Design science in information systems research

Hevner et al (2004)

Meta: COIN-Antrag hat das Paper hergenommen und interpretiert was das im Falle des konkreten Projektes bedeutet.

paper's goal: how to conduct, evaluate and present design-science research

approaches from:

- **behavioral science**
  - roots in natural science?
  - analysis of people↔tech
  - field studies → phenomena in context
  - goal is "truth"
  - evaluated against norms of truth and explanatory power
  - methods: data collection and empirical analysis
  - predict or explain phenomena with respect to:
    - artifact's use
    - perceived usefulness (intention to use)
    - impact on individuals and organizations (net benefits)
    - usually but not exclusively for instantiation
- **design science**
  - roots in engineering?
  - problem solving
  - changing phenomena that occur
  - creates and evaluates IT artifacts
  - problem-solution-space leaving freedom for style/expression/aesthetical choices
  - constructing to understand the problem
  - methods: "computational and mathematical @ quality and effectiveness of artifacts" (?) (what about User-tests of designs?)
  - fundamental questions
    - "What utility does the new artifact provide?"
    - "What demonstrates that utility?"
  - wicked problems (Brooks 1987, 1996; Rittel, Webber 1984)
    - unstable requirements, ill-defined enviromental contexts
    - complex interactions among subcomponents of problem and solution
    - inherent flexibility to change design processes and artifacts
    - critical dependence on human cognitive abilities (e.g. creativity) for effective solutions
    - critical dep. ... social abilities (e.g. teamwork) ...
    - **{** js-client architecture as wicked problem? changing a lot but i assume best-practices

        will form as they did for server-side **}**
    - vs routine design:
        - routine: existing knowledge/best practices for organizational problems
        - routine: full-grown systems
        - research: unsolved problems in unique/innovative ways
        - research: solved problems but more effective/efficient
        - research: contribution to foundations and methodologies
        - research: requisite knowledge is non-existent
            - **{** e.g. how to deal with web sockets in redux? **}**
            - **{** e.g. how to integrate rdf-store? **}**
            - **{** e.g. how to do this without switching to React **}**

design and theory inform each other and point out each other's short-comings via justify/evaluate-activity (p80)

implications of empirical IS research should be:

- implementable
- synthesize existing research
- or stimulate critical thinking among IS practitioners

technology and behavior are inseparable

Walls et al. (1992): design is both:

- process (set of activities)
- product (artifact)

March and Smith (1995):

- design processes
    - build
    - evaluate
- design artifacts
    - constructs
        - vocabulary and symbols
        - provide language to define problems and solutions
        - "solving a problem simply means representing it so as to make the solution transparent." – Simon (1996, p. 132)
        - formal problem definition: difference between goal and current state with search process in-between
        - simplified/rough early, complex/well-fitting after design-iterations
    - models
        - abstractions and representations

        - represent real-world situation ~= design problem and solution space
        - aid problem/solution understanding
        - enable exploration of effects of design decisions
    - methods (algorithms and practices)
        - how to solve problem / search problem-space
    - instantiations (implemented and prototype systems)
        - demonstrate feasibility
        - enable assessment of artifacts suitability to its intended purpose

Information Systems Research Framework – Hevner et al. (2004)

Rigor achieved by appropriately applying existing foundations and methodologies

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.
    - **demonstrates feasibility** (makes it research iff feasibility wasn't clear to begin with)
    - can be in form of tools and frameworks
    - can demonstrate possibility to automate
    - "proof by construction" (Nunamaker 1991a)
2. **Problem Relevance:** The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
    - **Relevance** is with respect to a constituent community (e.g. IS practitioners)
    - **Technology Acceptance Model** short TAM (Venkatesh 2000)
    - Combination of artifacts for acceptance building:
        - technology-based (e.g. system conceptualizations, practices, technical capabilities, interfaces,…)
        - organization-based (e.g. structures, reporting systems, social systems, …)
        - people-based (e.g. training, consensus building, …)
3. **Design Evaluation:** The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
    - includes integration into infrastructure/usage context
    - requires definition of appropriate metrics and gathering of appropriate data
    - provides feedback for iterations typical for design
    - for methods see "Design Evaluation Methods" below
    - evaluate in terms of:
        - functionality
        - completeness
        - consistency
        - accuracy
        - performance

        - reliability
        - usability
        - fit with the organization
        - other relevant quality attributes
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.
    - novelty, generality, significance of artifact
    - assessed via representational fidelity and implementability
    - artifact should extend knowledge-base or use previous knowledge in new and innovative ways
    - contributions to foundations extend knowledge-base
    - methodologies: evaluation methods and metrics (e.g. TAM)
5. **Research Rigor:** Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
    - over-emphasis on rigor often results in lower relevance (Lee 1999) {e.g. positivism}
    - environments and artifacts might defy excessive formalism
    - rigor is derived from the effective use of the knowledge-base
    - construction of effective metrics
    - “human-machine problem-solving-systems” → behavioral theories and empirical work
    - understand why an artifact works or doesn’t work
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.
    - heuristic search strategies
    - generate/test-cycle {~hci/ux/usability-pm-cycle}
    - problem solving: utilizing available means → desired ends + satisfying laws in environment
        - often not possible to determine, let alone explicitly describe due to wicked nature (Vessey and Glass 199)
    - often simplifies
        - **{** where did we start with the changes/refactoring? **}**
        - subset of problems/simpler subproblems
        - more realistic → more relevant
    - searching for a satisfactory solution, instead of explicitly specifying all possible solutions
    - often unclear why it works / the extend of its generalizability .
    - establish if it does work and in which environments
        - what constitutes “working” and “good”? which metrics?
            - **{** in what way is our current architecture better fitted? incl migration effort vs budget limits. what else might we want to try? **}**
        - compare with other solutions for the same problem by human experts
            - **{** compare to other architectures/setups **}**
        - **{** when to and when not to use this architecture? it comes with a lot of overhead in setup, code and learning curve. e.g. for Quadex’s problem angular 2 was the better tool **}**

7. **Communication of Research:** Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.
    - @ technology-oriented: construction and evaluation process { to allow reproduction }
    - @ managment-oriented:
        - { answer “is it worth the effort for my business?” }
        - required knowledge / {“who can use it?”}
        - importance of problem
        - effectiveness of solution
        - some detail in appendices that allow some understanding/appreciation

The guidelines are not mandatory / to be used as rote, but should all be addressed.

Design Evaluation Methods

1. **Observational**
    - **Case Study:** Study artifact in depth in business environment
    - **Field Study:** Monitor use of artifact in multiple projects
2. **Analytical**
    - **Static Analysis:** Examine structure of artifact for static qualities (e.g., complexity)
    - **Architecture Analysis:** Study fit of artifact into technical IS architecture
    - **Optimization:** Demonstrate inherent optimal properties of artifact or provide optimality bounds on artifact behavior
    - **Dynamic Analysis:** Study artifact in use for dynamic qualities (e.g., performance)
3. **Experimental Controlled Experiment:**
    - Study artifact in controlled environment for qualities (e.g., usability)
4. **Testing Functional (Black Box) Testing:**
    - **Execute artifact** interfaces to discover failures and identify defects Simulation – Execute artifact with artificial data
    - **Structural (White Box) Testing:** Perform coverage testing of some metric (e.g., execution paths) in the artifact implementation
5. **Descriptive**
    - **Informed Argument:** Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact’s utility
        - **{** this **}**
        - (only) usable for more innovative artifacts for which other methods aren’t feasible
    - **Scenarios:** Construct detailed scenarios around the artifact to demonstrate its utility