

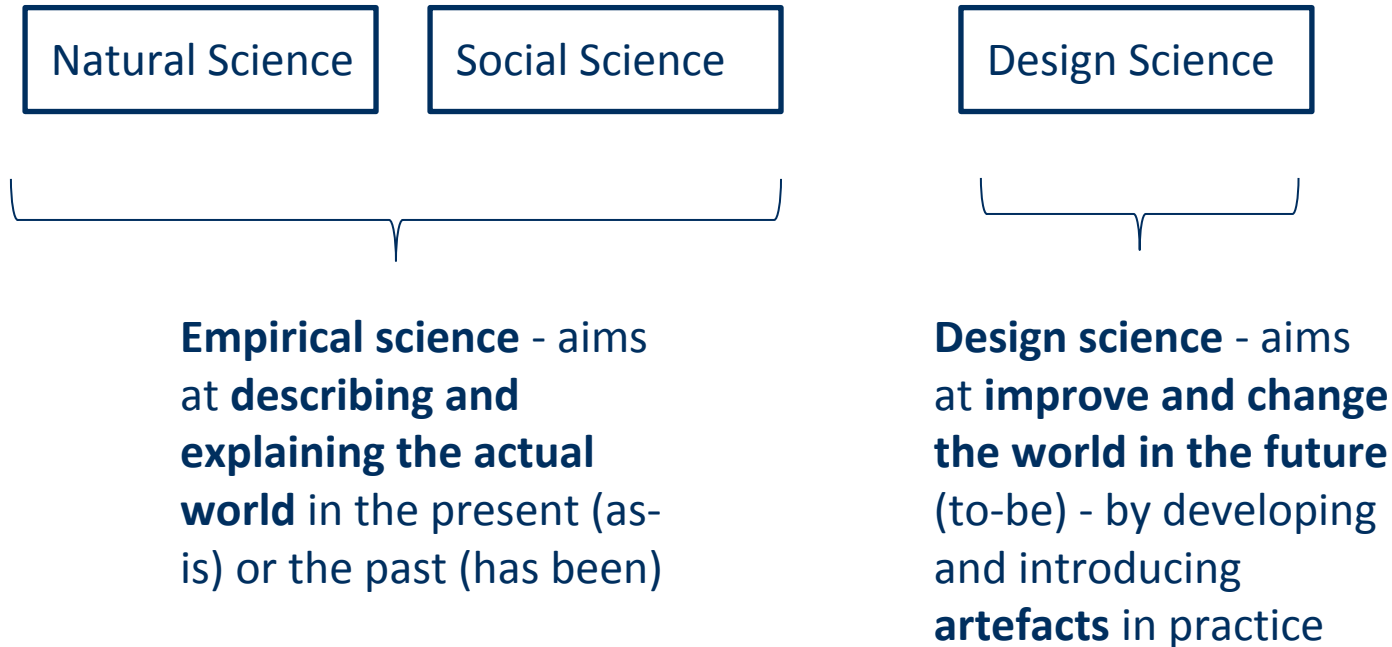
# Introduction to Design Science

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Stockholm University

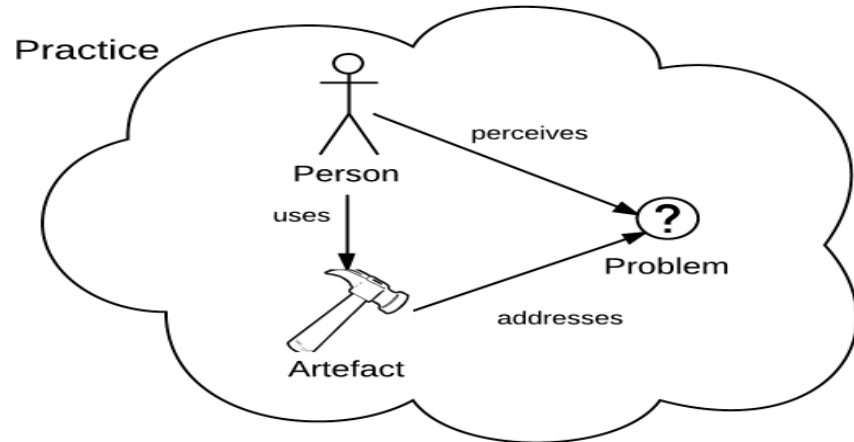
# What is Design Science?

# Positioning design science



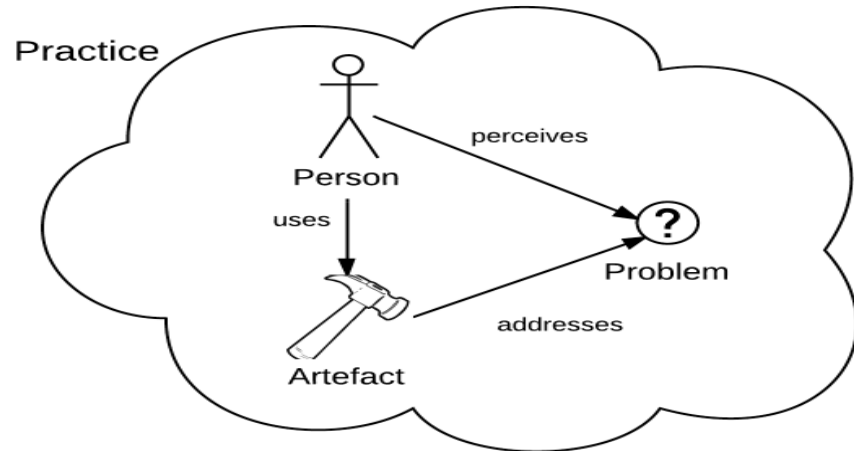
# Defining design science

- **Design science** is the scientific study and creation of **artefacts** as they are **developed and used by people** with the goal of **solving practical problems** of general interest



# Defining artefact

- An **artefact** is an object made by humans with the intention to be **used to address a practical problem** in a **practice**



# Artefact types in information systems

- IT system
- Prototype of an IT system
- Method
- Model
- Guidelines
- Requirements
- Algorithm
- Notation
- Metric
- Pattern
- Socio-Technical system
- ...

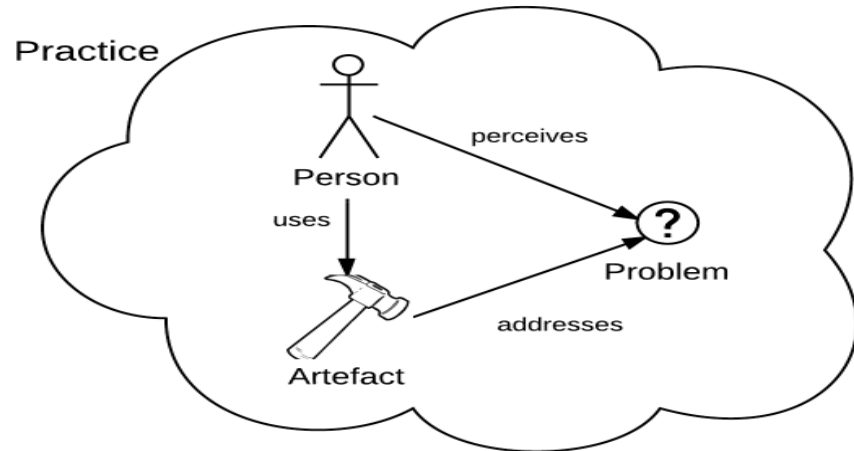
# Artefact types in information systems

Usually, **four types of artefacts** are presented when introduce design science (March & Smith, 1995):

- **Construct (构想, 观念)** – is a term, notation, concept needed for formulate problems and their possible solutions
- **Model** – is a representation of possible solution, that is, a model can be used for supporting construction of other artefact
- **Method** – defined guidelines and processes of how to solve problems and achieve goals
- **Instantiation (实例)** – is a working system that can be used in practice

# Artefact and practice

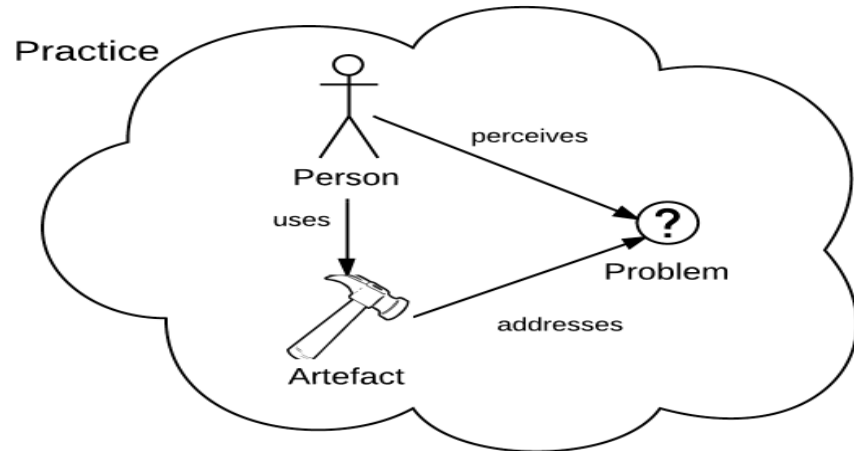
- An **artefact** is an object made by humans with the intention to be **used to address a practical problem** in a **practice**





# Defining practice

- A ***practice*** is a set of **human activities performed regularly** and seen as **meaningfully** related to each other by the people participating in them.

