Scientific Methods in Information Systems
- Kickoff -

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CIT

Information Systems and Business Process Management

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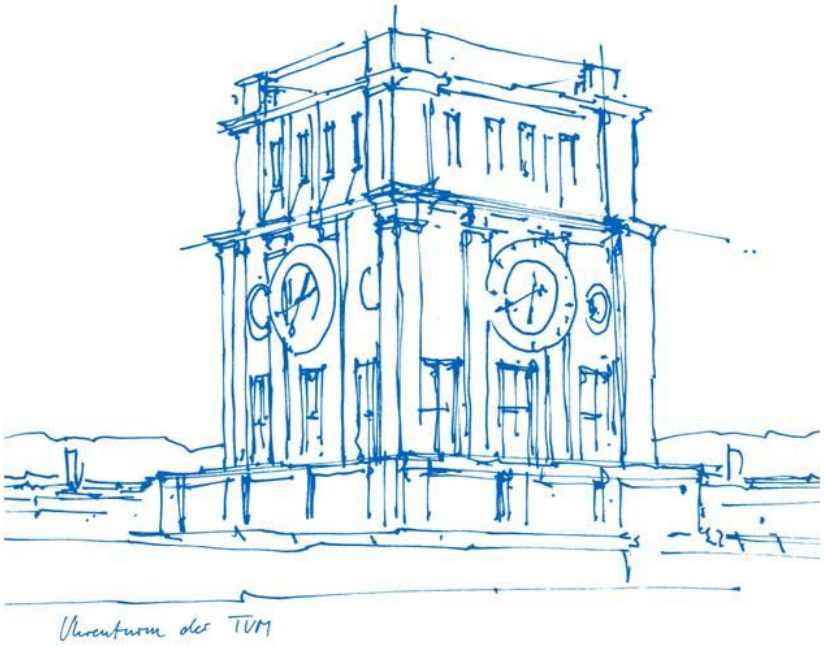
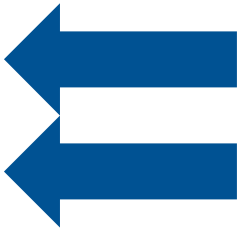


