# Methods for SE Research

# Literature review as a research method

**Tomi Männistö**

# Overview

- Literature review as a research methodology in software engineering

- Systematic literature reviews: a more rigorous form of literature reviews
  - Background
  - Phases
  - Challenges

- Points about good literature reviews
  - Concept centric
  - snowballing
  - mapping

- To think about during and after this lecture
  - Why, when and how to do literature reviews during your thesis work
  - What ideas to use to strengthen them methodologically and gain the understanding needed

# Literature review

- A review of prior, relevant literature is **an essential feature of any academic project**. An effective review creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed.
(Webster & Watson 2002)

- A literature review is a means of identifying, evaluating and interpreting available research relevant to a particular research question, topic area, or phenomenon (Kitchenham, 2004)

- Some terms of scientific studies that uses other scientific studies as data

  - Primary studies

    - Individual studies contributing to the review

  **data**

  - Secondary study

    - The review study you are constructing
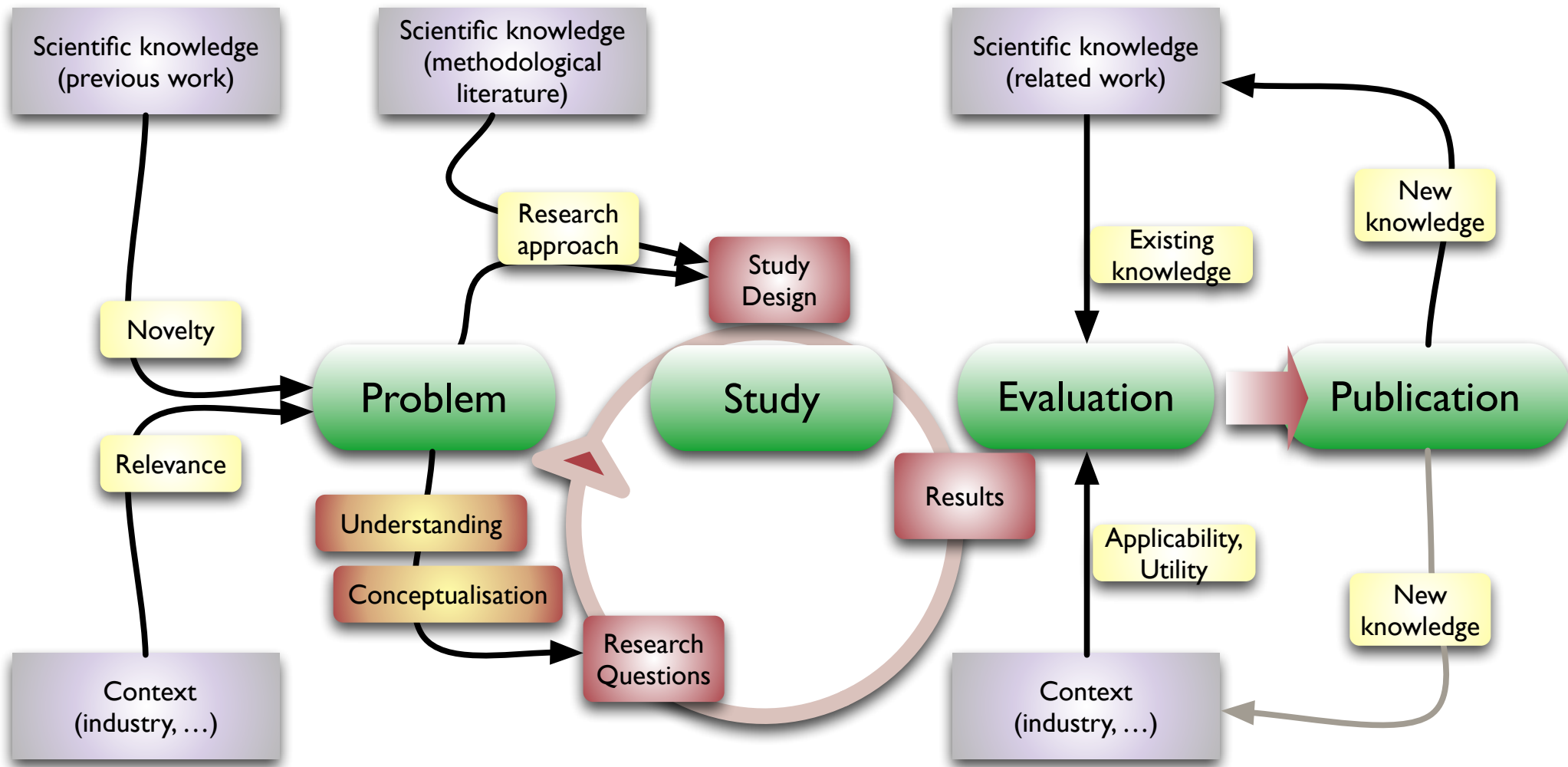
  - (Tertiary study)