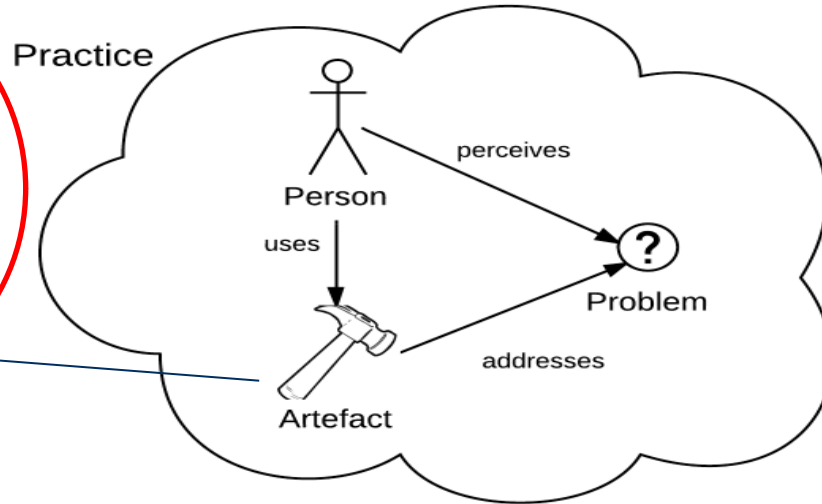


# An example of a practice

- The **practice of dentists** is an example a practice
- Dentist are engaging in cleaning teeth, drilling teeth, taking X-rays, and many other activities.
- To carry out the practice, dentists make **use of artefacts**, such as pliers, drills, X-ray machines, and other tools

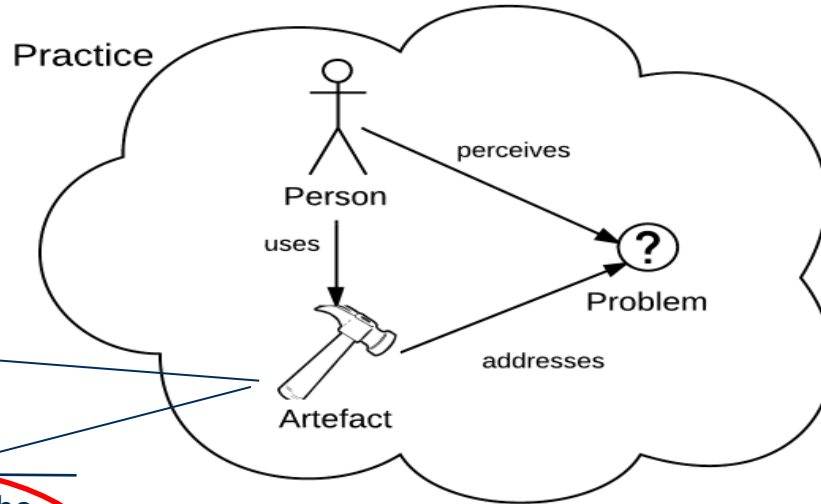
# What characterize design science?

The **artefact developed** in a design science project **needs to be novel, something new and original**, not previously developed



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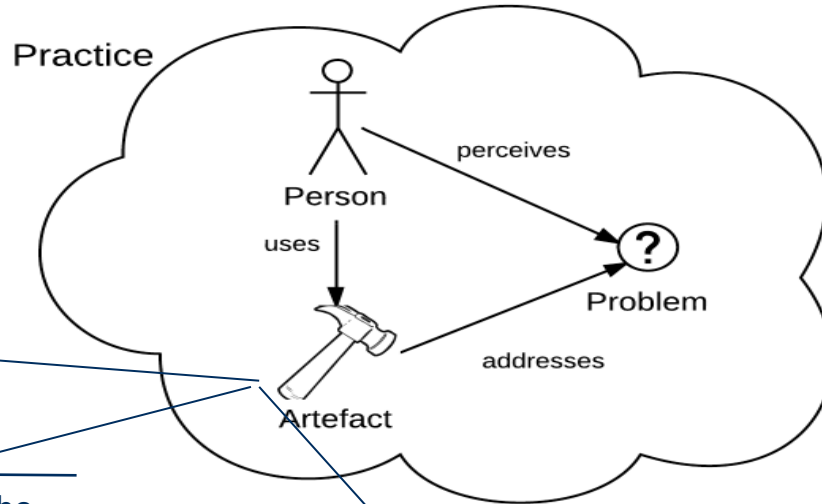
The **artefact is the solution that needs to be developed** to address the problem

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The **artefact is the solution that needs to be developed** to address the problem

The **artefact needs to be used in a practice**

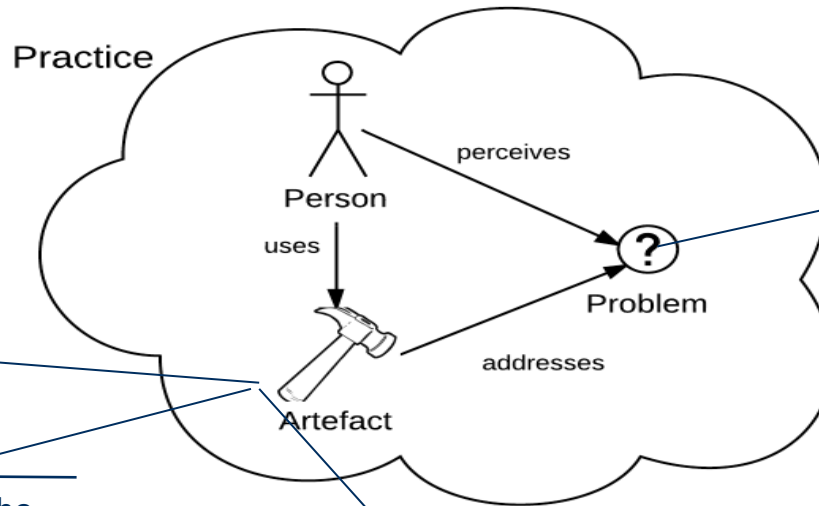


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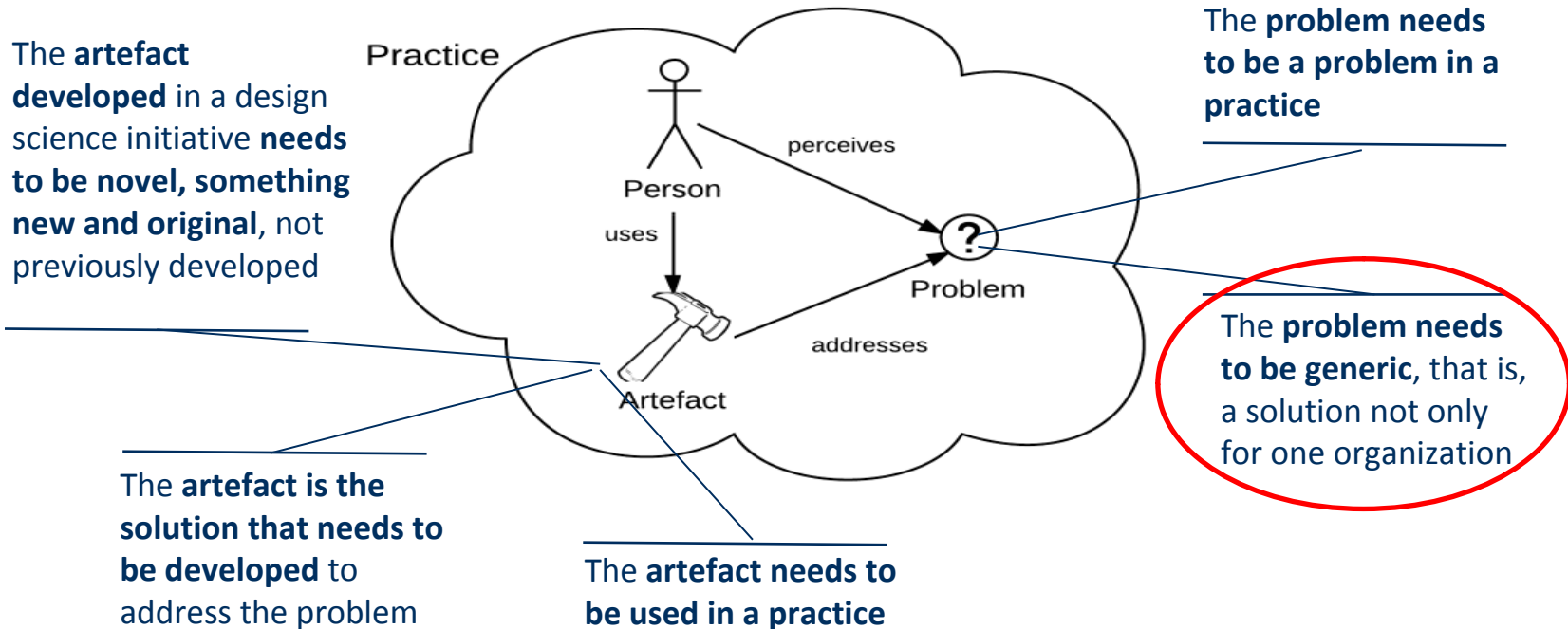
The **artefact is the solution that needs to be developed** to address the problem

