Advanced Research Methodology
Design Science

Sjaak Brinkkemper
Outline

• Fundamentals of Design Science
• Design Science: SPM maturity Matrix
• Design Science: Openness degree
• Reflection
Business Informatics Research Cycle

Information systems artifacts provide utility

Design Science Research

Behavioral Science Research

Information systems theories provide truth

(based on Hevner, 2004)
Issues in Business Informatics Research

- Multi-faceted phenomena
- Precise delineation or scoping
- Essence of a theory
- Position of the researcher
- Generalizability
- Aiming for truth, understanding, or creation
- Diversity in research approaches
Assumptions of research approach

Three main research approaches:

• Quantitative – Positivist
• Qualitative – Interpretive
• Design - Creative
# Research assumptions

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Positivist</th>
<th>Interpretive</th>
<th>Design</th>
</tr>
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<tbody>
<tr>
<td><strong>Axiology</strong>: what is of value</td>
<td><strong>Truth</strong>: universal and beautiful; prediction</td>
<td><strong>Understanding</strong>: situated and description</td>
<td><strong>Control</strong>: creation, progress (i.e. improvement), understanding</td>
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<tr>
<td><strong>Ontology</strong>: what concepts exists?</td>
<td>A single reality. Knowable, probabilistic</td>
<td>Multiple realities, socially constructed</td>
<td>Multiple, contextually situated alternative world-states. Socio-technologically enabled</td>
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<tr>
<td><strong>Epistemology</strong>: what do we know?</td>
<td>Objective: dispassionate. Detached observer of truth</td>
<td>Subjective: values and knowledge emerge from the researcher-participant interaction</td>
<td>Creative: objectively constrained construction within a context. Iterative circumscription reveals meaning</td>
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<tr>
<td><strong>Methodology</strong>: what is the scientific process?</td>
<td>Observation, quantitative, statistical</td>
<td>Participation, qualitative, hermeneutical, dialectical</td>
<td>Developmental, measure artifactual impacts on the composite system</td>
</tr>
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</table>
Research cycles in Design Research

Environment

People
- Roles
- Capabilities
- Characteristics
- Experience

Organizations
- Strategies
- Structure and culture
- Processes

Technology
- Infrastructure
- Applications
- Communications architecture
- Development capabilities

Design Science Research

Relevance cycle
- Requirements
- Field testing

Build design artifacts & processes

Rigor cycle
- Grounding
- Additions to knowledge

Design cycle

Evaluate

Scientific Knowledge

Foundations
- Theories
- Frameworks
- Instruments
- Constructs
- Models
- Methods
- Instantiations

Methodologies
- Data analysis techniques
- Formalisms
- Measures
- Validation criteria

(based on Hevner, 2007)
Design research cycles for
SPM maturity matrix

Environment
- People
  - Product managers
  - Release managers
  - SPM capabilities
- Organizations
  - Software vendors
  - Existing processes
  - Company culture
- Technology
  - Supporting tools

Design Science Research
- Relevance cycle
  - Requirements
  - Field testing
- Build
  - Maturity matrix
  - Situational assessment method
- Design cycle
- Evaluate
  - Expert interviews
  - Questionnaire
  - Case studies
- Rigor cycle
  - Grounding
  - Additions to knowledge

Scientific Knowledge
- Foundations
  - SPM literature
  - Software process improvement theory
  - Focus area oriented models literature
- Methodologies
  - Case study research (Yin)
  - Design research (Hevner et al.)

(based on Hevner, 2007)
Literature and debate

Design Science:
• Hevner et al.: Design Science
• Peffers et al.: Triggers for Design Science
• Gregor & Jones: Anatomy of Design Theory
• Gregor: Nature of Theory

Case Studies
• Yin: Case Study Research
• Kitchenham et al.: Case Studies
• Dul & Hak: Case Study Research
• Runeson and Höst: Guidelines for case study research

Action Research
• Baskerville: Action Research
• Davison et al.: Canonical Action Research

Mixed Methods
• Johnson & Onwuegbuzie: Mixed methods
• Jansen & Brinkkemper: Mixed methods in multi-case study

Extensive research methodology resources available at the website of the Association for Information Systems:
www.aisnet.org
# Mixed method research in dissertations

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Publication</th>
<th>Case study</th>
<th>Survey</th>
<th>Design research</th>
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• Reflection
Design Research: 
SPM Maturity Matrix

Maturity model for SPM

• Software Product Management (SPM)
  – The discipline that governs a product from its inception to the market/customer delivery in order to generate biggest possible value to the business (Ebert, 2007)

• Maturity matrix
  – An instrument for assessing and improving an organization’s processes in a certain functional domain
  – Existing maturity matrices: T-Map (testing), DyA (enterprise architecture)
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## Maturity matrix – Focus areas

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# Maturity matrix – Maturity levels

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# Maturity profile

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<td>Product lifecycle management</td>
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Why is a focus area better than a complete model like CMM?

