Design Science

Research Seminar

Homework

- IT-related research questions:
  - One academic questions
  - One practical questions

- Define:
  - Research question
  - What and how would you measure?
  - Research method(s)

The Research Methods Toolkit

Method	Setting	Data Type	Role
Action research	Field	Qualitative	Active
Case study	Field	Qualitative	Passive
Experiment	Laboratory	Quantitative	Active
Non-reactive	Laboratory	Quantitative	Passive
Survey	Field	Quantitative	Passive

Design Research

- A type of research in IS field
  - The process of developing a new idea or solution e.g. new language, method etc.
  - Tools, methods, languages are a prescriptive form of theory
  - Usually iscombined with an empirical method (action research, experiment) to validate its effectiveness

Design Research

Herbert Simon:

- “The natural sciences are concerned with how things are; design is concerned with how things ought to be, with devising artifacts to attain goals.”

- “Engineering, medicine, business, architecture and painting are concerned not with the necessary but with the contingent - not with how things are but with how they might be - in short, with design.”

Design Research

- Hevner, A.R., March, S.T., Park, J. and Ram, S. Design Science in Information Systems Research. MIS Quarterly, 28 (1). 75-105, 2004.
- The design-science paradigm has its roots in engineering. It is fundamentally a problem-solving paradigm.
- Design science "creates and evaluates IT artifacts intended to solve identified organizational problems."

Artifact

- Constructs
  - provide the language in which problems and solutions are defined and communicated
- Models
  - use constructs to represent a real-world situation—the design problem and its solution space
- Methods
  - define processes
  - provide guidance on how to solve problems, that is, how to search the solution space.
  - range from formal, mathematical algorithms that explicitly define the search process to informal, textual descriptions of “best practice” approaches, or some combination
- Instantiations
  - show that constructs, models, or methods can be implemented in a working system.