The **artefact needs to be used in a practice**



The **problem needs to be a problem in a practice**

# What characterize design science?

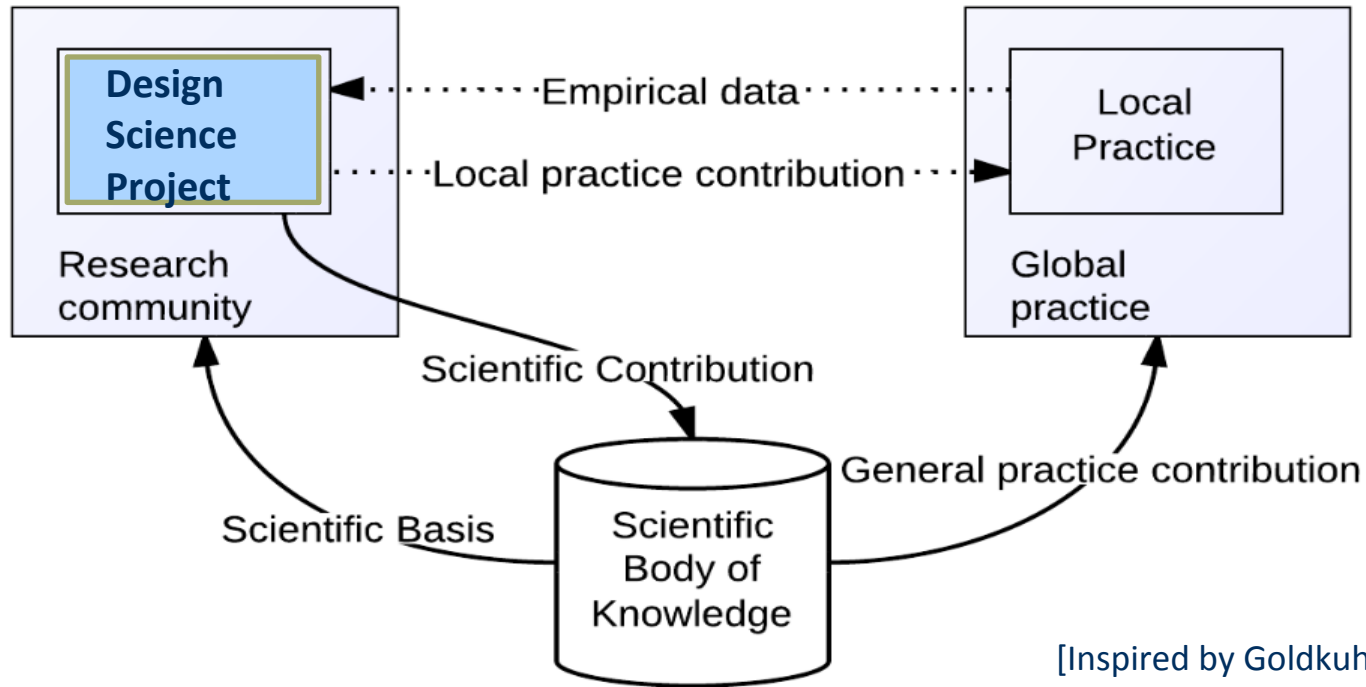


# Design science and Practice research

- ***Design science*** is often seen as part of what is called practical research
- ***Practice research*** is research that addresses problems in practices



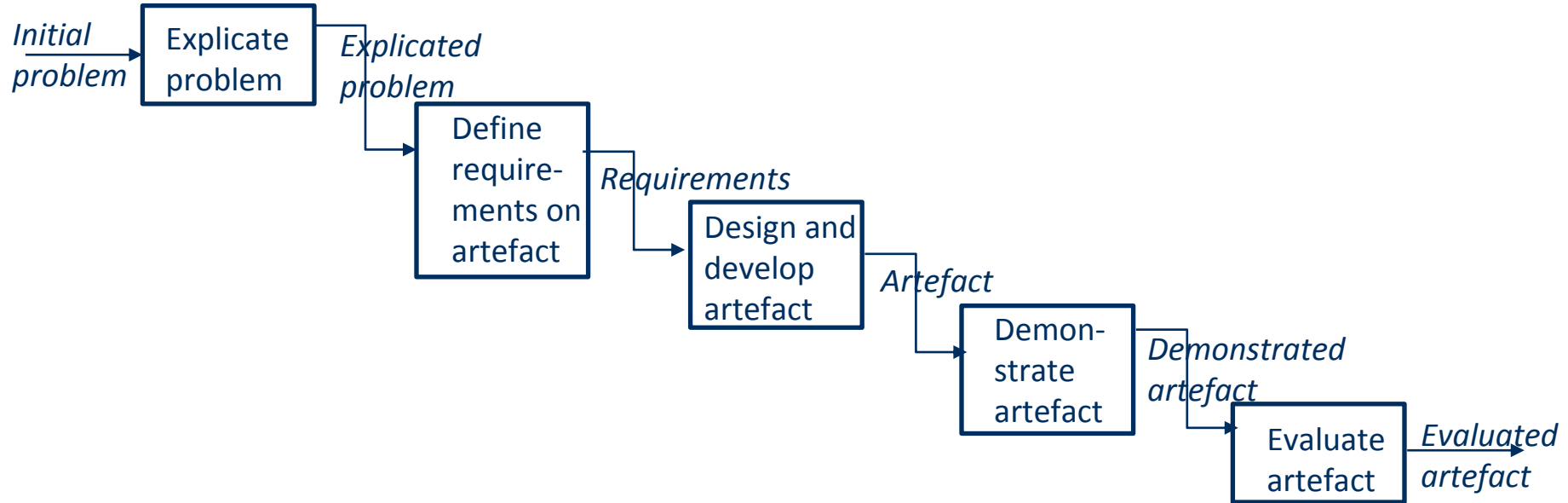
# Design science and Practice research



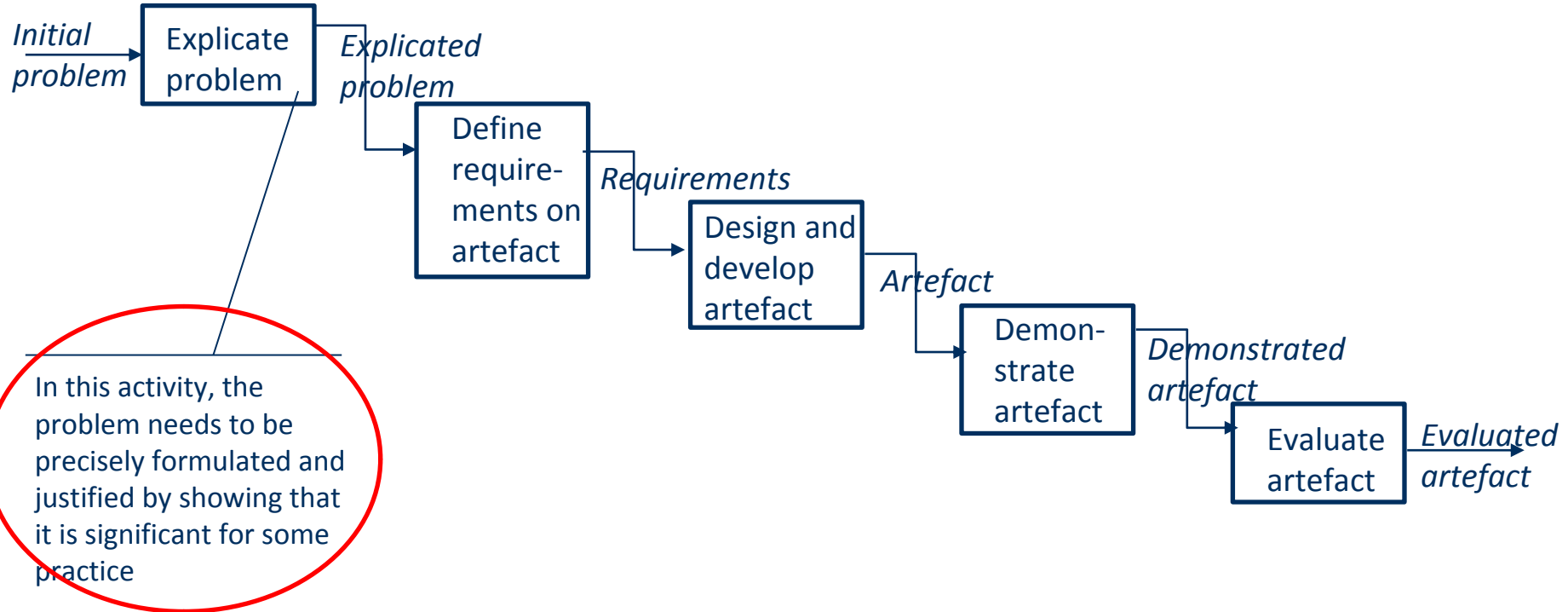
[Inspired by Goldkuhl, 2012]