# Motivation for literature reviews

- To better understand a mature topic where accumulated research needs analysis and synthesis

- To tackle an emerging research issue

- To identify gaps in current research and to suggest areas for future work

- To study how a theory or method is supported by empirical evidence

- To provide a framework in which new research can be positioned

(Webster & Watson, 2002; Kitchenham, 2004)

# Literature review in the context of other research

- Literature review as a main method

  - Bachelor's or Master's thesis

  - Seminar paper

  - Review paper / survey paper in journals and conference proceedings

- Literature review as a supporting method

  - Master's thesis

  - PhD thesis

- If literature review is conducted as a supporting method, it needs to be linked to the main method in a meaningful way

  - E.g., as providing background theory or covering existing and proposed methods for doing something you are about to do

Scientific knowledge (previous work)

Scientific knowledge (methodological literature)

Scientific knowledge (related work)

New knowledge

Research approach

Study Design

Novelty

Existing knowledge

Problem

Study

Evaluation

Publication

Relevance

Understanding

Results

Conceptualisation

Applicability, Utility

New knowledge

Research Questions

Context (industry, …)

Context (industry, …)

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# Role of literature in a thesis
# — Previous work

Literature

Research problem

Story as a"cone"

*OR*

Practical problem → Literature → Means, tools, etc. to address the problem

# Role of literature in a thesis — Related work



Scientific knowledge
(related work)