Seminar

1. Design science research
2. Systematic literature review
3. Organizational
4. Scientific writing



relevant for your bachelor thesis

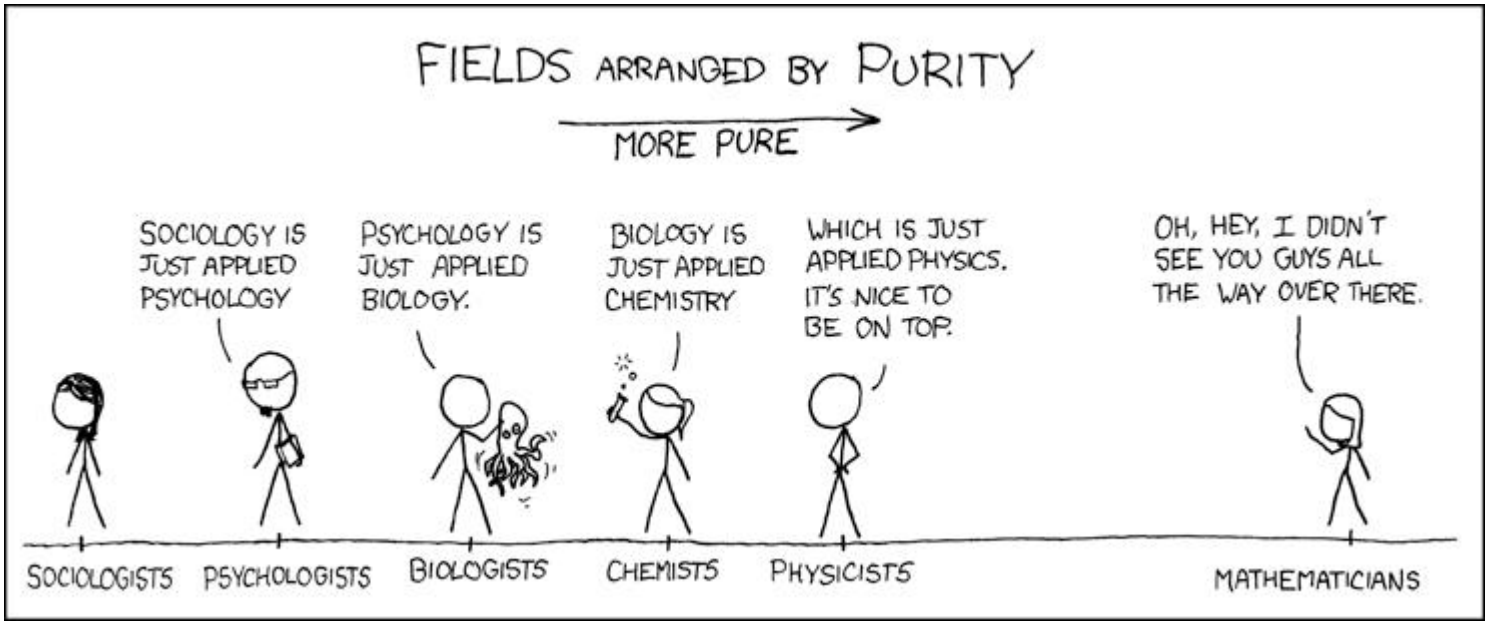
relevant for this seminar

Part I

Design science research

Science

What is science?



Randall Munroe, https://xkcd.com/435/

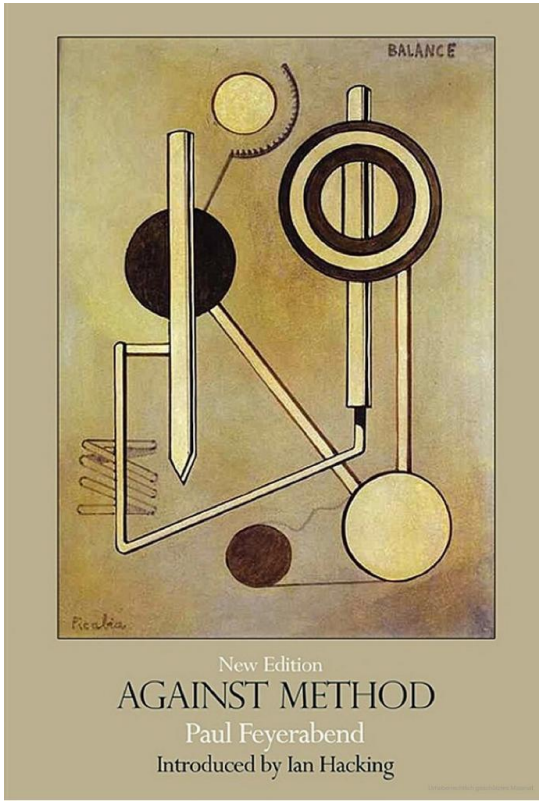
Scientific methods

Do we need scientific methods?

Some authors argue that scientific progress was often achieved by chance...

e.g.:

- Newtons gravity theory
- Nobels discovery of dynamite



Research

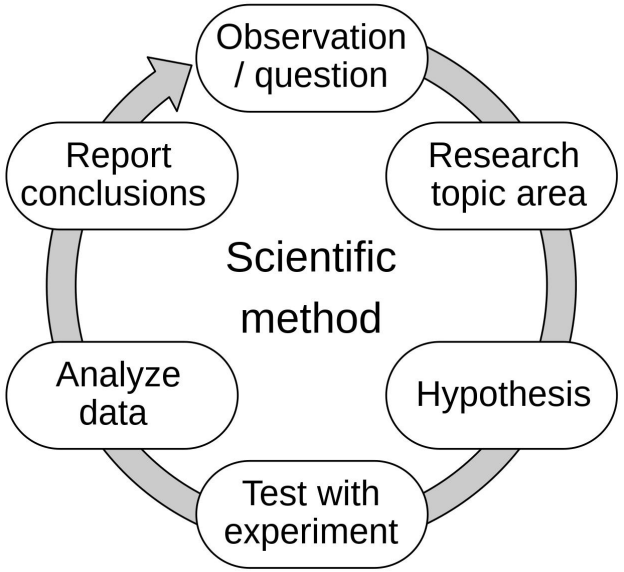
„Research is a process through which we attempt to achieve **systematically** and with the support of data the answer to a question, the resolution of a problem, or a greater understanding of a phenomenon.“ [1]

[1] Hevner, A., & Chatterjee, S. (2010). Design research in information systems. Theory and practice. Springer.