# A Design Science Framework

# A design science framework



# A design science framework



# Explicate problem

Two categories of problems, and both need to be stated:

- **Practical problem** – is an issue for practitioners in the practice that they want to be addressed
- **Knowledge problem** – is often a knowledge gap in research

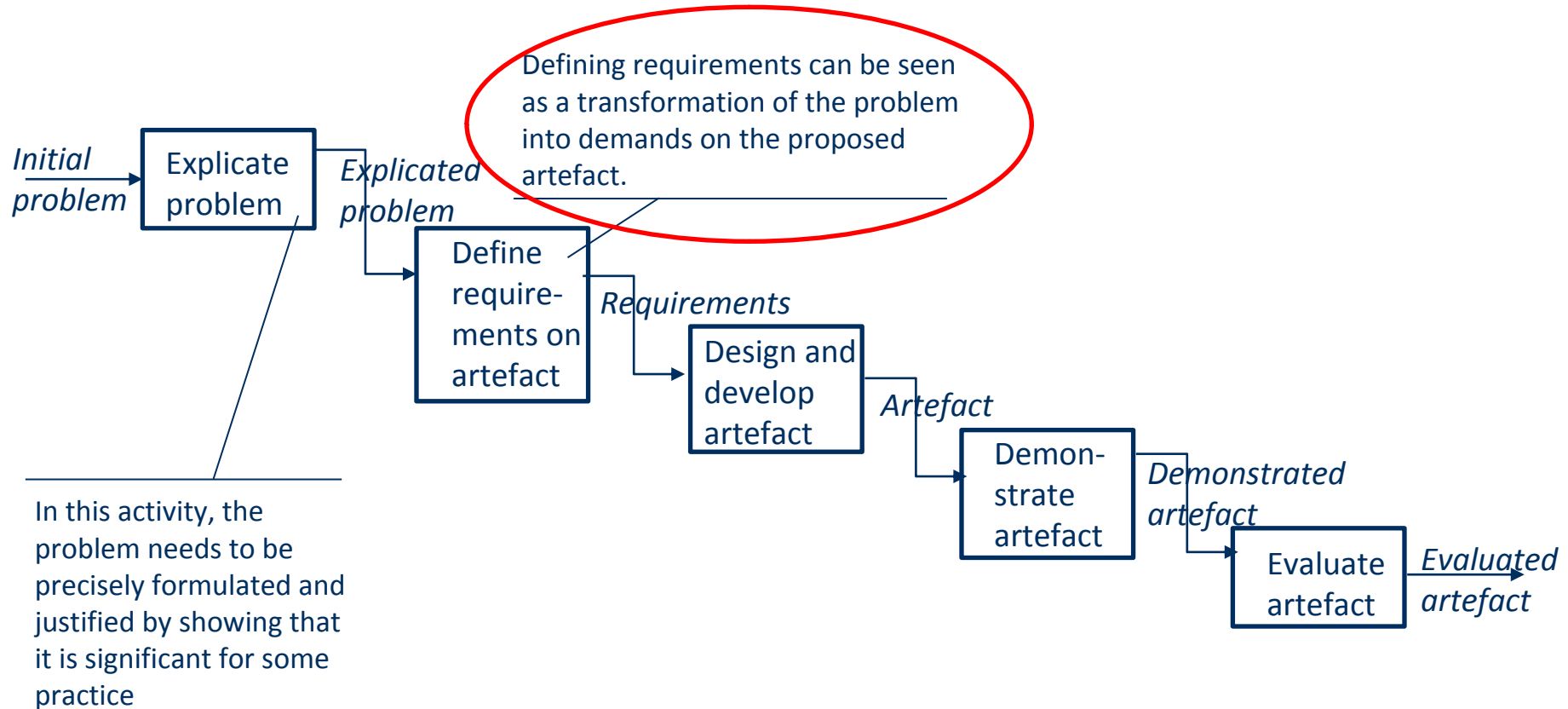
***Example of practical problem:***

*The difficulty of finding and selecting appropriate best practices (BPs) in large collections of BPs impedes the use of BPs.*

***Example of knowledge problem:***

*There is a lack of knowledge/research of how to find and select appropriate best practices (BPs) in BP repositories.*

# A design science framework



# Define requirement

Two categories of requirements:

- **Features/Functions** – for example, the artefact should support communication between decision makers
- **Generic qualities** – for example, the artefact should be easy to use for the users

# Define requirements

Example of requirements in form of **generic qualities**:

- *Understandability*: The artefact should be easy to comprehend for the users, since they need use it in an effective way
- *Efficient*: The artefact should make it possible to carry out improvement of business processes in a time and resource efficient ways, since business process improvement is a cost and resource intensive endeavor, where cost may easily exceed the benefit
- *Completeness* ....

Specify the generic quality for the artefact



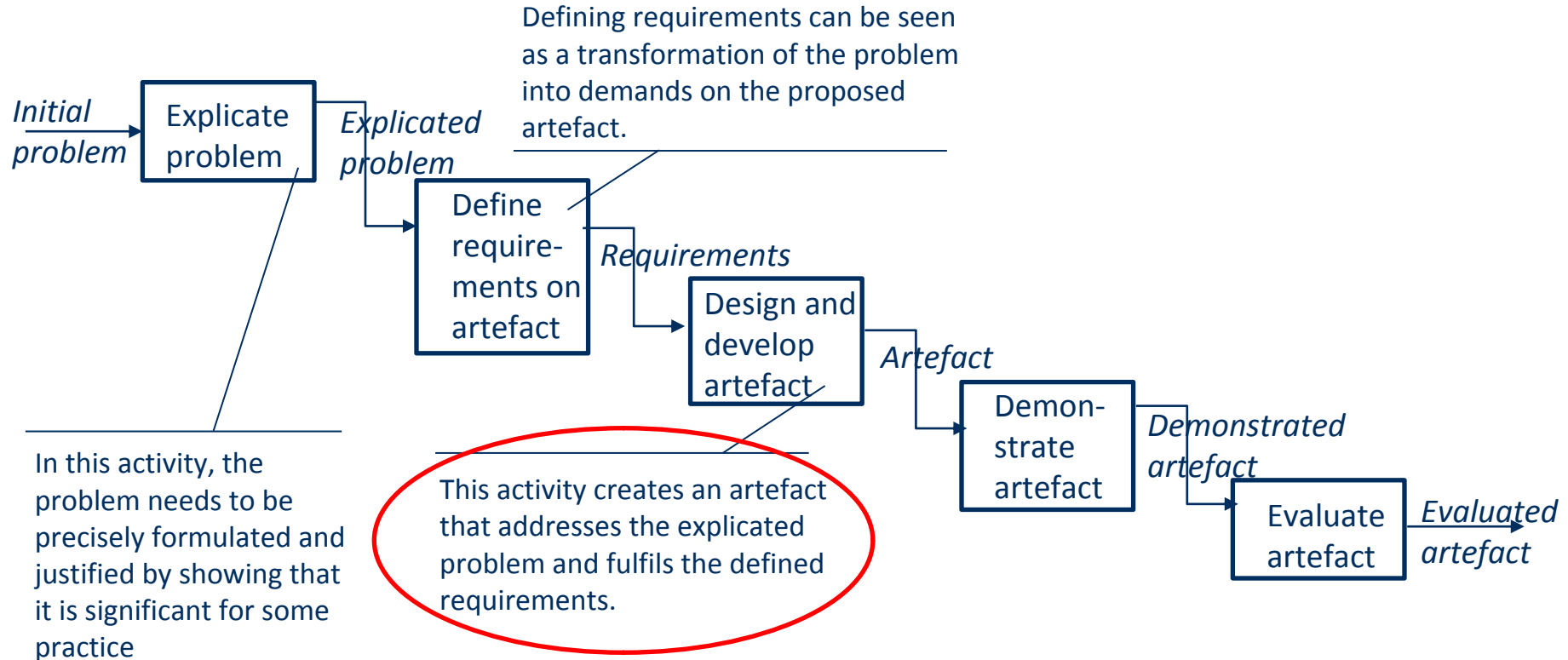
# Define requirements

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- *Completeness* ....

