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## Scientific Writing

Research Design

# Table of contents

- 1 Introduction to Research Design
- 2 SLR
- 3 DSR
- 4 Practice
- 5 Plenary Discussion

# 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 quantitative 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        |

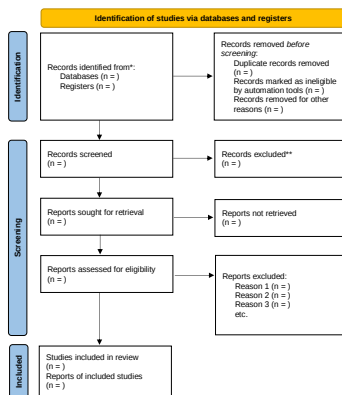
# Systematic Literature Review (SLR)

- 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

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



\*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

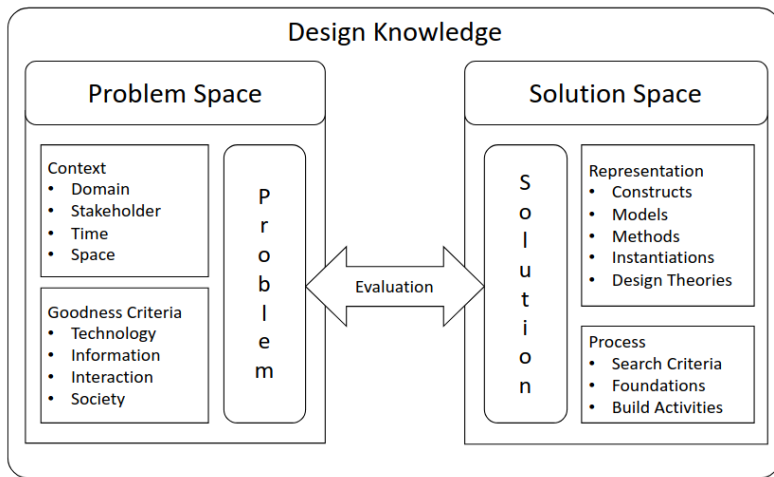


Image from **vom\_introduction\_2020**

# 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

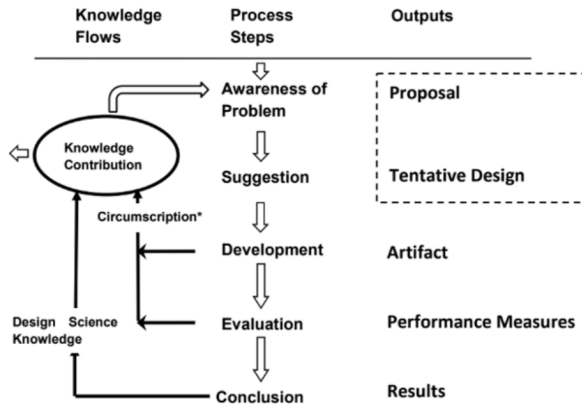


Figure: Design cycle (Vaishnavi and Kuechler 2012)

# Design Science Research

Peffers et al. (2007)

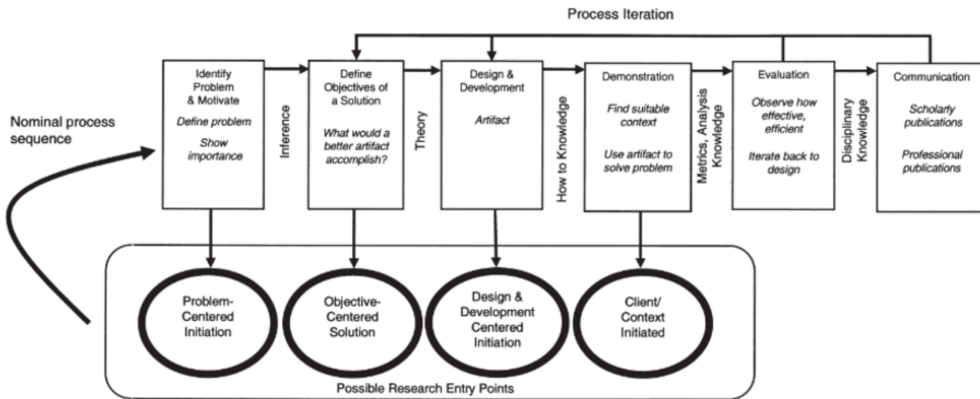


Figure: Design Science Research Process  
(Peffers et al., 2007)

# Design Science Research

Action Design Research (Sein et al. 2011)

## ■ Focus

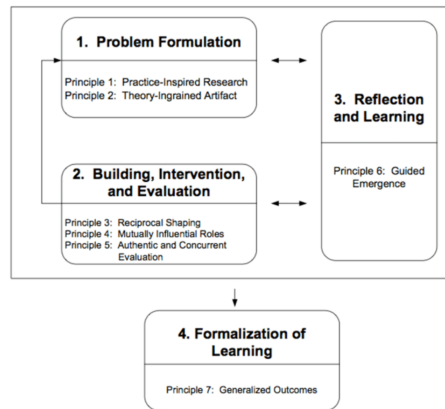
- ▶ Real-world problem solving
- ▶ Organizational context

## ■ 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.