Scientific methods

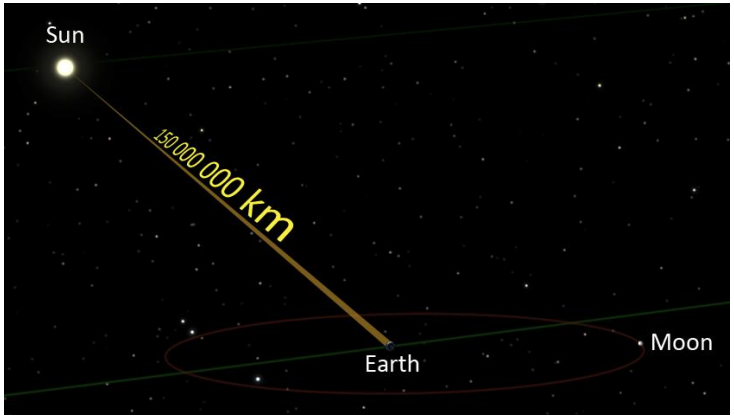
The scientific method is the process by which science is carried out.

- There is not the one scientific method
- See a scientific method as a (systematic) „framework“

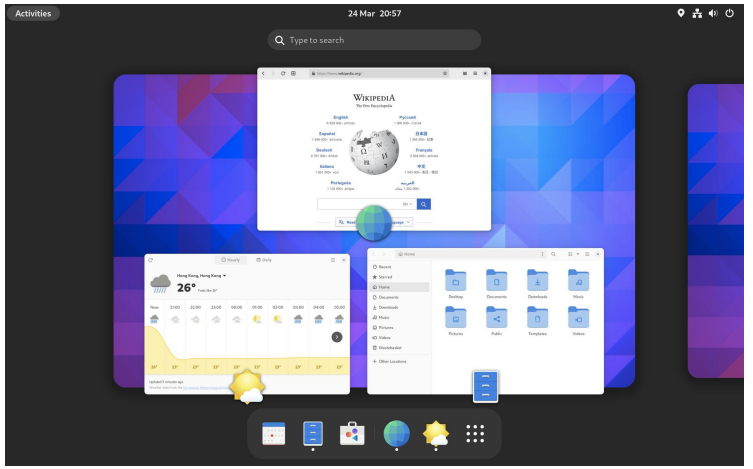


Exemplary scientific method

Branches of science



Natural sciences

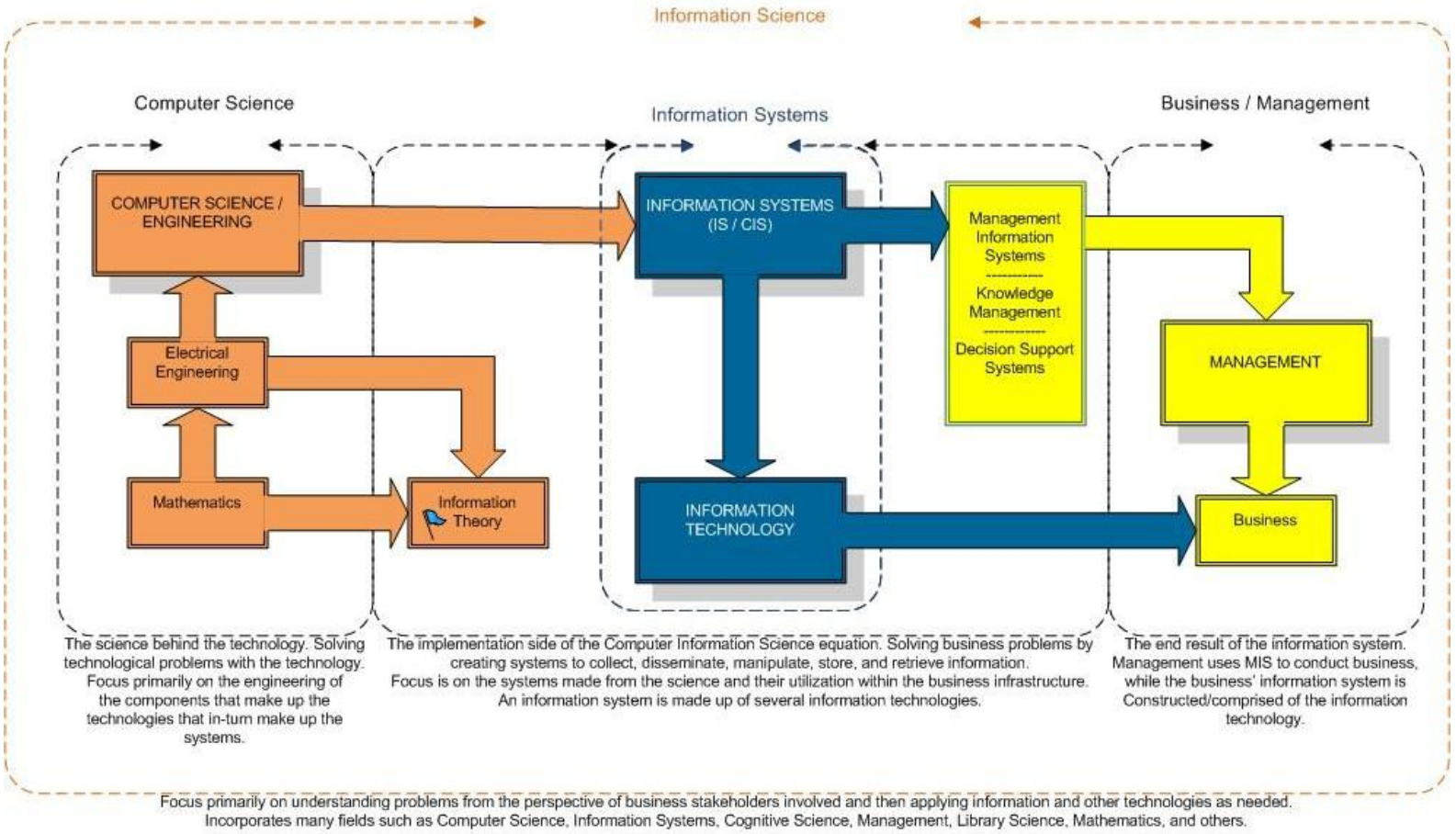


Formal sciences
(Social sciences)

Information science

- Phenoma depend on the choices of human designers rather than being true because they occur in nature

Information science



Information systems

- Research in the information systems field examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomenon that emerges when the two interact.

Design science research

- „Design science research is a research paradigm in which a designer answers questions relevant to human problems via the **creation of innovative artifacts**, **thereby contributing new knowledge to the body of scientific evidence**. The designed artifacts are both useful and fundamental in understanding that problem.“ [1]

- Is a common research methodology used in the information systems field

[1] Hevner, A., & Chatterjee, S. (2010). Design research in information systems. Theory and practice. Springer.

Design science research

Articfacts are according to [1]:

- Constructs (vocabulary and symbols)
- Models (abstractions and representations)
- Methods (algorithms and practices)
- Instantiations (implemented and prototype systems)
- Better design theories

[1] Hevner, A., & Chatterjee, S. (2010). Design research in information systems. Theory and practice. Springer.

Design science research

Guidelines:

Table 13.1 Design research criteria, adapted from (Hevner et al. 2004)

Criterion	Description
1. Design as an artifact	Design research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation
