Lorenz Glißmann, Sascha Safenreider

Scientific Writing

Research Design

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Research Design

- The blueprint of your scientific study.
- Defines how research questions will be answered.
- Ensures coherence between problem, method, and result.
- Includes:
  - Research question or hypothesis
  - Methodological framework
  - Data collection & analysis plan
  - Evaluation strategy

Why Research Design Matters

- A researcher wants to know:
  - Does a new teaching method improve student performance?
- Without a design: They might just use the method in one class and assume it worked because grades improved. But what if the class was already high-performing? Or if the improvement was due to other factors?
- With a strong design: They use a randomized controlled trial assigning students randomly to the new method or traditional method, measuring outcomes, and comparing results statistically.
- Key reasons why research design matters:
  - Ensures validity (internal and external)
  - Minimizes bias and confounding variables
  - Guides data collection and analysis
  - Enhances reproducibility and credibility

Types of Research in Data & Computer Science

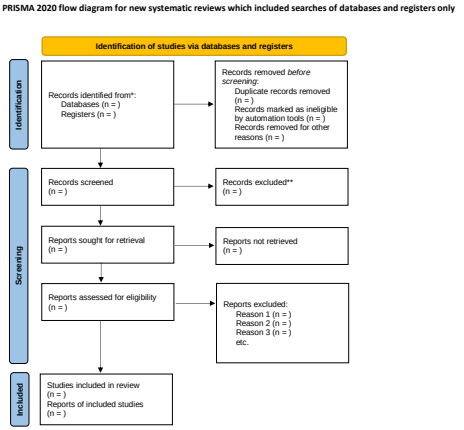
Type	Focus	Example
Quantitative	Data-driven, measurable results	Model performance benchmarking
Qualitative	Human-centered insights	UX study on AI interpretability tools
Mixed Method	Combining quantative and qualitative results	Survey + Interview
Conceptual	Theoretical or framework-based	New algorithmic model proposal
Systematic Review (SLR)	Evidence synthesis from prior studies	Deep learning fairness review
Design Science Research (DSR)	Artifact creation and evaluation	Visualization tool development

Systematic Literature Review (SLR)

- A structured, reproducible synthesis of existing research.
- Steps:
  1. Define research questions.
  2. Develop search strategy (databases, keywords).
  3. Select studies (inclusion/exclusion criteria).
  4. Extract & analyze data.
  5. Summarize findings and gaps.

Systematic Literature Review (SLR)

PRISMA 2020 Flow Diagram



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Design Science Research (DSR)

- Research approach focused on **creating and evaluating artifacts**.
- Artifacts can be:
  - Constructs (models, vocabularies)
  - Models (conceptual frameworks)
  - Methods (algorithms, processes)
  - Instantiations (software, tools)

Components of Design Knowledge for a Specific DSR Project

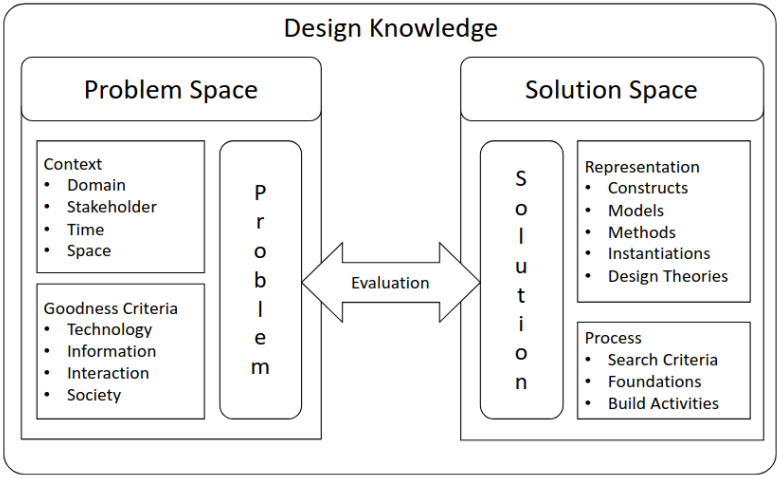


Image from **vom_introduction_2020**

Design Science Research (DSR): Overview

- Connects **theory** and **practice**
- Uses **iterative design cycles**
- Builds on **established theories** and **scientifically sound methods**
- Supports the **design, implementation, and evaluation** of systems
- Various **approach models** exist, differing in focus and granularity

Design Science Research

Kuechler and Vaishnavi (2019)

- **Understand Problem**
  - Identify real-world problem
- **Propose Solution**
  - Develop preliminary design idea
- **Develop Solution**
  - Implement design as an artifact
  - Focus on novelty of design
- **Evaluate Solution**
  - Assess with predefined metrics
- **Consolidate Learning**
  - Communicate design knowledge

