Introduction to design science methodology

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Design science

• Design science is the **design and investigation** of artifacts in context

• Examples
  – *Design and investigation of agent-based route planning algorithms*
  – *Design and investigation of goal-oriented enterprise architecture design method*
Design science versus observational science

• Design science is **solution-oriented**
• Natural science, social science are **problem-oriented**
  
  – *Observational studies of requirements engineering in agile projects*
  
  – *Observational studies of patterns of evolution of groupware systems*
  
  – *Experimental studies to understand how software engineers understand UML*
The engineering cycle

- Problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Implementation evaluation

Stakeholders, goals, phenomena, evaluation, diagnosis
The engineering cycle

- Problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Implementation evaluation

Treatment = interaction between artifact and context

- Interaction between pill and patient
- Interaction between Software and its Context
- Interaction between method and its context of use

- You design the artifact in order to create a treatment
The engineering cycle

• Problem investigation
• Treatment design
• Design validation  Artifact & Context $\rightarrow$ Effects?
  Effects satisfy Criteria?
  Trade-off: Changes in artifact
  Sensitivity: Changes in context
• Treatment implementation
• Implementation evaluation
The engineering cycle

• Problem investigation
• Treatment design
• Design validation
• Treatment implementation
• Implementation evaluation

Transfer to practice! Commercialization, sale
The engineering cycle

- Problem investigation
- Treatment design
- Design validation
- Treatment implementation
- Implementation evaluation

Phenomena: Artifact & Context → Effects?
Evaluation: Effects satisfy Criteria?
Where are we

Implementation evaluation = Problem investigation

- Stakeholders? Goals?
- Phenomena? Causes? Effects?
- Effects contribute to Goals?

Design implementation

Choose an artifact!
Transfer to practice!

Research project may be focussed on problems

Or on design & validation

Design validation

- Context & Artifact → Effects?
- Effects satisfy Requirements?
- Trade-offs for different artifacts?
- Sensitivity for different Contexts?

Treatment design

- Specify requirements!
- Contribution to goals?
- Available treatments?
- Design new ones!

Legend:
? Knowledge questions!
! Tasks

Engineering cycle

Legend:

11 June 2015
CAiSE 2015 Doctoral Consortium
Research problems in design science

To design an artifact to improve a problem context

Problems, Artifacts

Knowledge

To answer knowledge questions about the artifact in context

Solve using the engineering cycle:

- “Design a DoA estimation system for satellite TV reception in a car.”
- “Design a multi-agent aircraft taxi-route planning system for use on airports”
- “Design an assurance method for data location compliance for CSPs”

The design researcher iterates over these two activities

Solve using the empirical cycle

- “Is the DoA estimation accurate enough?”
- “Is this agent routing algorithm deadlock-free?”
- “Is the method usable and useful for cloud service providers?”
Validating new technology

Population

Samples

Single case

Stable regularities

Idealized conditions

Realistic conditions

Conditions of practice

Labatory credibility

Street credibility

Robust mechanisms

Scaling up
Validating new technology

- Stable regularities
- Population
  - Samples
  - Single case
- Single-case mechanism experiments
- Expert opinion, Technical action research
- Statistical difference-making experiments
- Conditions of practice
- Conditions of practice
- Expert opinion, Technical action research
- Single-case mechanism experiments
- Statistical difference-making experiments
- Robust mechanisms
- Scaling up
- Validating new technology
- Single-case samples
- Population

Validating new technology
The empirical research cycle

• This is the rational decision cycle applied to answer knowledge questions (empirical research questions)
  – Knowledge problem investigation
  – Research design
  – Design validation
  – Research execution
  – Results evaluation
• Knowledge problem investigation
• Research design
• Design validation
• Research execution
• Results evaluation

Theoretical framework, Research questions, Population
- Knowledge problem investigation
- Research design
- Design validation
- Research execution
- Results evaluation

Decisions about Object of study, measurement and treatment. Possible designs:
- Survey,
- Observational case study,
- Experiment,
- Action research,
- Simulation,
- ...
• Knowledge problem investigation
• Research design
• Design validation
• Research execution
• Results evaluation

Would this really answer our questions?
Risk assessment of doing the wrong thing to answer the questions
• Knowledge problem investigation
• Research design
• Design validation
• Research execution
• Results evaluation Did this really answer our questions?
  Risk assessment of answering the questions incorrectly
Research problem analysis
4. Conceptual framework?
5. Research questions?
6. Population?

Analysis of results
12. Data?
13. Observations?
14. Explanations?
15. Generalizations?
16. Answers?

Research design validation
7. Object of study justification?
8. Treatment specification justification?
9. Measurement specification justification?
10. Inference justification?

Research design
7. Object of study?
8. Treatment specification?
9. Measurement specification?
10. Inference?

Empirical cycle

Research execution
11. What happened?
• Where are you?
  – Problem investigation / implementation evaluation
  – Design & validation
  – Empirical research
• What are your research goals?
  – Focus