2. Problem relevance	The object of design research is to develop technology-based solutions to important and relevant business problems
3. Design evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation plans
4. Research contributions	Effective design research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies
5. Research rigor	Design research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact
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
7. Communication of research	Design research must be presented effectively to both technology-oriented and management-oriented audiences

Design science research

Research Methodology [1]

Table 1 Design and design science process elements from IS other disciplines and synthesis objectives for a design science research process in IS.

Objectives for a design science research process model	Archer (1984)	(Takeda et al. 1990)	Eekels and Roozenburg (1991)	Nunamaker et al (1991)	Walls et al (1992)	(Rossi et al. 2003)	(Hevner et al. 2004)
1. Problem identification and motivation	Programming Data collection	Problem enumeration	Analysis	Construct a conceptual framework	Meta-requirements Kernel theories	Identify a need	Important and relevant problems
2. Objectives of a solution			Requirements				Implicit in "relevance"
3. Design and development	Analysis Synthesis Development	Suggestion Development	Synthesis, Tentative design proposals	Develop a system architecture Analyze and design the system. Build the system	Design method Meta design	Build	Iterative search process Artifact
4. Demonstration			Simulation, Conditional prediction	Experiment, observe, and evaluate the system			
5. Evaluation		Confirmatory evaluation	Evaluation, Decision, Definite design		Testable design process/product hypotheses	Evaluate	Evaluate
6. Communication	Communication						Communication

[1] Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. Journal of management information systems, 24(3), 45-77.