Justify the generic quality for the artefact

# A design science framework

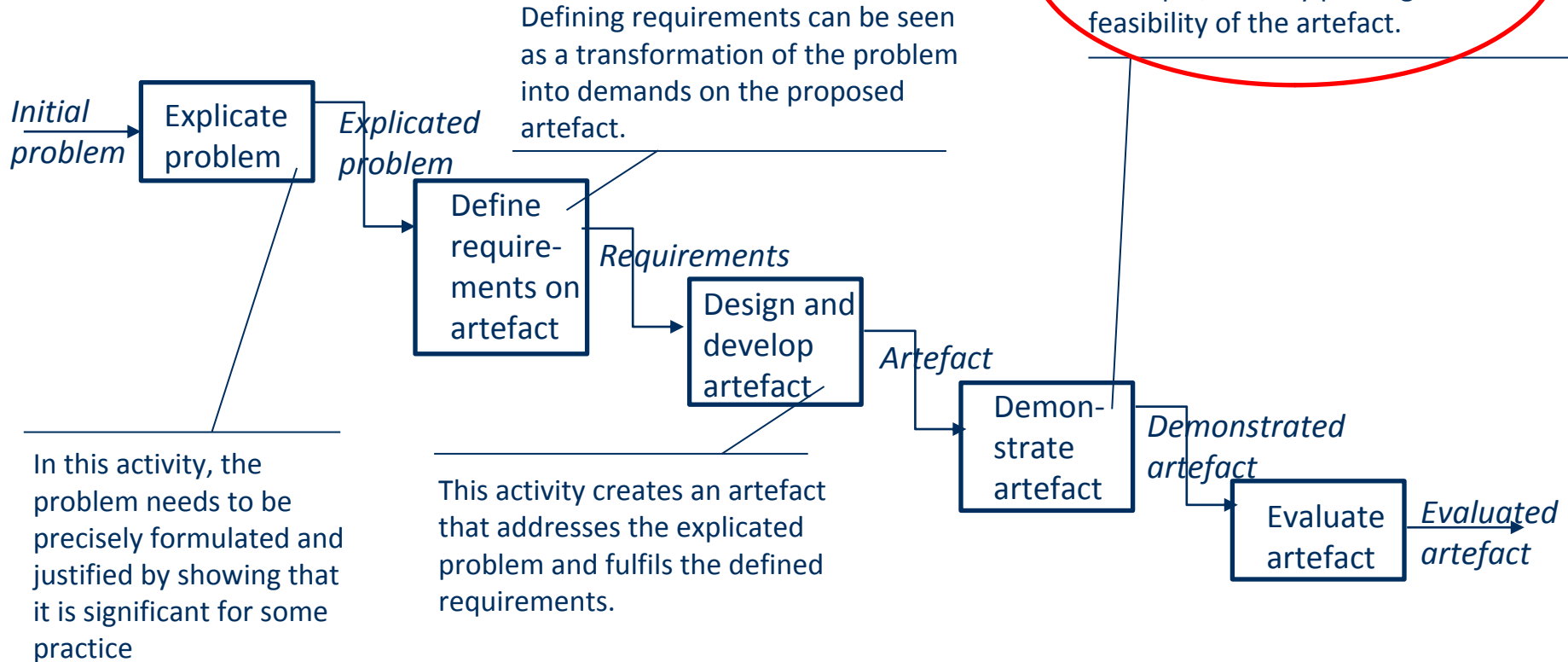


# Design and develop artefact

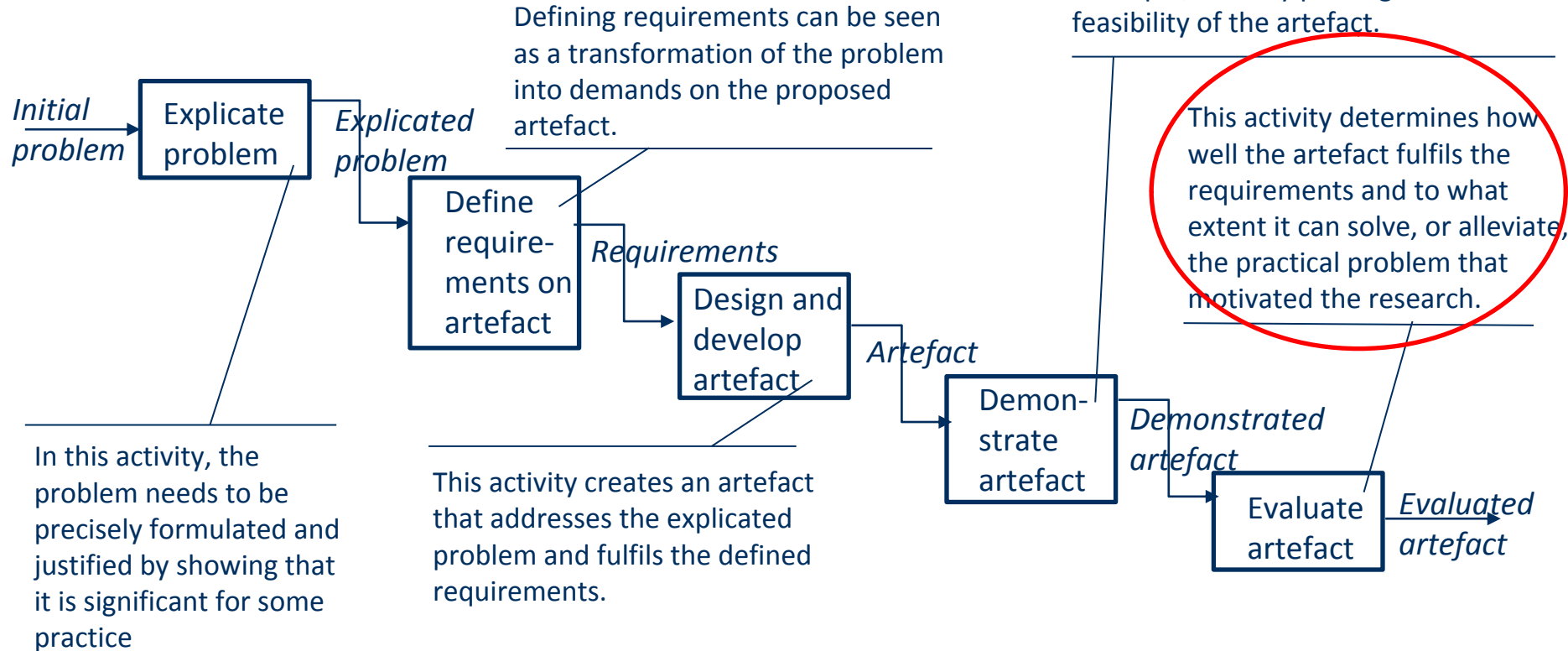
This part usually contains:

- A description of the artefact and its components
- A description of how the artefact was designed and developed

# A design science framework



# A design science framework



# Evaluate artefact

- ***Ex ante evaluation*** - means that the artefact is evaluated without being used or even being fully developed
  - For example, an ex ante evaluation of a **new collaborative editor software** (like Google docs) can be carried out by **interviewing a number of experts** on word processing and social software, based on a specification and early prototype of the editor.
- ***Ex post evaluation*** - requires the artefact to be employed.
  - An ex post evaluation can be done by **implementing the collaborative editor software in an organization and observing the use of it.**

# Evaluate artefact

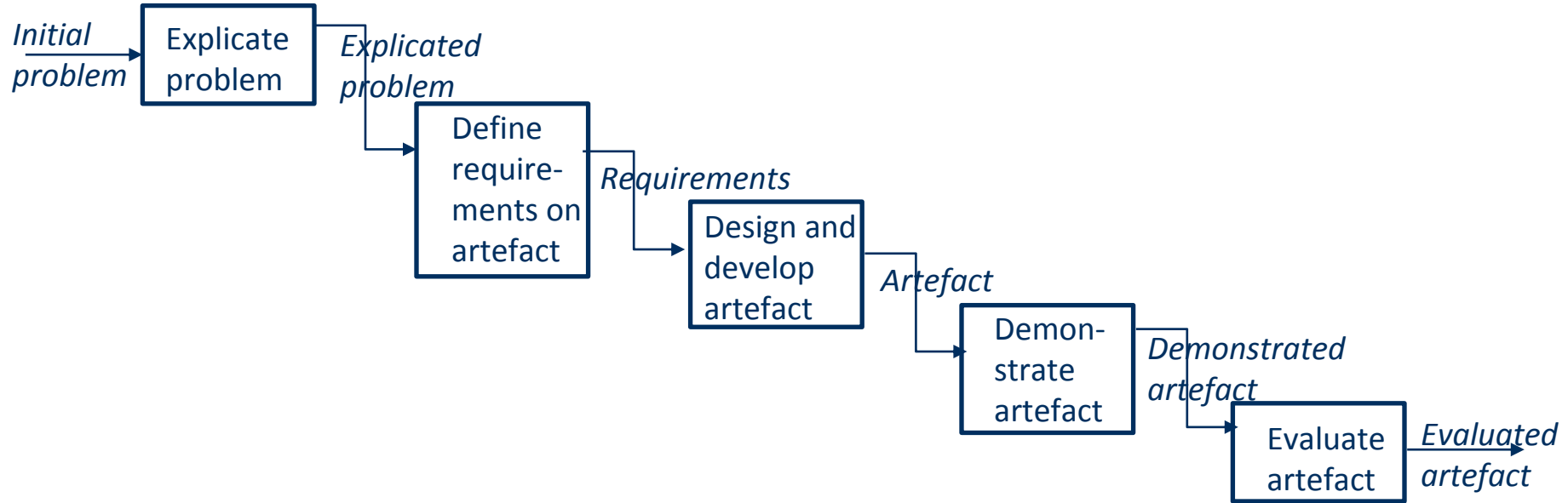
- Evaluate how the artefact **fulfills each requirement**, for example in form of strengths/benefits, weaknesses/drawbacks, and also suggested improvement
- Evaluate how the artefact **addresses the overall practical problems**, for example in form of strengths/benefits, weaknesses/drawbacks and suggested improvement

# Evaluate artefact: Informed argument

- **Informed argument** - is an **evaluation “method”** presented in Hevner et al. (2004).
- **Informed argument** - is a **lightweight evaluation method** where the **researchers who developed an artefact discuss its benefits and drawbacks**, and by this argumentation show that it does (or does not) fulfil the defined requirements.