Existing
knowledge

Evaluation

Results
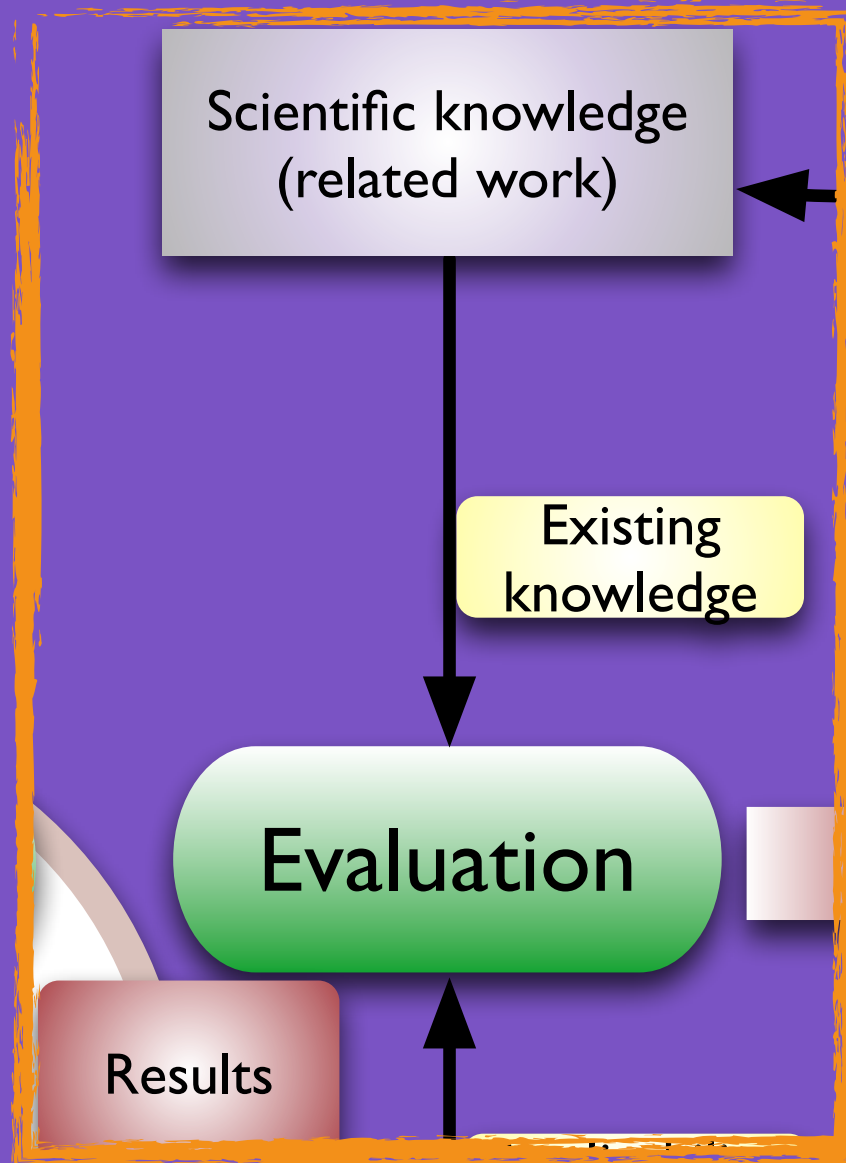
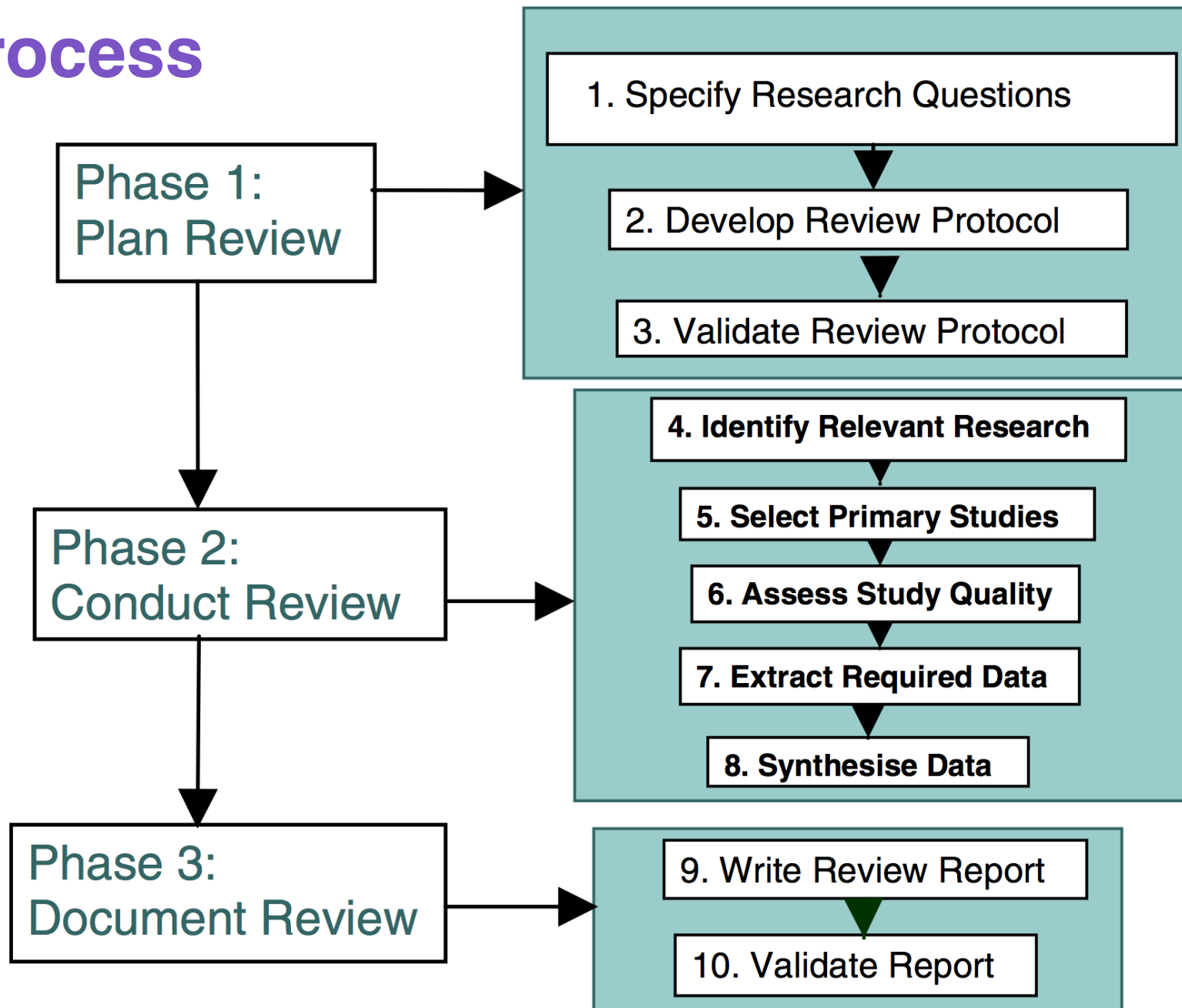# Problems with traditional literature reviews

- Traditional literature reviews are often (Tranfield et al., 2003)
  - Narrative, or worst still, numbing summaries over a set of articles and authors
  - Relatively ad hoc, and process not well documented
  - Too few – researchers are more interested in creating new
- Instead, the aim should be for (Kitchenham, 2004; Staples & Niazi, 2007)
  - Completeness – all relevent primary studies are included
  - Objectiveness – no researcher bias
  - Replicability – can be repeated
  - Validity – should be assessible outside

# Systematic literature reviews

(Kitchenham, 2004)