Design science research

1. Problem identification and motivation

- Define the specific research problem and justify the value of a solution
  - Can be done via a systematic literature review

- Motivates the researcher and the audience

Design science research

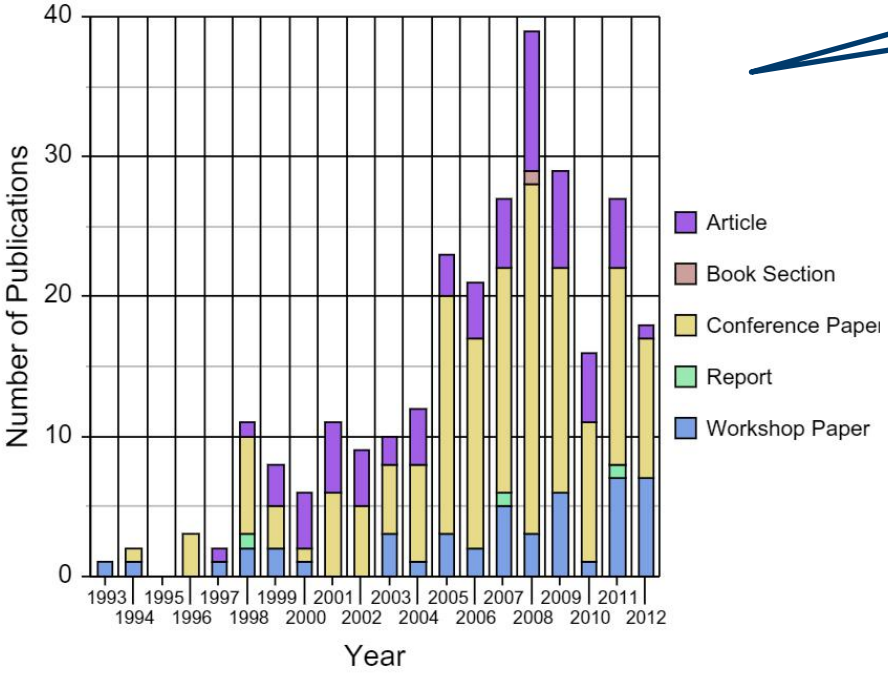
1. Problem identification and motivation

- “If one is interested in developing design propositions for a given type of field problem, **one starts with a systematic review of the existing knowledge-base on that issue**, to be followed by a synthesis of design propositions.
  The review and synthesis can produce design propositions to be developed further, but can also uncover gaps in the existing literature – for example, insufficient explanatory theory on certain aspects, deficient field testing and/or the absence of any knowledge for grounding the propositions.
  On the basis of these limitations, research questions or development objectives are defined and further research is initiated.“ [1]

[1] Van Aken, Joan Ernst, and Georges Romme. "Reinventing the future: adding design science to the repertoire of organization and management studies." Organization Management Journal 6.1 (2009): 5-12.

Design science research

Distribution / development over time
Is it a „hot topic“?
Are there „trends“?



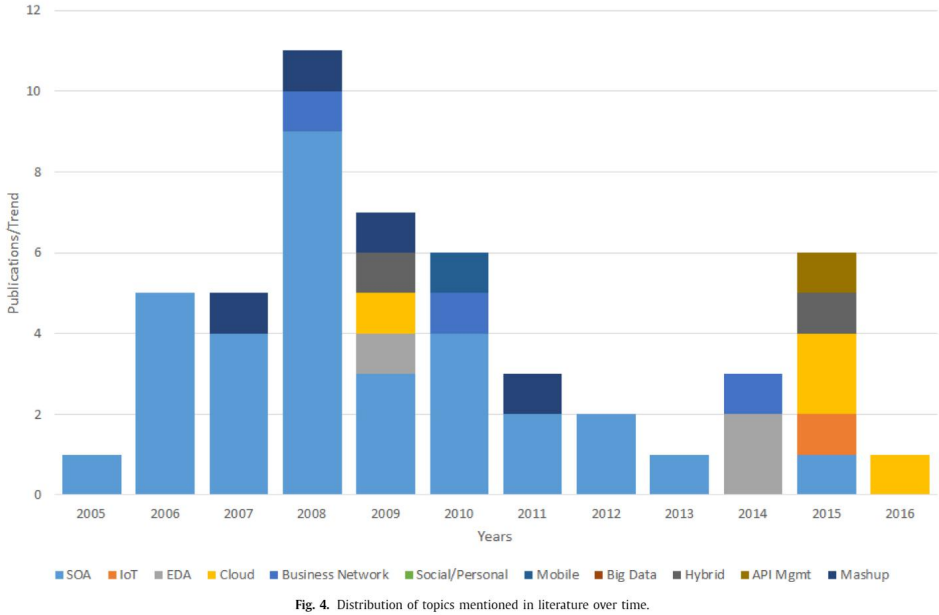


Fig. 4. Distribution of topics mentioned in literature over time.