Research in Information Systems

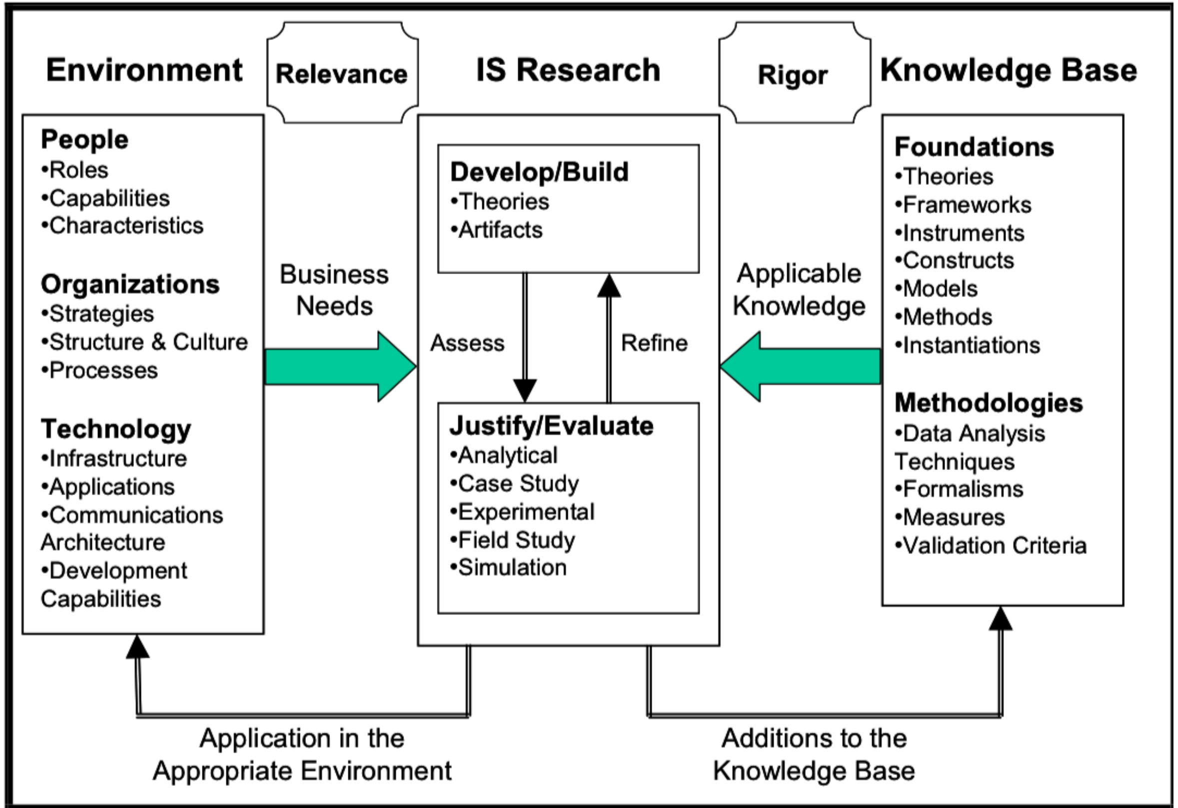
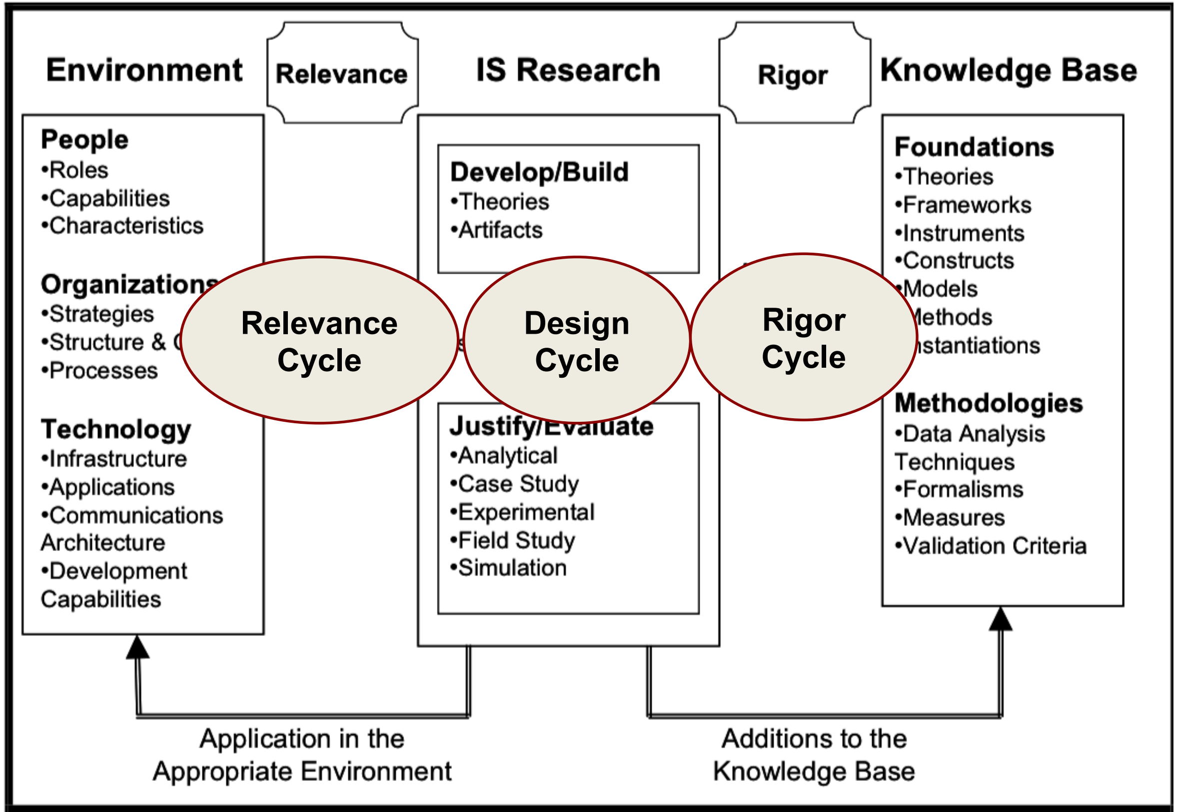