- Start by defining a review protocol

- Are based on a defined search strategy

- Document their search strategy

  - Readers can evaluate rigour and completeness

- Require explicit inclusion and exclusion criteria to select primary studies

- Specify quality criteria by which to evaluate primary studies

- Enable quantitative meta-analysis

- Require considerably more effort than traditional reviews

# SLR Process

## Phase 1: Plan Review
→
1. Specify Research Questions
↓
2. Develop Review Protocol
↓
3. Validate Review Protocol

## Phase 2: Conduct Review
→
4. Identify Relevant Research
↓
5. Select Primary Studies
↓
6. Assess Study Quality
↓
7. Extract Required Data
↓
8. Synthesise Data

## Phase 3: Document Review
→
9. Write Review Report
↓
10. Validate Report

These phases can also be adapted to ordinary literature reviews

(Brereton et al. 2007)

# Phase I: Planning the review

```
┌─────────────────────┐      ┌──────────────────────────────────────────┐
│    Phase I:          │ ───► │ Identification of the need for a review   │
│ Planning the review  │      ├──────────────────────────────────────────┤
│                      │ ───► │ Development of a review protocol          │
└─────────────────────┘      └──────────────────────────────────────────┘
```

- Motivation for the research, existence of previous reviews

- Review protocol describes the research questions and the method for answering them (Kitchenham, 2004)

  - Research questions to be answered

  - Detailed strategy and procedures for all steps in Phase II

- This phase and especially review protocol distinguishes systematic reviews from traditional ones

# Phase II

| Phase II: Conducting the review | → | Identification of research |
| | → | Selection of primary studies |
| | → | Study quality assessment |
| | → | Data extraction |
| | → | Data synthesis |
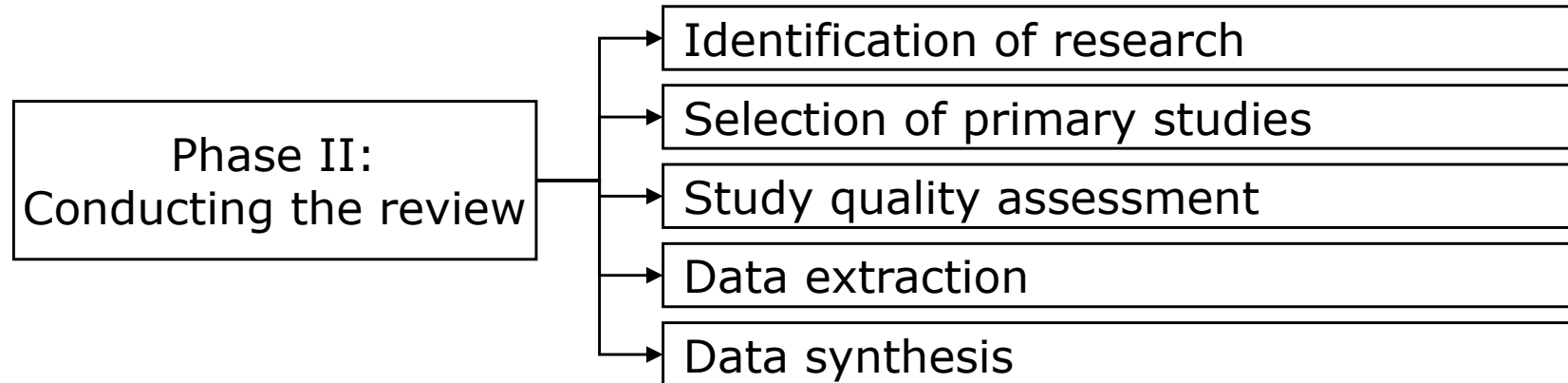
- The most laborious part of literature reviews
  - Compare to other research methodologies
  - Utilise tools where available!
- Produces, besides final results, also intermediate artifacts: search record and archives, list of selected publications, extracted data from each publication etc.

# Phase II: Identification of research

- Idea: find out sources of primary studies and ways of searching for them

- Database-centric

    - Identify relevant SE databases

    - Based on research questions, construct search strings

    - Problem: synonyms, unestablished terminology, database search issues, huge search strings