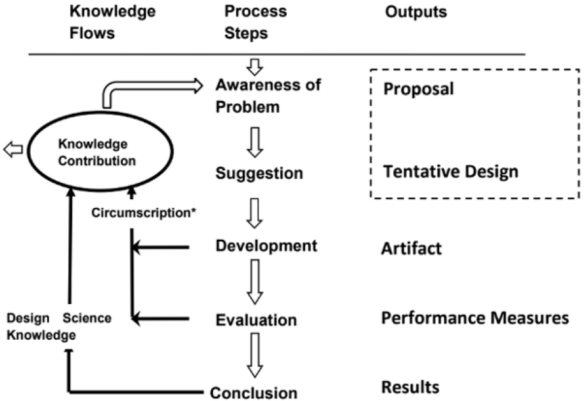


Figure: Design cycle (Vaishnavi and Kuechler 2012)

Design Science Research

Peffers et al. (2007)

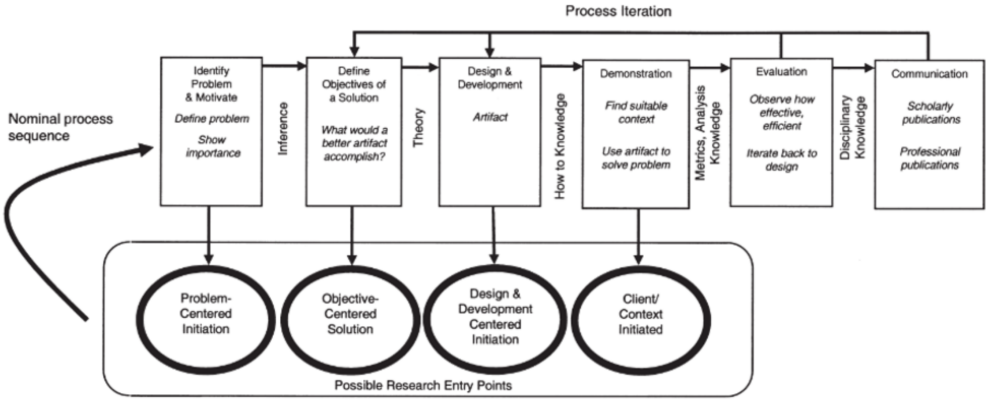


Figure: Design Science Research Process (Peffers et al., 2007)

Design Science Research

Action Design Research (Sein et al. 2011)

- **Focus**
  - Real-world problem solving
  - Organizational context
- **Phases**
  - Problem formulation
  - 'Building, Intervention, Evaluation' cycle
  - Reflection & learning
  - Formalization
- **Characteristic**
  - Joint work of researchers and practitioners within the process

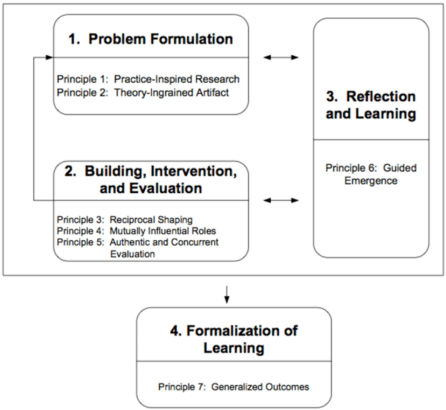


Figure: Action Design Research Process (Sein et al., 2011)

Design Science Research

Developing an Own Approach Model According to Wambsganß (2021)

- **Context**
  - No uniform DSR procedure models established
  - Researchers develop individual, theory-linked approaches
- **Step 1 – Problem Identification**
  - Define and justify a relevant real-world problem
- **Step 2 – Descriptive Knowledge**
  - Gather knowledge via literature analyses
- **Step 3 – Prescriptive Knowledge**
  - Derive design requirements from expert input
  - Represented as user stories
- **Step 4 – Preliminary Design Knowledge**
  - Develop artifacts at different abstraction levels
- **Step 5 – Validation of Design Principles**
  - Validate through expert feedback, instantiation or argumentation

Exercise: Applying Design Science Research (DSR)

Group Task 30 Min

1. Identify a practical real-world problem relevant to your field.
2. Discuss which type of artifact (construct, model, method, instantiation) could best address this problem.
3. Apply one DSR process on your problem
   - Here you find more context

Discussion: Insights from Group Work

Plenary Discussion 20 Min

- Presentation of selected group results:
  - Identified real-world problems and proposed artifacts
  - Chosen DSR process models and justifications
  - Suggested evaluation approaches
- Reflect together on:
  - Common challenges in defining and evaluating artifacts
  - How DSR bridges theory and practice

Take Home Message

- There are much more possibilities for Research Designs..
- Your research design isn’t just a method — it’s the foundation of credibility.