Figure 2. Information Systems Research Framework

Design Research Guidelines



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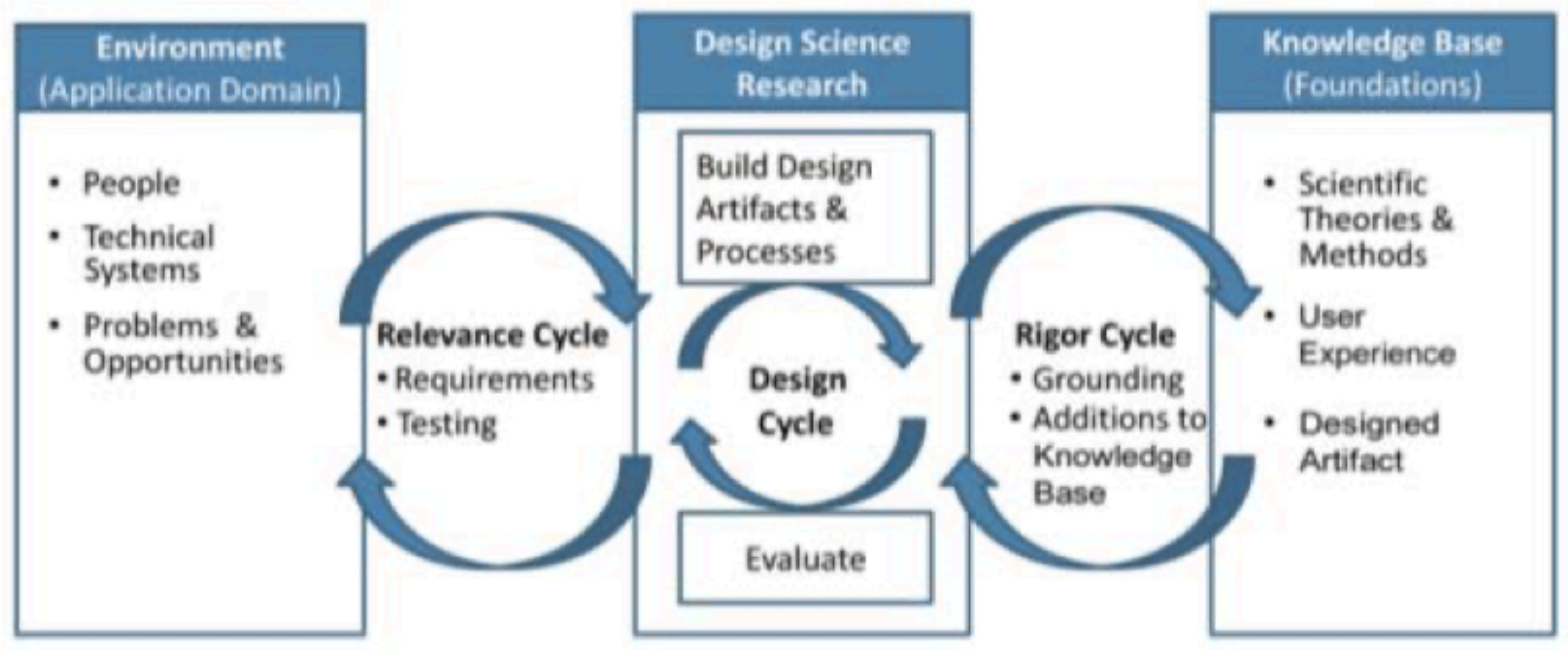

Hevner et al. (2004)

Design Research Guidelines

Table 1. Design-Science Research Guidelines	
Guideline	**Description**
Guideline 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.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 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.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 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.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Hevner et al. (2004)

Design Research Guidelines

Table 9. Design science contributions

Guideline [14]	Contribution
Design as an Artifact	The research outcomes: 1. DeepCause artifact for extracting elements of a hypothesis 2. Influence of different model parameters on the performance
Problem Relevance	Because of the exponentially increasing number of scientific papers, we need methods for extracting causal claims for theory ontology learning
Design Evaluation	Evaluation of the artifact based on a test set, measured on F1 score, accuracy, precision, and recall
Research Contributions	Compared to the rule-based CauseMiner tool, this paper shows the potential of deep learning for hypothesis extraction
Research Rigor	Creating a gold standard, split of the data into training, development, and test sets
Design as a Search Process	Extensive test of different hyperparameters
Communication of Research	Detailed information of the best deep learning architectures

