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 natural 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
- Treatment implementation
- Implementation evaluation

Artifact & Context → Effects?
Effects satisfy Criteria?
Trade-off: Changes in artifact
Sensitivity: Changes in context
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?
**Engineering cycle**

**Design implementation**
- Choose a treatment!
- Transfer to practice!

**Implementation evaluation = Problem investigation**
- Stakeholders? Goals?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

**Research project may be focussed on problems**
- Or on design & validation

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

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

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Legend:
- ? Knowledge questions
- ! Tasks
Design cycle

Implementation evaluation = Problem investigation

- Stakeholders? Goals?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Treatment 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!

Design implementation
Choose a treatment!
Transfer to practice!
Real-world implementation is not part of your research project

Legend:
? Knowledge questions
! Tasks

any time
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Research problems in design science

To design an artifact to improve a problem context

Problems, Artifacts

To answer knowledge questions about the artifact in context

Knowledge

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”

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

The design researcher iterates over these two activities any time.

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Validating new technology

Stable regularities

Population

Samples

Single case

Laboratory credibility

Idealized conditions

Realistic conditions

Conditions of practice

Scaling up

Robust mechanisms

Street credibility

any time

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Validating new technology

- Statistical difference-making experiments
- Single-case mechanism experiments
- Expert opinion, Technical action research

Axes:
- Stable regularities
- Population
- Samples
- Single case

Steps:
- Idealized conditions
- Realistic conditions
- Conditions of practice

Process:
- Validating new technology
- Single-case mechanism experiments
- Scaling up

Any time

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

New research problem

Research problem analysis
4. Conceptual framework?
5. Research questions?
6. Population?

Empirical cycle

Research execution
11. What happened?

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?
• Where are you?
  – Problem investigation / implementation evaluation
  – Design & validation
  – Empirical research

• What are your research goals?
  – Focus