(c) Elsevier, 2014
Source: Maria Leitner, Stefanie Rinderle-Ma:
A systematic review on security in Process-Aware Information Systems - Constitution, challenges, and future directions. Inf. Softw. Technol. 56(3): 273-293 (2014)
https://doi.org/10.1016/j.infsof.2013.12.004

(c) Elsevier, 2017
Source: Daniel Ritter, Norman May, Stefanie Rinderle-Ma:
Patterns for emerging application integration scenarios: A survey. Inf. Syst. 67: 36-57 (2017)
https://doi.org/10.1016/j.is.2017.03.003

Design science research

What can we derive from this?
What is the benefit?

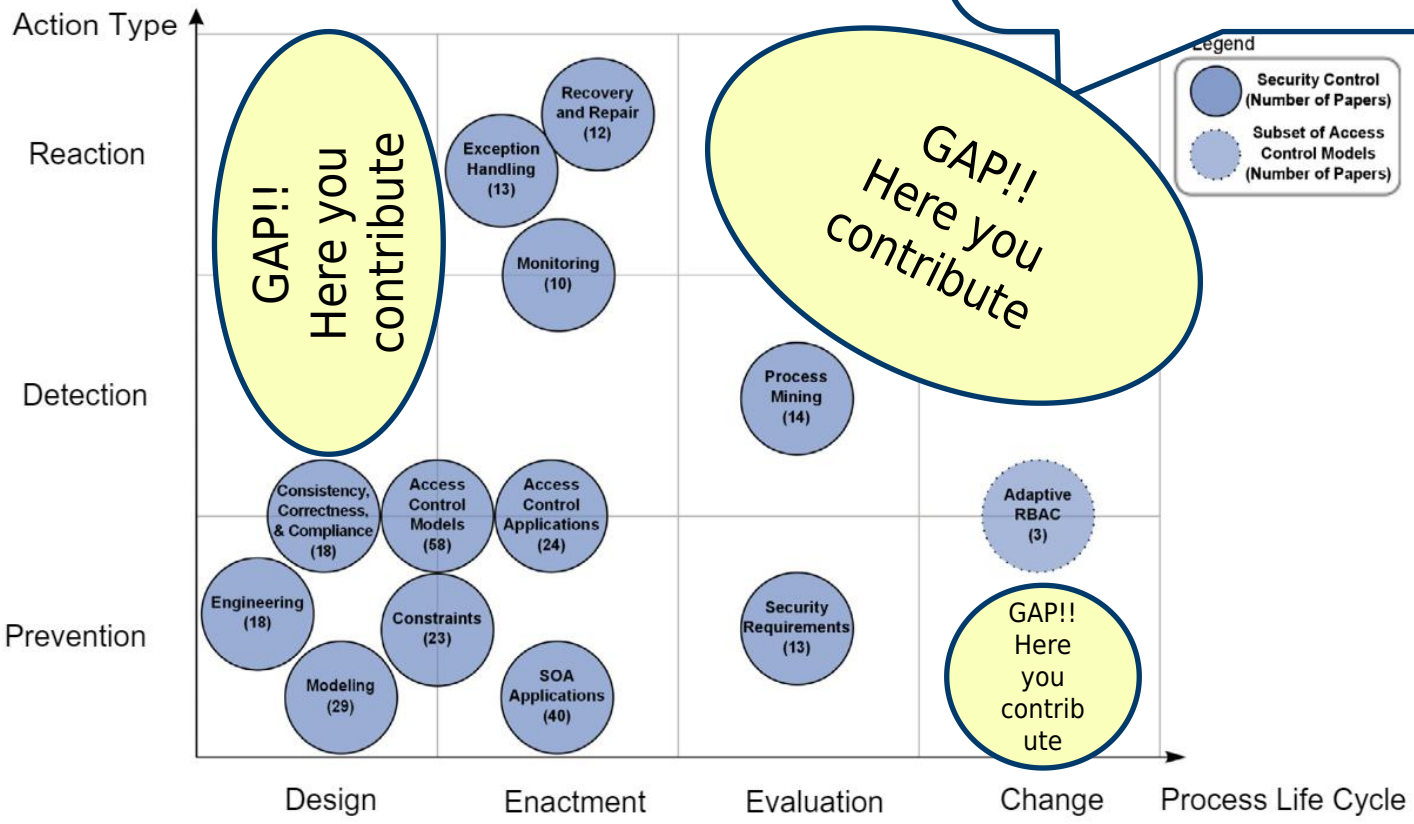


Fig. 9. Classification of controls.