- Forum-centric

    - Identify relevant SE journals and conferences

    - Problem: missing relevant primary studies published in unusual forums

        - May need to augment study selection with backward and forward referencing

    - Systematic review community does not endorse this as a primary means

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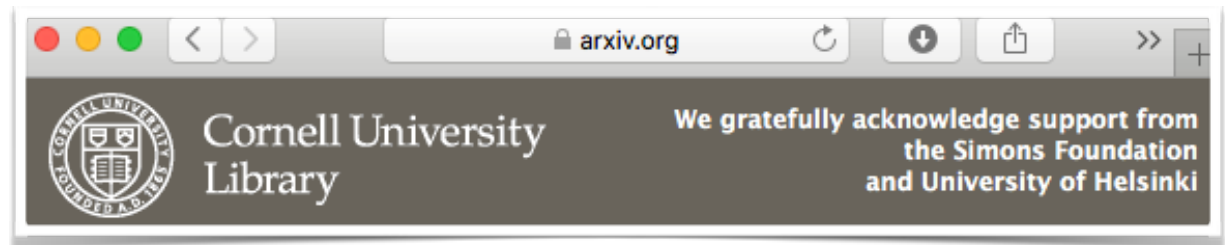
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| ☐ 2018 (1) > | | View abstract ⌄    🔴 Links    View at Publisher    Related documents | | | | |
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| ☐ 2015 (224) > | | View abstract ⌄    🔴 Links    View at Publisher    Related documents | | | | |
| ☐ 2014 (177) > | ☐ 3 | Agile digital transformation of System-of-Systems architecture models using Zachman framework | Bondar, S., Hsu, J.C., Pfouga, A., Stjepandić, J. | 2017 | Journal of Industrial Information Integration 7, pp. 33-43 | 1 |
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| **Author name** ⌃ | ☐ 4 | Design, Manufacturing, and Ground Testing of a Control-Moment Gyro for Agile Microsatellites | Arena, L., Piergentili, F., Santoni, F. | 2017 | Journal of Aerospace Engineering 30(5),04017039 | 0 |
| ☐ Bosch, J. (15) > | | View abstract ⌄    🔴 Links    View at Publisher    Related documents | | | | |
| ☐ Barata, J. (13) > | ☐ 5 | Data to Decisions: Creating a Culture of Model-Driven Drug Discovery | Brown, F.K., Kopti, F., Chang, C.Z., (...), Glick, M., Waller, C.L. | 2017 | AAPS Journal 19(5), pp. 1255-1263 | 0 |
| ☐ Zimmermann, A. (12) > | | View abstract ⌄    🔴 Links    View at Publisher    Related documents | | | | |
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| ☐ Computer Science (1,759) > | | | | | | |
| ☐ Engineering (1,235) > | | | | | | |
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# Examples of difficulties with search strings

- Aim: to study the motivation for organisations to embark CMM or CMMI (Staples & Niazi, 2007)
  - Initial search string: (CMM <or> CMMI) <and> (reason <or> motivation)
  - Used search string: (CMM <or> CMMI),  for some databases also "<and> capability maturity" was added to trunctate the results below maximum level
  - 591 hits in ScienceDirect

- Aim: to study variation or adaptation of quality attributes
  - ((quality <or> non-functional <or> NFR <or> QoS <or> nonfunctional <or> reliability <or> security <or> performance <or> availability <or> usability <or> fault-tolerance) <and> (variability <or> adaptation <or> reconfigurable <or> adaptive <or> variation <or> variant) <and> software)
  - 3981 hits in IEEE Xplore

# Snowballing

1. The major contributions are likely to come from journal articles, and hence it is recommended to start with the leading journals in the field.

2. Go backward using the reference lists.

3. Go forward by looking at citations of the articles identified in steps 1 and 2 using the ISI Web of Science.

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(Wohlin & Prikladniki 2013)

# Snowballing – Backward

**References in the paper**

References (39)

☐ All    Export    🖶 Print    ✉ E-mail    🗎 Save to PDF    Create bibliography

☐ 1   Cunningham, W.
The WyCash portfolio management system
(1992) *SIGPLAN OOPS Mess.*, 4, pp. 29-30. Cited 191 times.

☐ 2   Kruchten, P., Nord, R.L., Ozkaya, I.

Technical debt: From metaphor to theory and practice

(2012) *IEEE Software*, 29 (6), art. no. 6336722, pp. 18-21. Cited 115 times.
doi: 10.1109/MS.2012.167

🔗 Links    View at Publisher

☐ 3   Kruchten, P., Nord, R.L., Ozkaya, I., Falessi, D.
Technical debt: towards a crisper definition report on the 4th international workshop on managing technical debt
(2013) *ACM SIGSOFT Softw. Eng. Notes*, 38, pp. 51-54. Cited 15 times.

☐ 4   Tom, E., Aurum, A., Vidgen, R.

A consolidated understanding of technical debt

(2012) *ECIS 2012 - Proceedings of the 20th European Conference on Information Systems.* Cited 5 times.
ISBN: 978-848897154-8

🔗 Links

☐ 5   Tom, E., Aurum, A., Vidgen, R.