# A design science framework



# The design science framework

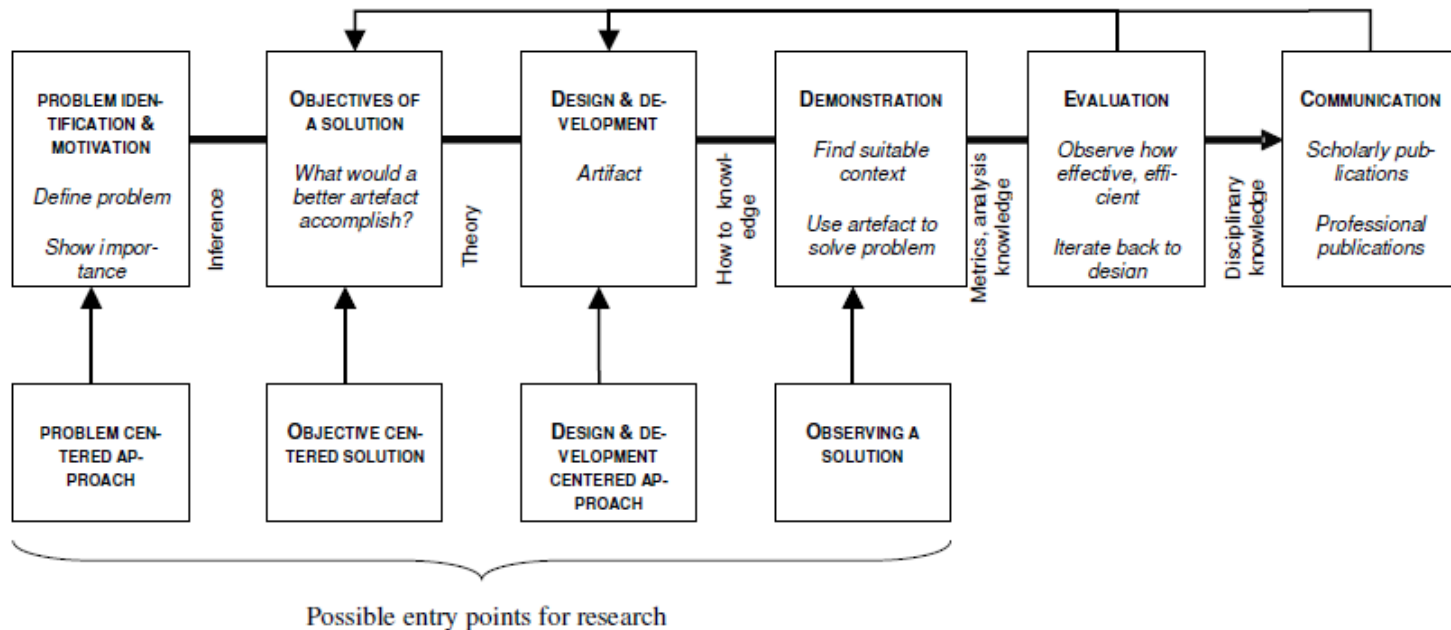
- **IMPORTANT:** The design science framework **supports presentations of the research methodology: it presents the result of each activity.**
- However, the design science framework is **NOT a description of how the research has been carried out.**

# The design science framework

- The actual design science research **can be carried out in different ways**, for example:
  - often a design science research project is carried out **using several iterations of design and evaluation** (as in agile software development methods). **This is not explicitly showed in the framework.** The framework just present the result of each activity when the research project has been finished
  - the developed artefact **may solve another problem than the first expected**, therefore the original problem statement (and probably also the requirements) need to be changed

