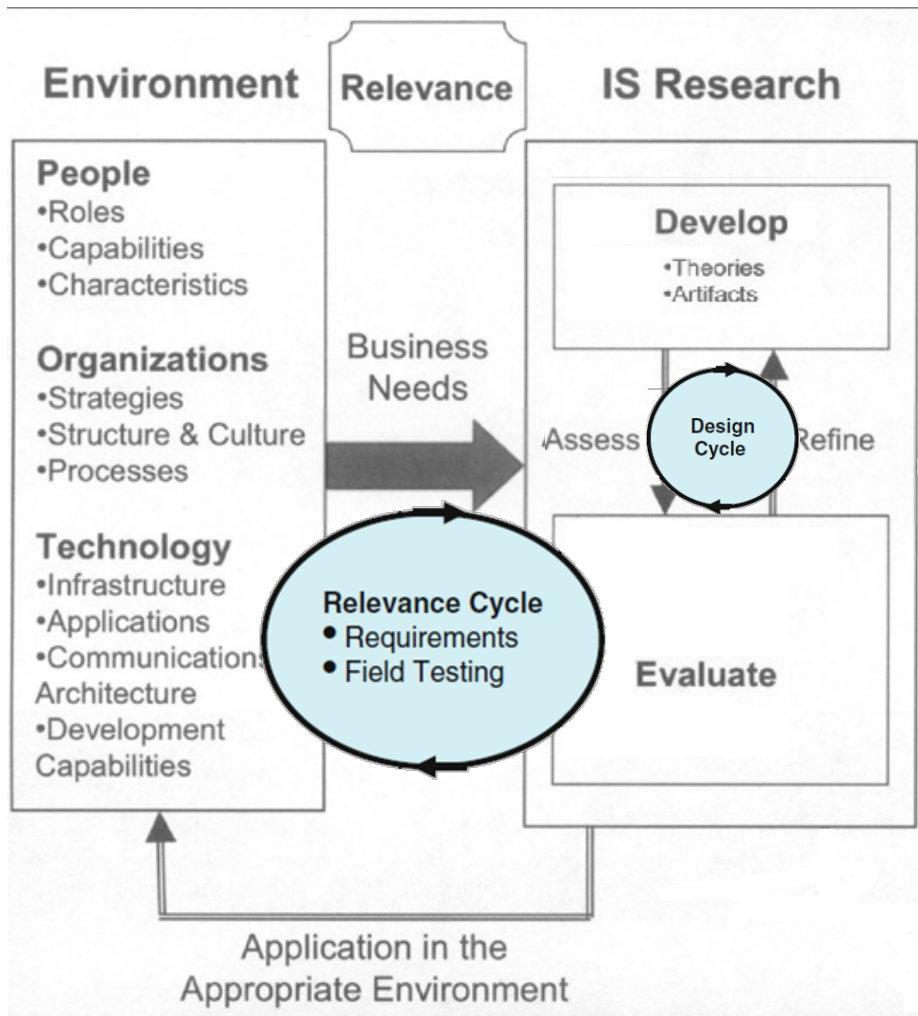
(Hevner et al 2004)

Rigor Cycle: Strict Application of Scientific Method

- **Scientific rigor** as 'the strict application of the **scientific** method to ensure robust and unbiased design, methodology, analysis, interpretation and reporting of results.
- Rigor Cycle in Design Science Research
 - ◆ Using knowledge about
 - Foundations
 - Methodologies
 - ◆ Additions to the Knowledge Base