An exploration of technical debt

# Snowballing – Forward

**Other papers citing / referring to the paper**

Cited by 3 documents

Intertemporal choice: Decision making and time in software engineering

Becker, C. , Walker, D. , Mccord, C.
*(2017) Proceedings - 2017 IEEE/ACM 10th International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE 2017*

Agile scalability requirements

Brataas, G. , Fægri, T.E.
*(2017) ICPE 2017 - Proceedings of the 2017 ACM/SPEC International Conference on Performance Engineering*

Investigating the evolvability of financial domain models

Deryck, M. , Dvořák, O. , De Bruyn, P.
*(2017) Lecture Notes in Business Information Processing*

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# Phase II: Study selection

Search databases, browse journals and conference proceedings

↓

Include / exclude studies based on titles

↓

Include / exclude studies based on abstracts

↓

Include / exclude studies based on paper content (introduction, conclusions)
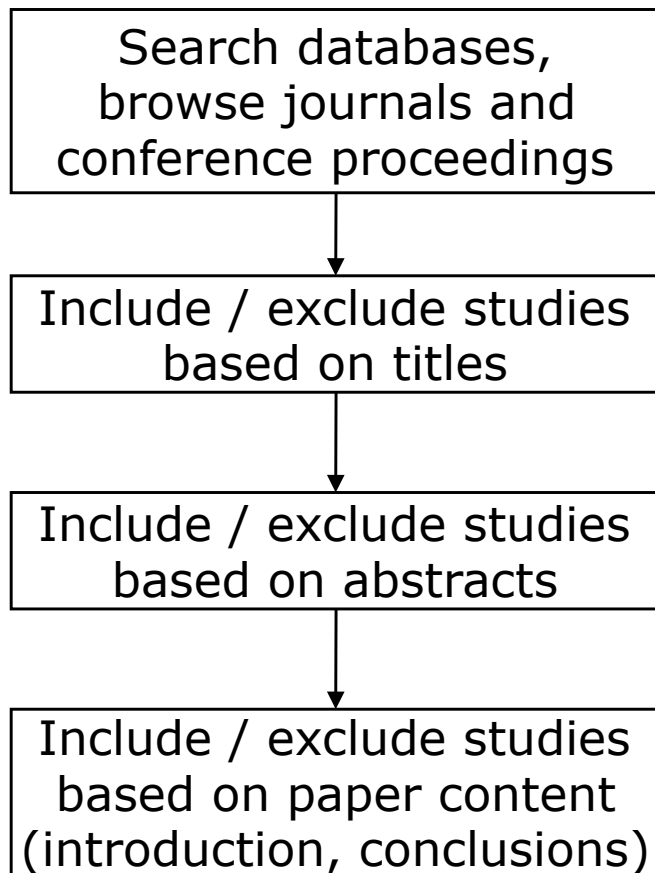
(modified from Dybå et al., 2007)

- For each step, apply predefined inclusion / exclusion criteria
  - Example inclusion criteria
    - Addresses any agile method in software engineering AND is a case study
  - Example exclusion criteria
    - Does not concentrate on software development
- For each step, may report the number of included / excluded papers
- Problem: is the study selection replicable?
  - To remove bias, may need to check other researchers' opinion
- Problem: lack of rigour in SE
  - Poor abstracts, misleading titles, unestablished terminology, methods not reported

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# Phase II: Study quality assessment

- Idea: evaluate paper quality to assess its relevance for analysis (Kitchenham, 2004)

  - Quality of the methodology, threats to validity, how research questions are answered, possible bias in results

  - Can be in the form of checklists or questions

  - If something cannot be determined from the report, contact original authors

- However, difficult to judge quality of the primary studies (Staples & Niazi, 2007, Tranfield et al., 2003)

  - In medical science, it is easy to determine what is "relevant" and "good research" (Tranfield et al., 2003)

  - SE publications are often methodologically weak, also variation in methods, multiple types of methods

  - Hence, quality assessment should depend on the type of review (Staples & Niazi, 2007)

## TABLE 3
## Questions to Assess Study Quality

| # | Question |
|---|----------|
| Q1 | Is there a rationale provided for why the study was undertaken? |
| Q2 | Is there an adequate description of the context (industry, laboratory setting, products used, etc.) in which the research was carried out? |
| Q3 | Is there a justification and description for the research design? |
| Q4 | Is there a clear statement of findings, including data that supports findings? |
| Q5 | Did the researcher(s) critically examine his / her (their) own role, potential bias, and influence during the study? |
| Q6 | Are limitations and credibility of the study discussed explicitly? |

## TABLE 6
## Studies with a Total Quality Score of 6 and 5.5

Each quality assessment question was answered by assigning a numerical value (1 "yes", 0 "no", and 0.5 "to some extent").

| Study ID | Quality score |
|----------|---------------|
| 5 | 6 |
| 16 | 6 |
| 42 | 6 |
| 46 | 6 |
| 57 | 6 |
| 17 | 5.5 |
| 52 | 5.5 |
| 59 | 5.5 |
| 66 | 5.5 |
| 144 | 5.5 |
| 146 | 5.5 |
| 187 | 5.5 |

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# Phase II: Data extraction and synthesis