- Incremental capability development
  - Survey among 1,804 organizations: median time to move from one CMM level to another ranges from 13 to 24 months (SEI, 2006)
  - Maturity matrix facilitates incremental improvement

- Local improvements
  - Matrix makes it possible to identify problem areas and start with these
Research framework SPM maturity matrix

Environment
People
• Product managers
• Release managers
• SPM capabilities

Organizations
• Software vendors
• Existing processes
• Company culture

Technology
• Supporting tools

Design Science Research
Build
• Maturity matrix

Evaluate
• Expert interviews
• Questionnaire
• Case studies

Rigor cycle
- Grounding
- Additions to knowledge

Relevance cycle
- Requirements
- Field testing

Scientific Knowledge
Foundations
• SPM literature
• Software process improvement theory
• Focus area oriented models literature

Methodologies
- Case study research (Yin)
- Design research (Hevner et al.)

(based on Hevner, 2004, 2007)
Research approach

1. Identify focus areas
2. Identify and describe capabilities
3. Position capabilities
4. Validate capability positions
5. Finetune capabilities
1. Identify focus areas

- Extracted from Reference Framework for SPM (van de Weerd et al., 2006)
2. Identify and describe capabilities

- Experience
- Literature research
- Interviews domain experts

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<tr>
<th>Relevance cycle</th>
<th>Design cycle</th>
<th>Rigor cycle</th>
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<tbody>
<tr>
<td>First evaluation with domain experts</td>
<td>Build capabilities</td>
<td>Grounding on existing SPM literature</td>
</tr>
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</table>

RPA: Internal stakeholder involvement

**Goal:** Improved product quality & increased involvement of internal stakeholders in the product management process.

**Action:** All relevant internal stakeholders (e.g. the product manager, support, services, development, sales & marketing, research & development) indicate the requirements that should be incorporated in future releases by assigning priorities to the requirements from their point of view.

**References:** Ebert (2007), Berander (2009)

<table>
<thead>
<tr>
<th>Requirements prioritization (RP)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
</table>

- RPB: Prioritization method
- RPC: Customer involvement
- RPD: Cost revenue consideration
- RPE: Partner involvement
3. Position capabilities

- Determine dependencies
- Use preferred implementation order

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<td><strong>Requirements prioritization</strong></td>
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</tbody>
</table>

| **RPA: Internal stakeholder involvement** | Prerequisite(s): RGA |
| **RPB: Prioritization method**          | Prerequisite(s): -  |
| **RPC: Customer involvement**           | Prerequisite(s): RPB |
| **RPD: Cost revenue consideration**     | Prerequisite(s): RIB |
| **RPE: Partner involvement**            | Prerequisite(s): -  |

| **Design cycle** | Build maturity matrix |
| **Rigor cycle**  | Grounding on literature on focus area MM |
4. Validate capability positions

- Questionnaire among *product managers* and *product management experts* (researchers, consultants, etc.)
- 48 valid responses
4. Validate capability positions (cont’d)

Analysis of results
4. Validate capability positions (cont’d)

• Some results
  – Several capabilities shifted one or more cells
  – Some capabilities appeared to be too ‘broad’ and needed to be split up
5. Finetune capabilities

• Maturity matrix is not static, we continue to improve it

• Case studies statistics
  – Currently appr. 35 case studies (or: assessments) have been carried out
  – Company size ranges from 5 to 5,800 fte
  – Mostly Dutch companies, 2 Swiss, and Finland is on the way
Current status

• PhD student started in 2008 (4 days Centric, 1 day UU)

• International attention (Germany, Switzerland, Germany, Finland)

• More info on how to create your own maturity matrix: van Steenbergen et al. (2010)
References


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• Fundamentals of Design Science
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• Reflection
Design research by means of Case Study research

Case study research

- Theory building – Theory testing
- Single case – Multi-case

Process for Case Study research

1. Formulate Case study research questions
2. Establish case study protocol
3. Perform case studies and fill case study database
4. Write case study report

Essential is to establish a Chain of Evidence
Gathering Evidence

• **Document Study**
  – Operational documents
  – Archives
  – e-Mail, etc.