(c) Elsevier, 2014
Source: Maria Leitner, Stefanie Rinderle-Ma:
A systematic review on security in Process-Aware Information Systems - Constitution, challenges, and future directions. Inf. Softw. Technol. 56(3): 273-293 (2014)
https://doi.org/10.1016/j.infsof.2013.12.004

Design science research

1. Problem identification and motivation

In a thesis (I)

Introduction

1.1 Motivation

- general introduction in your topic
- statements/claims supported by references

1.2 Problem Statement

- WHAT is the problem?
- WHY is it a problem? a problem can be also trivial
- Challenges, e.g., volume, velocity, veracity

[1] Van Aken, Joan Ernst, and Georges Romme. "Reinventing the future: adding design science to the repertoire of organization and management studies." Organization Management Journal 6.1 (2009): 5-12.

Design science research

1. Problem identification and motivation

In a thesis (II)

Problem statement + short gap
- Research questions (or hypotheses)
- 2 - 3 questions
- avoid questions with yes/no answers (only where really feasible)
- „How….?“ „Which….?“

1.3 Research method: what we are talking about in this seminar
1.4 Contribution: artefacts
1.5 Structure of the thesis

[1] Van Aken, Joan Ernst, and Georges Romme. "Reinventing the future: adding design science to the repertoire of organization and management studies." Organization Management Journal 6.1 (2009): 5-12.

Design science research

2. Define the objectives for a solution

- Determine the performance objectives for a solution
- Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible.
- The objectives can be quantitative, such as terms in which a desirable solution would be better than current ones, or qualitative, such as a description of how a new artifact is expected to support solutions to problems not hitherto addressed.

[1] Van Aken, Joan Ernst, and Georges Romme. "Reinventing the future: adding design science to the repertoire of organization and management studies." Organization Management Journal 6.1 (2009): 5-12.

Design science research

3. Design and development

- Determining the artifact’s desired functionality and its architecture
  - Platform? Programming language(s)? ...
- Create the artifact

Design science research

4. Demonstration

- Demonstrate that the artifact is able to solve one or more instances of the problem „proof of concept“

- experimentation, simulation, case study, proof, ...
  - e.g. case study participants know how to use the artifact

Design science research

5. Evaluation

- Evaluate if the artifact is able to solve the stated problem
  „real-world applicability“
  - If not, consider to iterate back to step 3

- Compare artifact to other artifacts identified in step 2

- Methods:
  - Metrics: System performance, response time, availability, ...
  - Emperical evidence
  - Logical proofs

Design science research

Fig. 14. Experiment setup, on the left VR, on the right Signavio and 3DViz.

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Source Manuel Gall, Stefanie Rinderle-Ma: Assessing Process Attribute Visualization and Interaction Approaches Based on a Controlled Experiment. Int. J. Cooperative Inf. Syst. 29(4): 2050007:1-2050007:33 (2020) https://doi.org/10.1142/S0218843020500070

Design science research

6. Communication

- Communicate the problem, its importance, the artifact, its utility and novelty, the rigor of its design and its effectiveness to researches

- Journals, conference papers, ...

Part II

Systematic literature review

Systematic literature review

[1] Pearl Brereton, Barbara A. Kitchenham, David Budgen, Mark Turner, Mohamed Khalil: Lessons from applying the systematic literature review process within the software engineering domain. J. Syst. Softw. 80(4): 571-583 (2007)

[2] B. Kitchenham, Procedures for Performing Systematic Reviews, Joint Technical Report, Department of Computer Science, Keele University and Empirical Software Engineering, National ICT Australia Ltd., 2004 (http://www.elizabete.com.br/rs/Tutorial_IHC_2012_files/Conceitos_RevisaoSistematica_kitchenham_2004.pdf)

Systematic literature review

„A systematic literature review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest.“ [2]