- Use a predefined form for data extraction (Kitchenham, 2004)
  - For each primary study, fill in the form
- Questions or data models to be filled in
  - Stardard parts like paper title, author, etc.
  - Items related to the research questions, e.g., proposed method, organisation size, how method was evaluated
- Kitchenham advocates the extraction of numerical data
  - To enable quantitative analysis of primary studies
  - However, this can be relatively difficult in SE
- After extraction has been conducted, synthesis can be drawn by combining collected data

**Think about how much this makes sense to your topic**

# Phase III: reporting the review

- Report
  - Method: activities performed in Phase I and Phase II
  - Results: your analysis
  - A suggested paper structure exists (Kitchenham, 2004)
- Consider publishing detailed coverage of the method in a separate technical report (Kitchenham, 2004)
- Tone: being overly negative or critical to previous literature is an indicator of amateurism (Webster & Watson, 2002)
- Tense: present tense preferable (Webster & Watson, 2002)
  - "Staples and Niazi (2007) report their experiences on..."
- Be careful in distinguishing
  - Findings in primary studies (claims of original papers)
  - Findings in the secondary study (your analysis)

# Systematic literature reviews

- Background in medical science (Tranfield et al., 2003)

  - Methodological rigour (medicine) vs. methods not well established (SE)

  - Quantitative (medicine) vs. mainly qualitative (SE)

  - Established research questions (medicine) vs. opening up new questions (SE)

  - Accumulating knowledge (medicine) vs. lack of confirming or repeated studies (SE)

- Despite these differences, Kitchenham (2004) has proposed guidelines for applying systematic literature reviews in SE

  - Quite straightforward application, and hence certain difficulties

# Systematic?
# Why and when?

**Mapping study** —————— **meta-ethnography**

**Systematic
Literature
Review**

# Analysis / Synthesis – Writing

# Phase II: Data extraction and synthesis

## Table 1. Approaches to Literature Reviews

| Concept-centric | Author-centric |
|---|---|
| Concept X … [author A, author B, …]<br>Concept Y … [author A, author C, …] | Author A … concept X, concept Y, …<br>Author B … concept X, concept W, … |

## Table 2. Concept Matrix

| Articles | Concepts | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | … |
| 1 | | ✖ | ✖ | | ✖ |
| 2 | ✖ | ✖ | | | |
| … | | | ✖ | ✖ | |

## Table 3. Concept Matrix Augmented with Units of Analysis

| Articles | A | | | B | | | C | | | D | | | … | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit of analysis | O | G | I | O | G | I | O | G | I | O | G | I | O | G | I |
| 1 | | | | | ✖ | | | | ✖ | | | | | | ✖ |
| 2 | ✖ | | | | ✖ | ✖ | | ✖ | | | | | | | |
| … | | | | | | | | ✖ | ✖ | | | ✖ | | | |

Legend: O (organizational), G (group), I (individual)

(Webster & Watson, 2002)

# A literature review is concept-centric

| Articles | Concepts | | | |
|----------|----------|---|---|----|
|          | A | B | C | .... |
| 1        | x |   | x | x |
| 2        |   | x |   | x |
| ...      |   | x | x |   |

A **concept matrix** is a
good tool to start with.