## Peffer et al (2007)

### Nominal process sequence



# Research strategies and methods

*Initial  
problem*

Explicate  
problem

*Explicated  
problem*

Define  
require-  
ments on  
artefact

*Requirements*

Design and  
develop  
artefact

*Artefact*

Demon-  
strate  
artefact

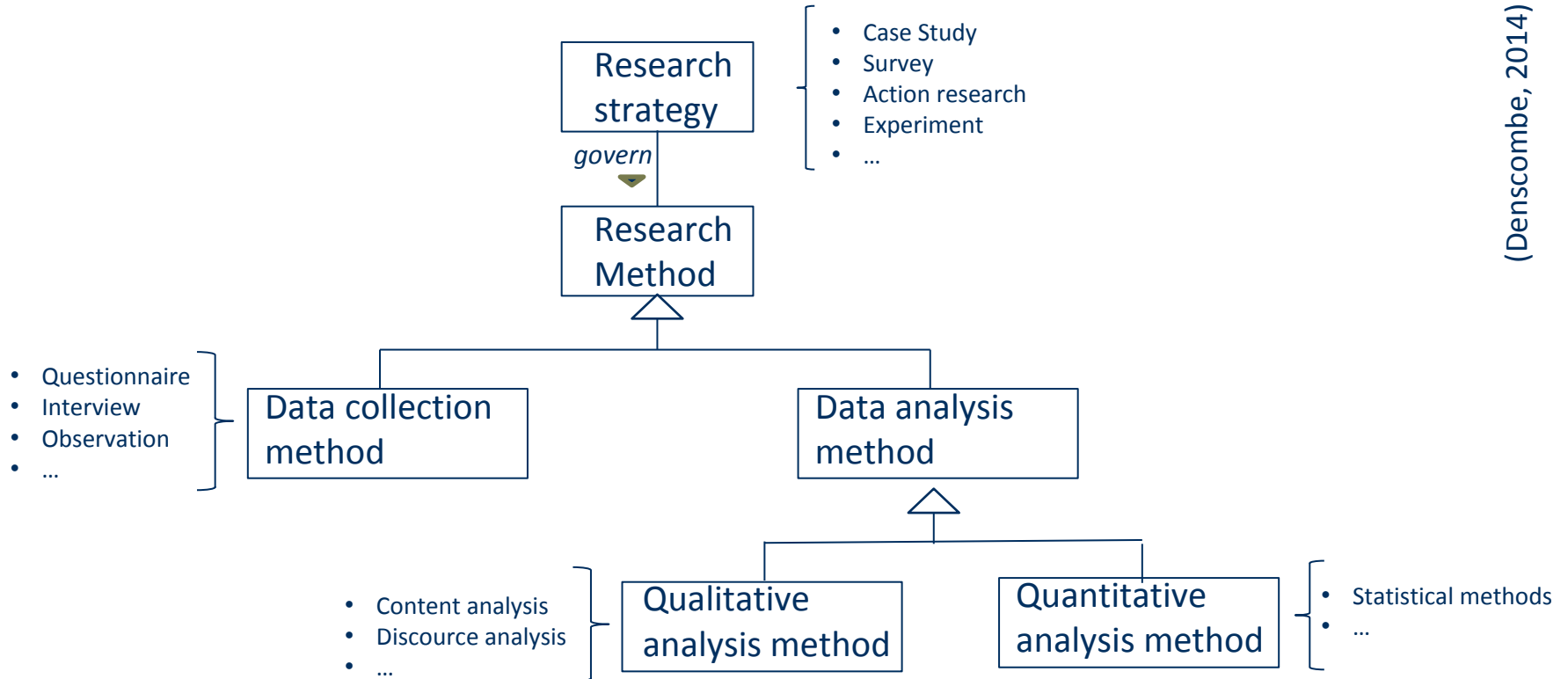
*Demonstrated  
artefact*

Evaluate  
artefact

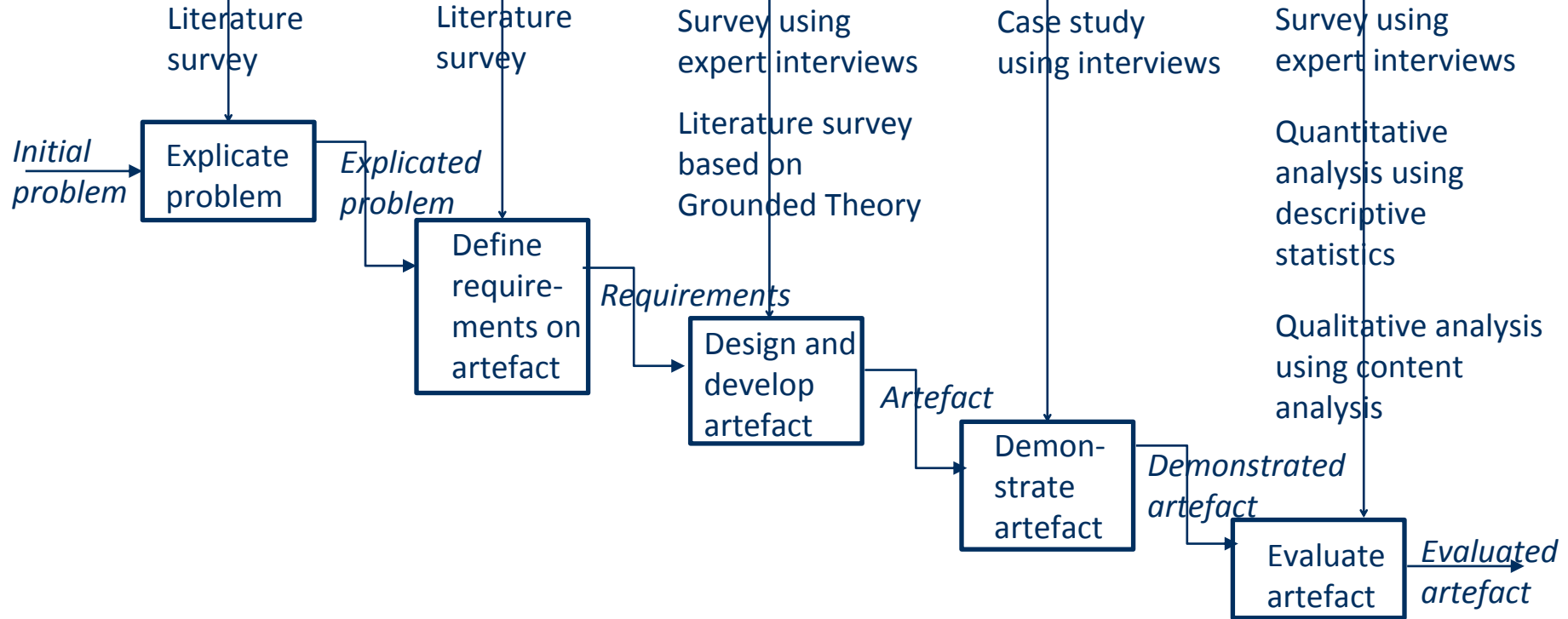
*Evaluated  
artefact*



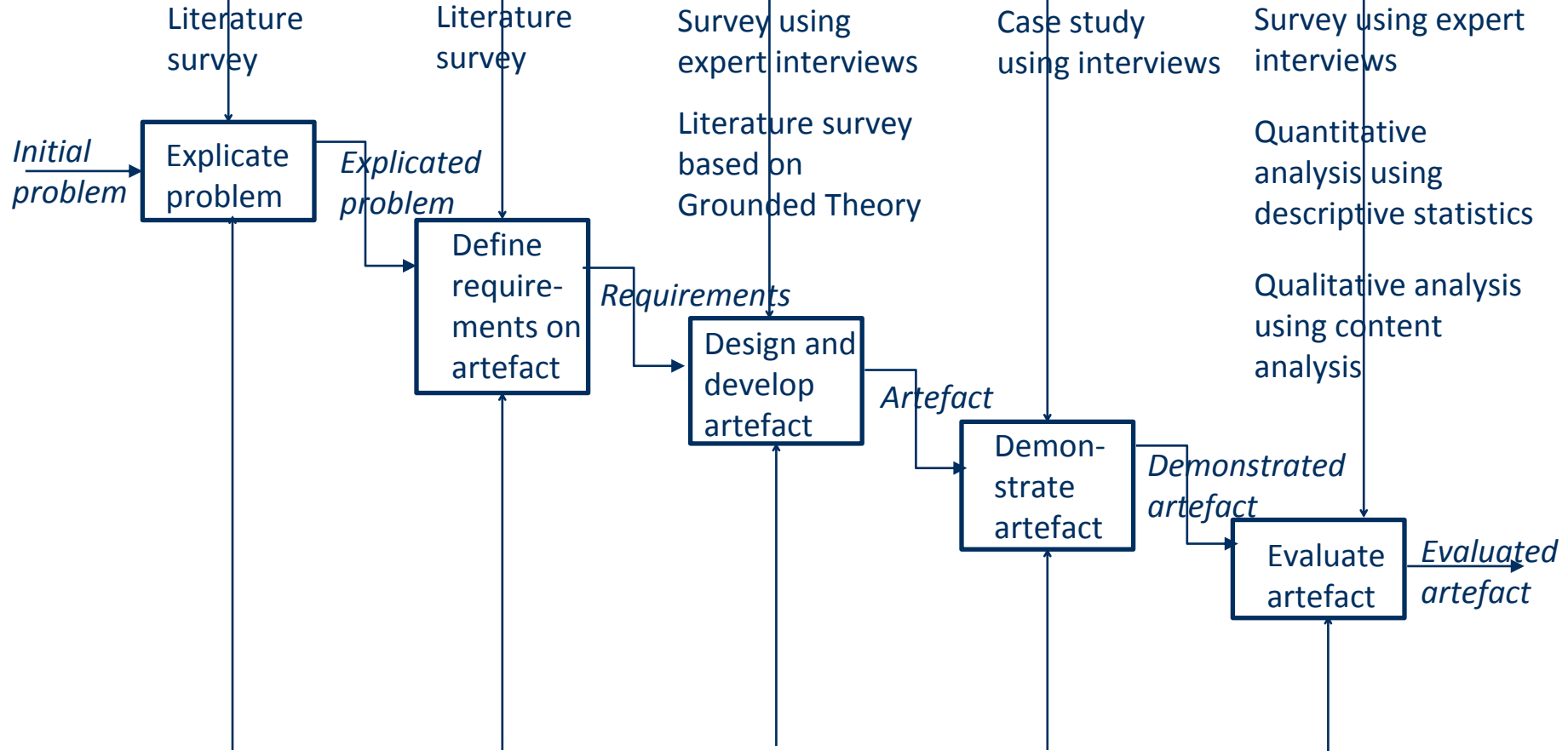
# Research methods



# Research strategies and methods



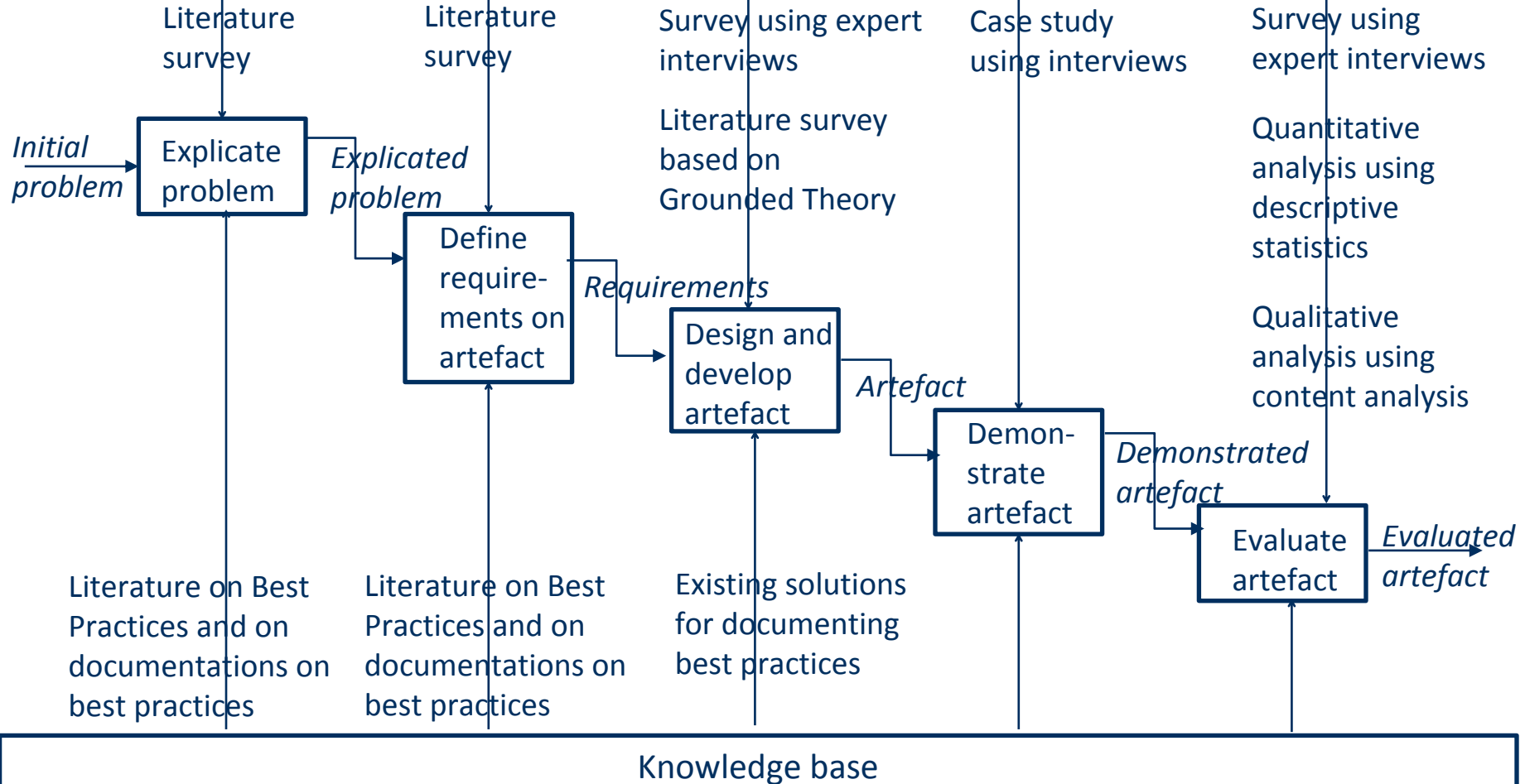
# Research strategies and methods



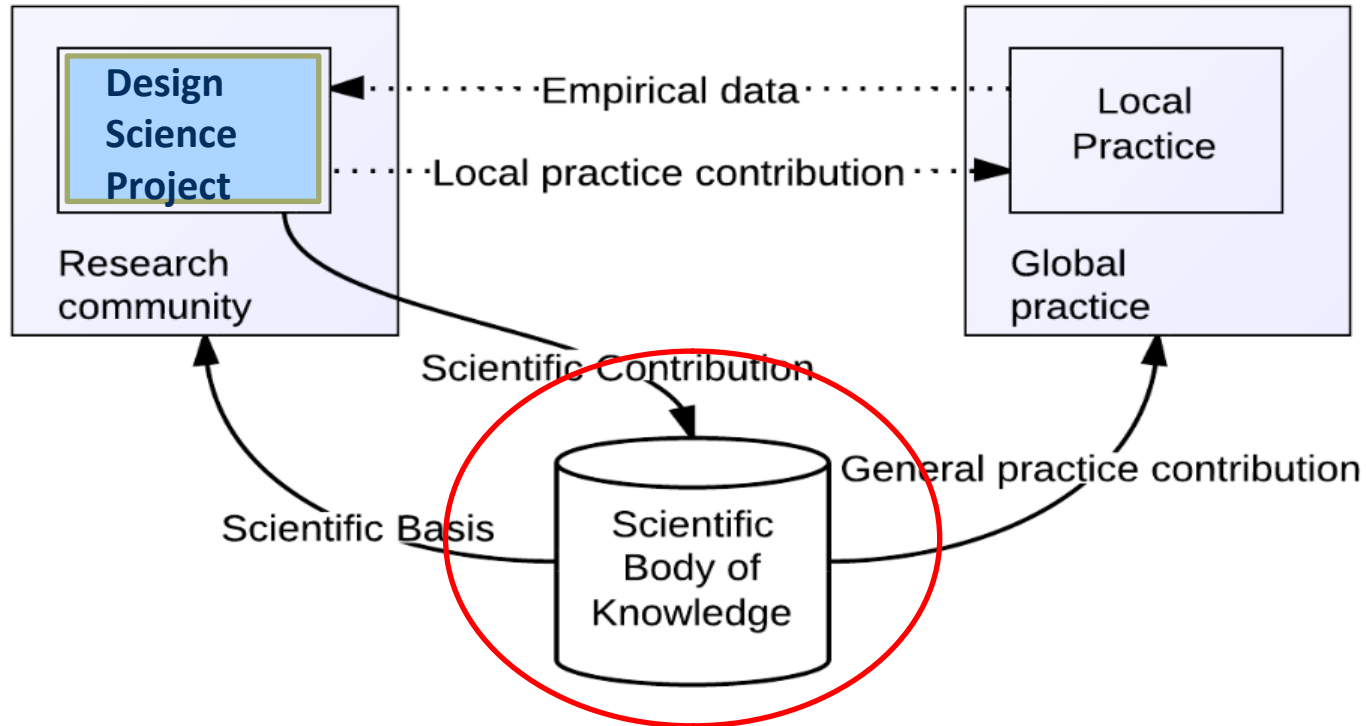
Knowledge base



# Research strategies and methods



# Knowledge base

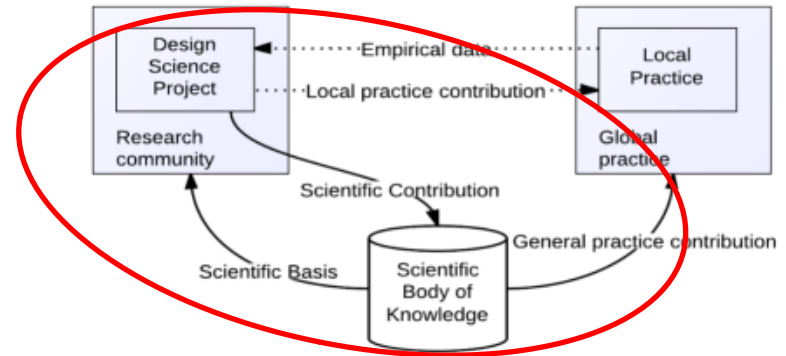


# Cases of Design Science

- Many design science projects **do not undertake all of the five activities of the method framework** in depth.
- Instead, they may focus on one or two of the activities, while the others are treated more lightly.
- Typical cases of design science research:
  - *Problem-focused Design Science Research*
  - *Requirements-focused Design Science Research*
  - *Requirements- and development-focused Design Science Research*
  - *Development- and evaluation-focused Design Science Research*
  - *Evaluation-focused Design Science Research*

# What is the science part of Design Science?

- Design science needs to develop artefacts that are:
  - **generic**, in that they are solutions for generic problems
  - **new, novel, original**
  - **based on the knowledge base/scientific body of knowledge**
  - **contributing to the knowledge base/scientific body of knowledge**
  - well described, so it is possible to critically discuss and evaluate the artefact **using rigorous scientific strategies and methods**
  - **evaluated/tested**
  - **communicated to both researchers**  
and practitioners



# Positioning Design Science

# What is design science?


Which of the following statements are OK to use

- Design science is a methodology
- Design science is a research approach
- Design science is a branch of science, such as natural, social and formal science
- Design science is a paradigm, such as positivism and interpretivism
- Design science is a research strategy, such as case study and survey

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These statements are OK to use according to me