• **Interviews**
  – Much of the same impact factors as for surveys
  – open ended questions
  – closed questions
  – interview protocol, etc.

• **Direct observations**
  – During case study you’ll encounter many interesting phenomena

• **Participant observation**
  – Taking part in the process
  – Observation influences the end result

• **Physical artifacts**
  – Physical goods
  – Software artifacts
  – etc.
Openness in Software Producing Organizations

- **Research Question:** “Can a model be created that establishes how open a software producing organization is?”

- **Approach:** Design research including case study research for evaluation

- **Three cases**
  - Eclipse Foundation
  - Open Design Alliance
  - GX

- **Artifacts:** The Open Software Enterprise Model
  - Method for establishing how open a software enterprise is
  - Model that can be used to establish openness or to evaluate new openness strategies
  - Software Producing Organization Openness Degree

\[
O_d(x) = \frac{n(O_d(x))}{n(O_d)} \land d \in D
\]  

(1)

\[
O(x) = \sum_{d \in D} O_d(x) \cdot 20
\]  

(2)
Case studies for Evaluation

• Interviews (2 per person, several per case)
• Document study
• Three case study databases
• One case study protocol
• 2 researchers

• Findings
  – Cases require that factors are further detailed
  – Cases illustrate use of the model

• Results
  – Openness is not only determined by open source
  – Main activity for a consortium: development
  – Main activity for an open source foundation: governance
  – Openness not necessarily beneficial to organization

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<td>Total Openness Degree</td>
<td>55%</td>
<td>45%</td>
<td>67%</td>
<td>58%</td>
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Table 3: Openness Degree of the Evaluated Organizations
Case Study Report Outline

1. Introduction – describing the case study and motivivation in short

2. Research – describing the research questions, method and vision
   2.1 Research project
   2.2 Conceptual model and terminology
   2.3 CCU model description
   2.4 Research questions
   2.5 Research methods

3. Description of the host organization
   3.1 Short description
   3.2 Main product(s)
   3.3 Employees and organizational structure
   3.4 Customers
   3.5 The market

4. Description of Openness of Case Study Subject
   4.1 Historical development and Ecosystem Health
   4.2 Openness Degree
   4.3 Business Model vs Openness

5. Observations and Conclusions

6. Potential Improvements
Case Study Research Discussion

• Advantages
  – Fits well in curriculum (usually fits well within master student project)
  – Enables study of a phenomenon, black sheep case
  – Explorative
  – Easy to publish

• Disadvantages
  – Hard to generalize
  – Easy to meddle
  – Recent review comment: “Overall how representative are your companies for European companies? I doubt it, the effect allow that they were involved in University networks leads to a high probability that they were special in some way. Moreover, for the specific kind of results you are interested in (e.g., is the information complete), you do not want to have average companies, but rather best practice.”
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Business Informatics Research Framework

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  - Processes
- Technology
  - Infrastructure
  - Applications
  - Communications architecture
  - Development capabilities

Information Systems Research
- Develop / build
  - Theories
  - Artifacts
- Justify / evaluate
  - Analytical
  - Case study
  - Experimental
  - Field study
  - Simulation
- Assess
- Refine

Scientific Knowledge
- Foundations
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Relevance
- Business needs
- Application in the appropriate environment

Rigour
- Applicable knowledge
- Additions to the knowledge base

(based on Hevner, 2004)
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Build design artifacts & processes

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(based on Hevner, 2007)
In Retrospect

1. First study
   - Artifact: Maturity Matrix
   - Design cycle: Survey

2. Second study
   - Artifact: Openness Degree
   - Design cycle: Case study
### Research Approach

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<td><strong>Axiology</strong>: what is of value</td>
<td><strong>Truth</strong>: universal and beautiful; prediction</td>
<td><strong>Understanding</strong>: situated and description</td>
<td><strong>Control</strong>: creation, progress (i.e. improvement), understanding</td>
</tr>
</tbody>
</table>

In many scientific domains the methodological schools are strongly segregated with own approaches, theories, communities, conferences, journals. Often the schools look down on each other.

**We think science is found in the situational research method, i.e. the utilization of the (combination of) best research methods for the research problem at hand.**
Discussion and questions?