Design Science Research Method Process Model

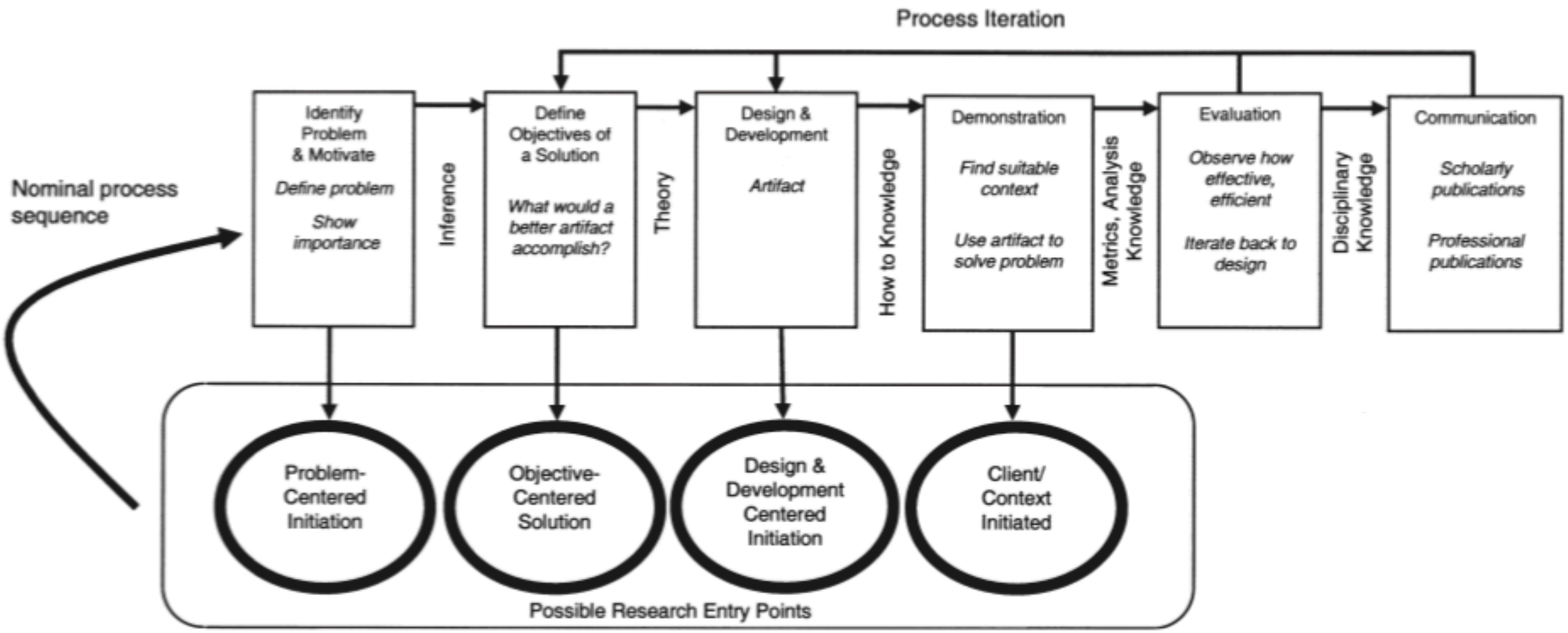

Figure 1. DSRM Process Model

Design Research Guidelines

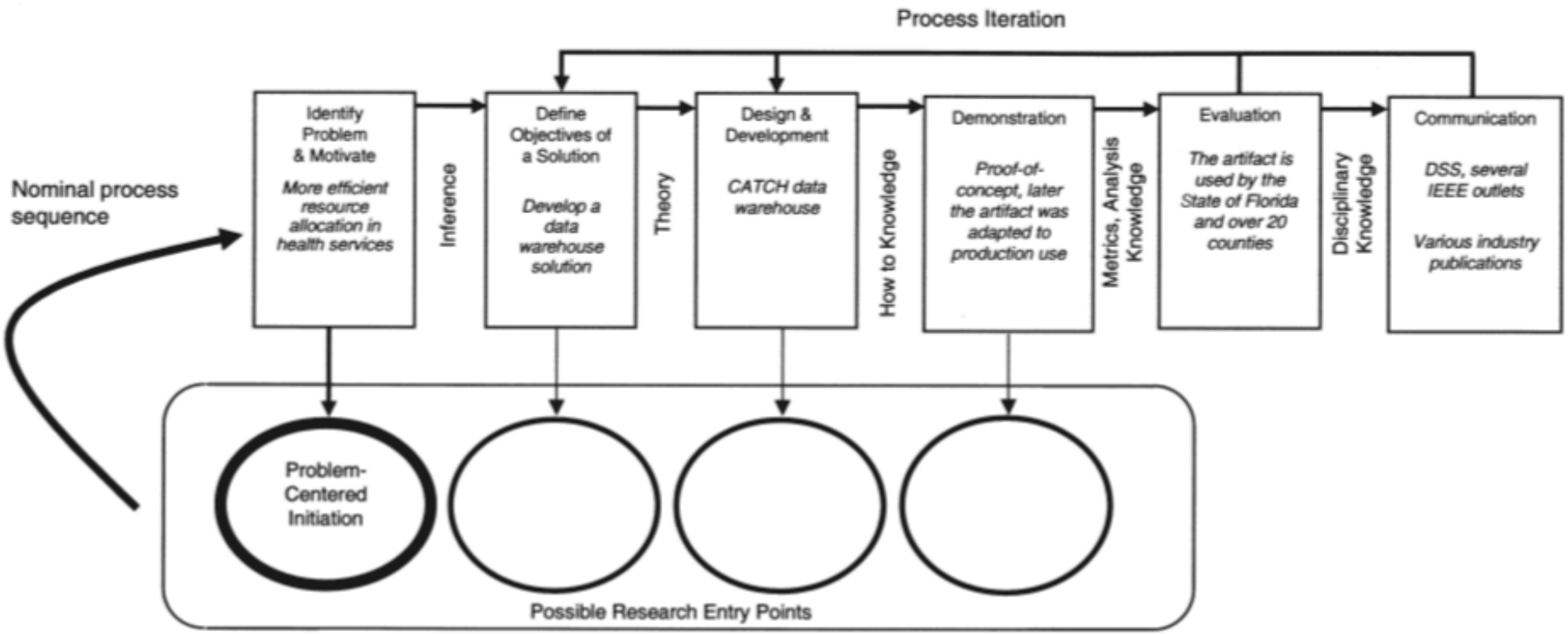

Figure 2. DSRM Process for the CATCH Project

Design Science Research Knowledge Contribution

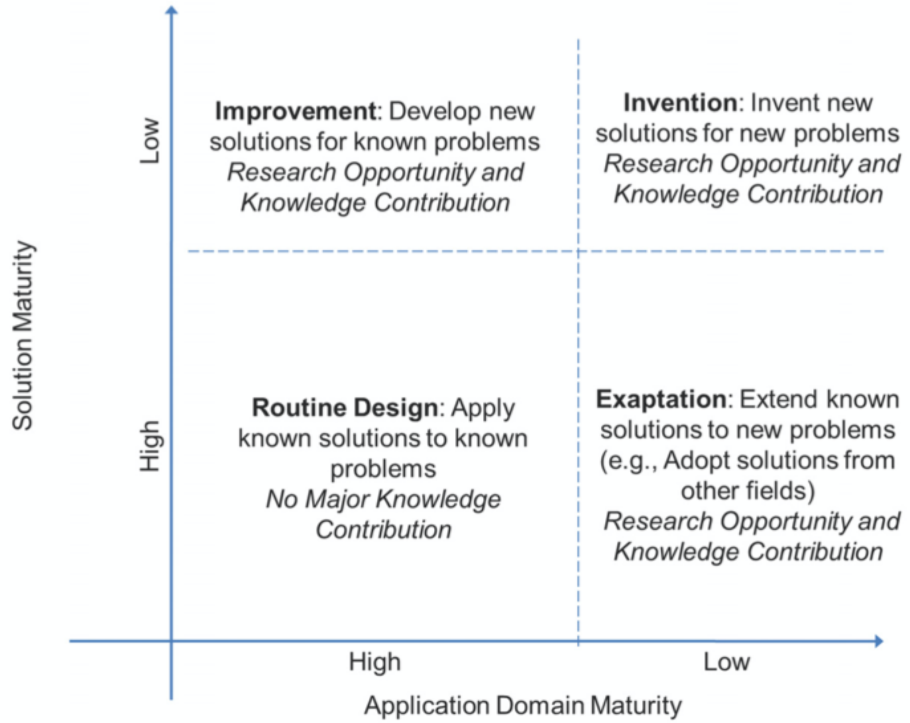

Figure 3. DSR Knowledge Contribution Framework

Framework for Evaluation in Design Science (FEDS)