# What is design science?

The core of design science is based of **prescriptive knowledge**:

- **Definitional knowledge** - consists of concepts, constructs, terms, definitions, classifications
- **Descriptive knowledge** - describes an existing or past reality
- **Explanatory knowledge** - provides answers to questions of why
- **Predictive knowledge** - offers black-box predictions, i.e. it predicts outcomes based on underlying factors but without explaining causal or other relationships between them.
- **Explanatory and predictive knowledge**
- **Prescriptive knowledge**

(Gregor, 2006)



# Prescriptive knowledge

- ***Prescriptive knowledge*** consists of **prescriptive models** and **methods** that help solve **practical problems**
- ***Prescriptive methods*** are **guidelines and procedures** that help people to work in systematic ways when solving problems.
- ***Prescriptive models*** can be seen as **blueprints** for developing, for example, business processes or IT systems

# Prescriptive knowledge

- Typical examples of *prescriptive methods* are **systems and software development methods**, such as the **Rational Unified Process (RUP)** (Kroll et al. 2003), or agile methods, such as **XP and SCRUM** (Cohn 2009).
- Typical examples of *prescriptive models* are **conceptual reference models, such as SCOR** (Bolstorff and Rosenbaum 2007), or **architectural models, such as OSI** (Day and Zimmerman 1983).

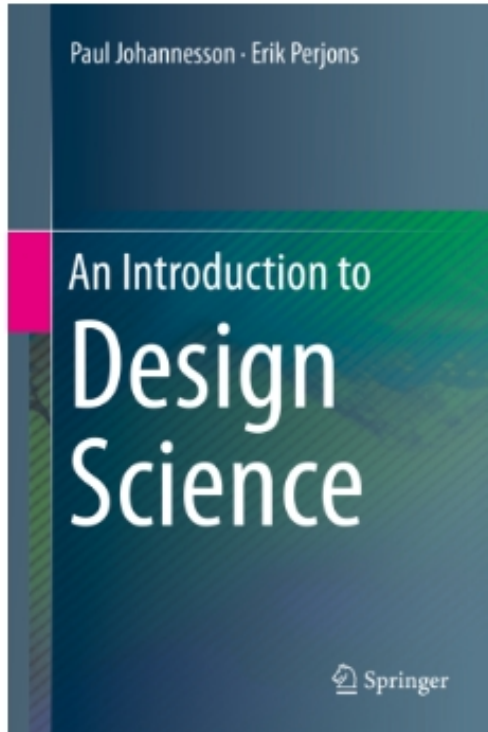
# Prescriptive knowledge

- *Prescriptive models and methods* can be viewed as comprising two parts.
- **The first part** - is the **model or method itself**
- **The second part** - is a **statement** about some desirable effect of using the model or method.
- This **statement** (the second part) implies that if a prescriptive model or method is used in a certain practice, this will contribute to effects desired by some stakeholders.
- In this sense, prescription can be seen as a special case of prediction.

# Prescriptive knowledge

- Examples of ***prescriptive knowledge***:
  - Apply sun lotion before sun bathing!
  - Develop your software system iteratively!

# Book and presentations



Johannesson, P., & Perjons, E. (2014). *An introduction to design science*. Springer.

Presentation of the major chapters:

<https://introtodesignscience.wordpress.com/>