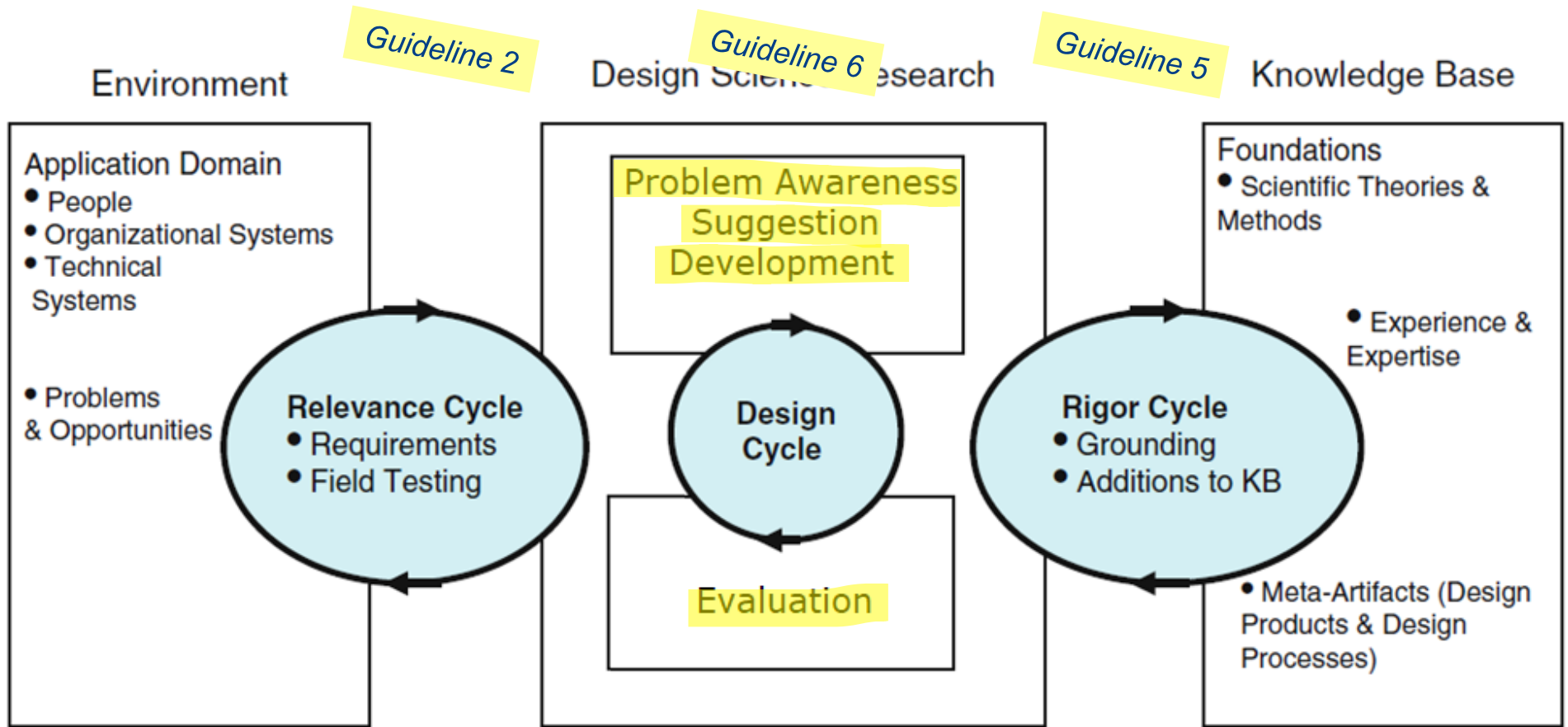
Relevance: Practice-Oriented Research



■ Relevance Cycle

- ◆ Collect and analyse data from reality (requirements)
- ◆ Artefact is applicable in practice

Rigor and Relevance in Design Research



Relevance and Rigor Cycle refer to usefulness and novelty

Based on (Vaishnavi & Kuechler 2004) and (Hevner & Chatterjee 2010, p. 16)

Rigor and Relevance in the Awareness Phase

- Awareness phase tries to get a deep understanding of the problem, **using analytical methods / techniques**
 - ◆ Roughly corresponds to requirements analysis in software engineering
- Possible activities in the awareness phase
 - ◆ Literature research (state of the art)
 - ◆ Studying existing practice using appropriate collection and analysis of primary data
 - ◆ Studying experience reports and discussions (e.g. blogs)
 - ◆ Studying secondary data (e.g. studies, statistics)

rigor

relevance

Rigor and Relevance in the Suggestion Phase

- Suggestion phase explores possible solutions for the problem
 - ◆ Roughly corresponds to conceptual design in software engineering

- Possible activities in the suggestion phase
 - ◆ Literature research for solution alternatives
 - ◆ Feedback from practice (e.g. interviews, focus groups, workshops)
 - ◆ Studying experience reports

rigor

relevance

Novelty and usefulness of an artifact

When does an artifact constitute research?