Systematic literature review

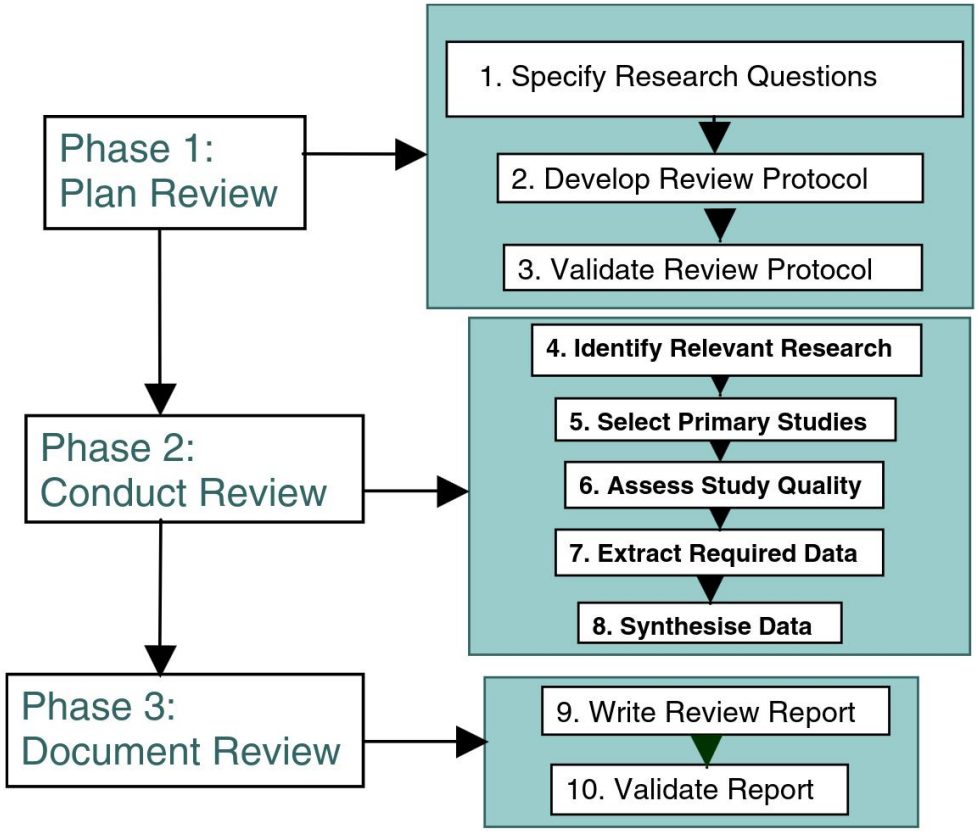

Fig. 1. Systematic literature review process.

from [1]

1. Specify research questions

- What are the review’s objectives?

- Research questions can be revised during protocol development as the understanding of the problem increases

2. Development of a Review Protocol

- The strategy that will be used to search for primary studies including:
  - search terms
  - resources to be searched (databases, [specific journals, and conference proceedings])

- Criteria for including in, or excluding a study from, the systematic review.
  - It is usually helpful to pilot the selection criteria on a subset of primary studies.

- Data extraction strategy. This should define how the information required from each primary study would be obtained. If the data require manipulation or assumptions and inferences to be made, the protocol should specify an appropriate validation process.

3. Validate review protocol

- Pilot run
- External review
- Revision of the protocol

4. Identify relevant research

- Find as many studies relating to the research question as possible
- Avoid language bias
- Use Boolean logic within search queries

(('technology acceptance model' <and> (usage <or> 'actual usage') <and> **(assessment <or> evaluation) <and> empirical** <in> (metadata, pdfdata))) <and> (pyr >= 1989 <and> pyr <= 2005)

Fig. 2a. Boolean search expression a.

(('technology acceptance model' <and> (usage <or> 'actual usage') <and> **empirical <and> (assessment <or> evaluation)** <in> (metadata, pdfdata))) <and> (pyr >= 1989 <and> pyr <= 2005)

Fig. 2b. Boolean search expression b.

from [1]

4. Identification of Research

- IEEExplore
- ACM Digital library
- Google scholar (<scholar.google.com>)
- Citeseer library (<citeseer.ist.psu.edu>)
- Keele University’s electronic library (<opac.keele. ac.uk>)
- Inspec (<www.iee.org/publish/inspec/>)
- ScienceDirect (<www.sciencedirect.com>)
- EI Compendex (<www.engineeringvillage2.org/controller/servlet/athensservice>)

- DBLP (dblp.org)
- Scopus (eAccess: https://ub.tum.de/datenbanken/details/3636)
- Web of Science (eAccess: https://ub.tum.de/datenbanken/details/3366)

Next steps

- ... intermediate meeting

Part III

Organizational

Organizational

- Negotiate a topic / existing survey with me

- Read the survey article assigned to you
- Briefly summarize the topic:
  - Motivation
  - Research questions / hypothesis
  - ...
- Assess the survey (based on the surveys conclusion, noticable trends, ...)
  - Specify your own research questions (can remain unchanged)
  - Conduct „phase 1“ of the literature review process
  - Perform „step 4“ of the literature review process
  - Come up with ideas to categorize / cluster results

=> Prepare a concise presentation (max. 10 slides, ~10 minutes) about the summary and your assessment.

Topic selection

Questions?