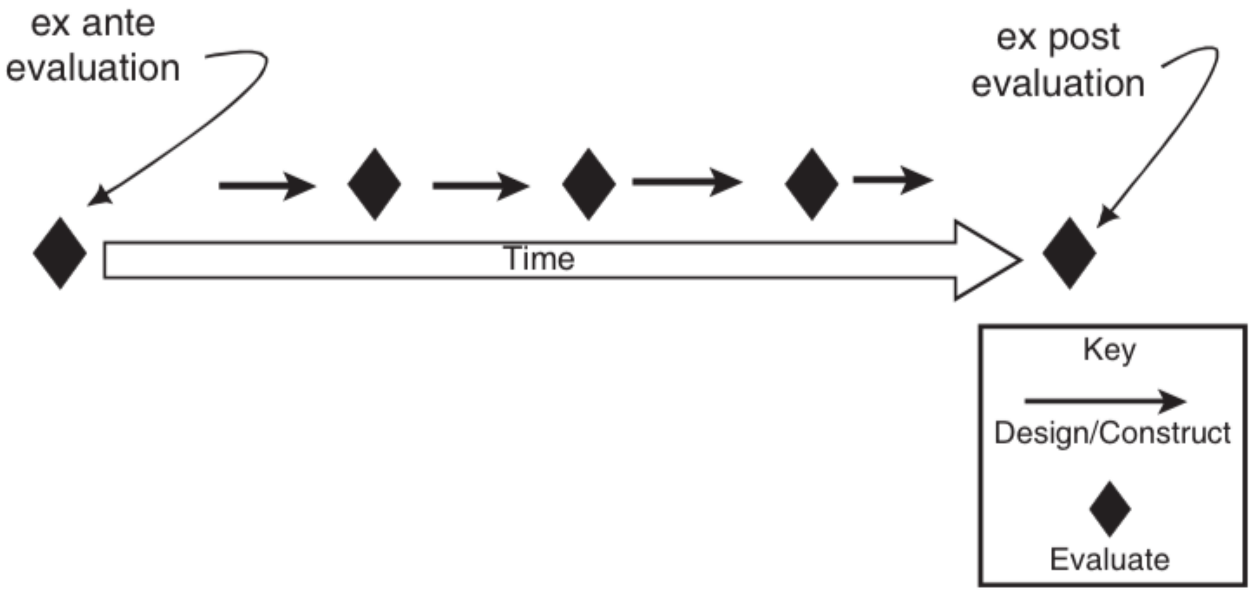

Figure 1 *Ex ante–ex post* evaluation time continuum.

Framework for Evaluation in Design Science (FEDS)

- Why to evaluate:
  - Formative Evaluation
    - Ex Ante
    - help improve the outcomes of the process under evaluation
  - Summative Evaluation
    - Ex Post
    - judge the extent that the outcomes match expectations
- How to evaluate:
  - Artificial Evaluation
    - includes laboratory experiments, simulations, criteria-based analysis, theoretical arguments, and mathematical proofs
  - Naturalistic Evaluation
    - explores the performance of a solution technology in its real environment

Venable et al. (2014)

Framework for Evaluation in Design Science (FEDS)

	Ex Ante	Ex Post
Naturalistic		
Artificial		

Framework for Evaluation in Design Science (FEDS)