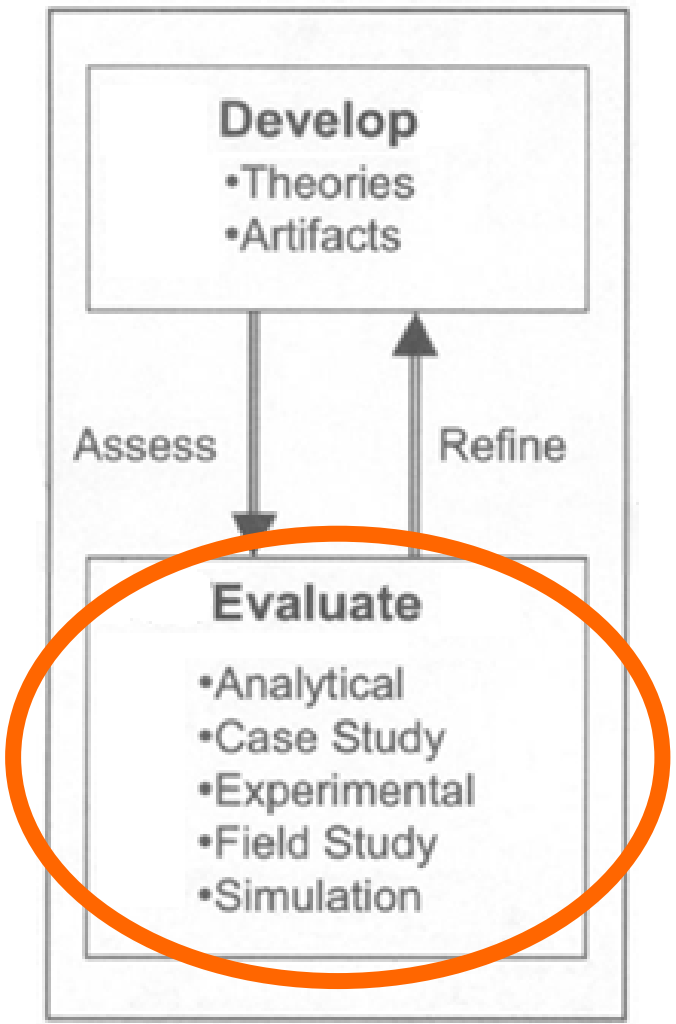
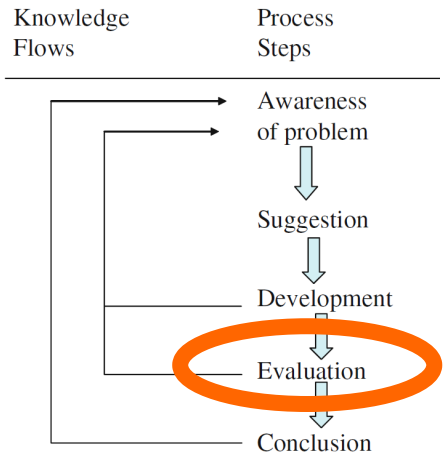
- it must be sufficiently new - with respect to knowledge base
 - ◆ thus, it must sufficiently differ from existing artifacts
 - ◆ this can be proven by a careful literature review
- it must be sufficiently useful – with respect to environment
 - ◆ artifact is something fundamentally new
 - e.g. a new computer language, a new modeling concept, a new method
 - ◆ applied in a new domain (replication)
 - e.g. an information system used in a new field
 - ◆ adapted for a a new domain (modification, extension)
 - e.g. a learning theory is demonstrated, analyzed, or supported by an e-learning package

rigor

relevance

adapted from Thomas Hanne

Evaluation in Design Science Research



- Examine whether the artifact meets the requirements.
- Evidence-based evaluation: evaluate the artifact within the application environment.

relevance

- Critical assessment of the artefact: identify possible weaknesses

Problems of Design Orientation

- Success criterion: relevant, useful results
- Validation often by
 - ◆ implementation in practice
 - ◆ economic payoff
- Consequence:
 - ◆ Many publications of results are without rigorous, scientific evidence
 - no research

Goal: Simultaneous achievement of

- Design orientation
- Scientific rigor

based on (Österle et al. 2010)

Structure Design Science Research with Research Questions

Thesis Statements in Design Research

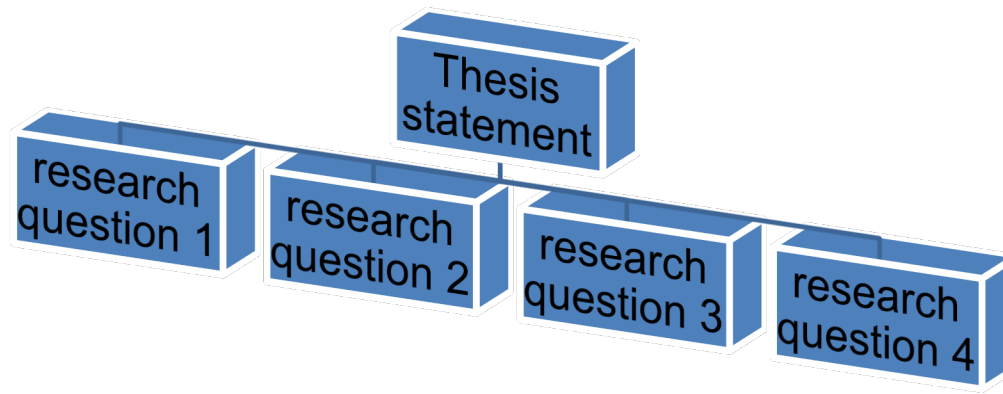
- Thesis statements in design research are often referring to an **artefact** and the **benefit / business value** of the artefact
 - ◆ Evaluation should validate this claimed benefit

- Example

“It is possible to develop a system based on Natural Language Processing that recognizes if students copied from each other when writing their assignments.”

Breakdown of the Thesis Statement into Research Questions

- The thesis statement specifies your contribution to the research problem
- Research questions break down your thesis statement into manageable tasks
- Each research question corresponds to a step in your research



Typical Breakdown of a Thesis Statement into (Sub-)Research Questions in Design Research

- Rule of thumb: Have a research question for each phase
- Example
 - ◆ Thesis statement: *“It is possible to develop a system based on Natural Language Processing that recognizes if students copied from each other when writing their assignments.”*

Phase	Objective	Research question (generic)	Research question (example)
Awareness of problem	Understanding the problem	How is it done today? What problems are people facing?	How do lecturers recognize copying today? What are examples? What do students do to hide that they copied?
Suggestion	Explore characteristics and alternatives of an artefact	Which methods can be used? What are features of an artefact?	How can similarities of texts be recognized? Which NLP tools can be used?
Development	Create an artefact	How can the artefact be realized?	How can the tools be integrated?

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