DSR Evaluation Method Selection Framework	Ex Ante	Ex Post
Naturalistic	•Action Research •Focus Group	•Action Research •Case Study •Focus Group •Participant Observation •Ethnography •Phenomenology •Survey (qualitative or quantitative)
Artificial	•Mathematical or Logical Proof •Criteria-Based Evaluation •Lab Experiment •Computer Simulation	•Mathematical or Logical Proof •Lab Experiment •Role Playing Simulation •Computer Simulation •Field Experiment

Venable et al. (2012)

Framework for Evaluation in Design Science (FEDS)

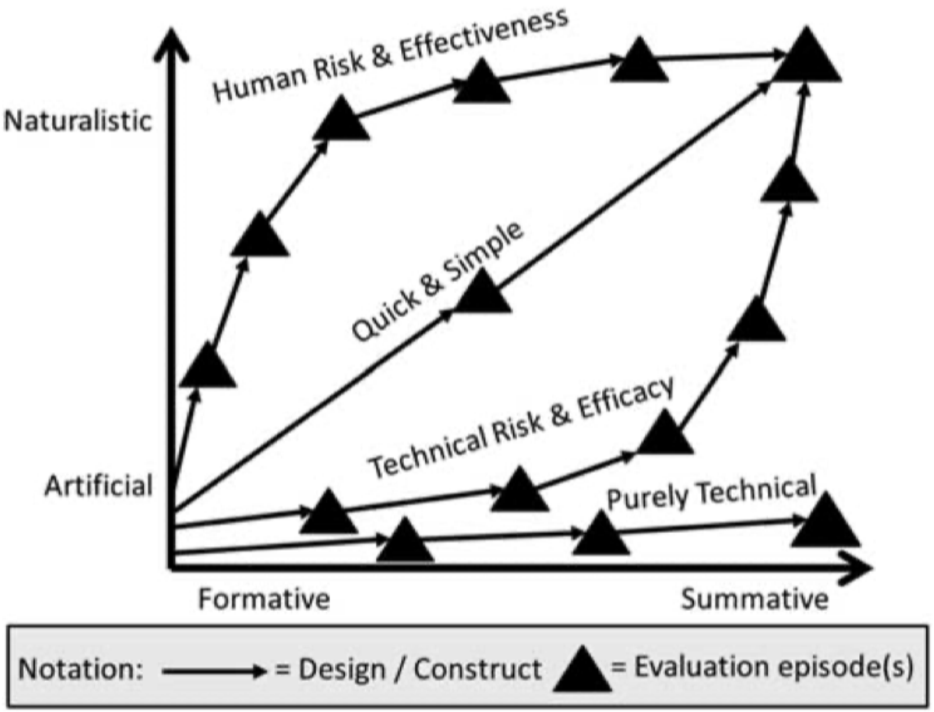

Figure 2 FEDS (Framework for Evaluation in Design Science) with evaluation strategies.

Design Research Guidelines

Table 2. 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)
	Simulation – Execute artifact with artificial data
4. Testing	Functional (Black Box) Testing: Execute artifact interfaces to discover failures and identify defects
	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
	Scenarios: Construct detailed scenarios around the artifact to demonstrate its utility

Hevner et al. (2004)

Common Mistakes in Data Science Master Theses

- No clear separation of training and test data
  - E.g. use of test data for hyperparameter tuning
- Data Leakage (Target Leakage)
- Used evaluation metric is not appropriate for the problem
- Theoretical Concepts are not explained properly

Homework

- Is your master thesis design Science research?
  - If yes: Use your research question for the homework
  - If no: Formulate a design science research question

1. What kind of artifact do you want to design
   - construct, model, method, instantiation? (Hevner et al., 2004)
2. What is your Research Entry point
   - Based on the DSRM process model (Peffers et al., 2007)
   - Problem-centered initiation, objective-entered solution, design & developement centered initiation, client / context initiated
3. Design Science Research Knowledge Contribution
   - Routine design, improvement, exaltation, invention (Gregor & Hevner, 2013)
4. Framework for Evaluation in Design Science (FEDS)
   - Naturalistic vs. Artificial, Ex Ante vs. Ex Post
   - Possible Evaluation Methods