**Conceptual model**
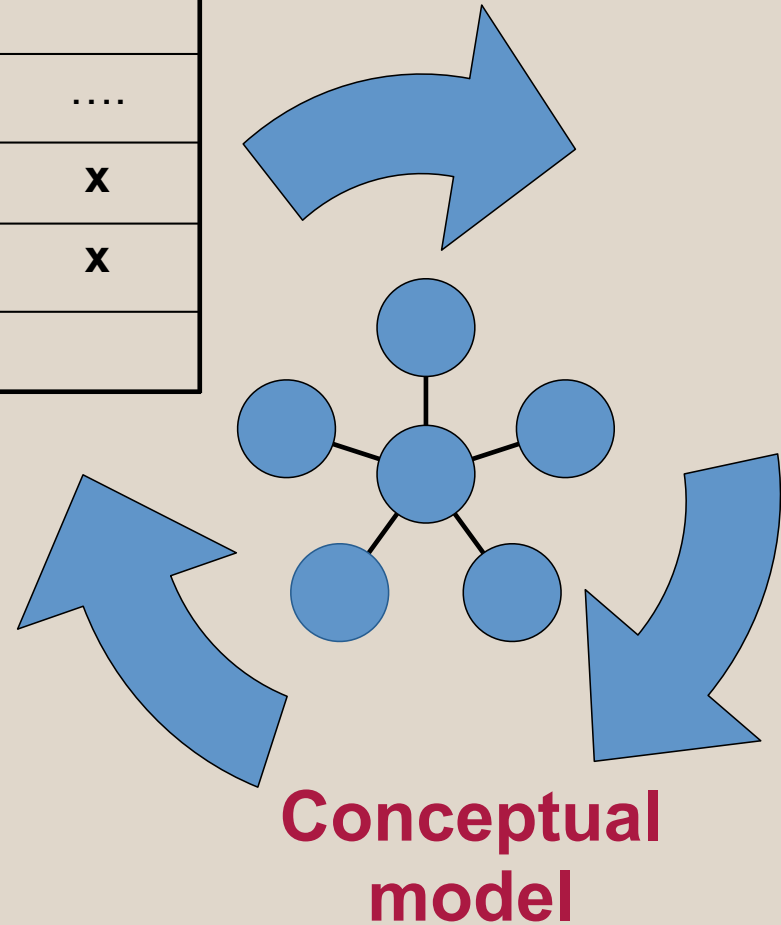
# Author-prominent

———

# Information-prominent

# Bloating the list of references

…techniques to deal with crosscutting features (e.g. [10][21][27][29][31][37]).

…there are similar metrics suites as the introduced one in [13][14][34][38].

# Comments about referencing

*" Have they even read the paper???? "*

"You only need to read the abstracts…"

**"Most references are to the introduction of the source."**

not just a summary of the relevant literature

**your own critical judgement and analysis**

# Example on structure

Conradi, R. & Westfechtel, B., 1998.
Version models for software configuration
management. *Computing Surveys*, 30(2).

CONTENTS

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# Example, meta-ethnography

da Silva, F.Q.B. et al., 2013.
Using meta-ethnography to synthesize research: A worked example of the relations between personality and software team processes.
In International Symposium on Empirical Software Engineering and Measurement.
pp. 1–10.

TABLE III.      MAIN CONCEPTS FROM EACH STUDY

| Concepts | TP1 | TP2 | TP3 | TP4 |
|---|---|---|---|---|
| Task Characteristics | X | | | |
| Personality | X | X | X | X |
| Conflict | X | X | | X |
| Cohesion | X | | | X |
| Team Composition | | X | X | X |
| Performance | | X | X | X |
| Satisfaction | X | X | | |
| Software Quality | X | | | |

TABLE II.      CONTEXTUAL INFORMATION ABOUT THE STUDIES

| Context | TP1 [1] | TP2 [24] | TP3 [22] | TP4 [23] |
|---|---|---|---|---|
| Objective | "This article analyses the relationships between personality, team processes, task characteristics, product quality and satisfaction" | "We test the impact of problem solving preferences (a sub-set of the MBTI scale) on group conflict and performance". | "… investigate interactions of personalities in software engineering (SE) teams and how disruptions and lack of debate between individuals affected performance". | "… to gain a qualitative understanding of how cohesiveness relates to personality type, performance and adherence to a methodology (XP)." |
| Sample | Second-year computing undergraduate students (105 participants divided in 35 teams) | Undergraduate students, enrolled in two 15-week SE courses. (38 members in 9 teams) | Three teams (5-6 individuals each) of Master's-level students. | Five teams (5-6 individuals each) of Master's-level students. |
| Research Method | Quasi-experiment | Quasi-experiment | Ethnographically-informed | Ethnographically-informed |
| Design | "The students were divided into 35 three-member teams … formed at random and … blind to the quasi-experimental conditions and hypotheses." | "… students were assigned to 4-5 person teams: five control groups of numerical dominant problem solving style and four experimental groups of diverse styles." | Convenience sampling of the three teams participating in the "Maxi Project". | "The teams were selected on the basis of personality type, nationality and previous skills/experience". |
| Data Collection | "Measurements were taken before the project (NEO FFI personality test), during the project (conflict, cohesion) and after the project (autonomy, interdependency and satisfaction)." | "At the conclusion of every phase of the team project, peer evaluations were collected. Team members were asked five questions related to team dynamics". | Observations and online personality test based on the MBTI. | Observations, focus group interviews, document analysis, workgroup cohesion test, and online personality test based on the MBTI. |
| Setting | "Special-purpose project with non-professional participants (… students) undertaking a (toy) project using an adaptation of the agile XP method within a laboratory environment". | "The semester long projects were complex and ill-structured, requiring teams to consider the pros and cons of several design options". | "The teams … worked on real software development projects for real clients in the project "Maxi Project" (a two semester long project during 2004-2005)". | Teams of students participating in professional software house known as Genesys Solutions as part of the Software Engineering Observatory at the University of Sheffield. |
| Country | Spain | United States | England | England |

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# Conclusions

- Literature review can act as a primary or secondary research method

- Systematic literature review guidelines have been proposed
  - Background in medical science, challenging as such in SE
  - Balancing between rigour (following the guidelines) and relevance (finding relevant primary studies)

- However, ideas from systematic reviews can be stolen to conduct a semi-systematic review
  - E.g., reporting on how literature study was conducted in one's thesis

- Being systematic in wrong places or for wrong reasons makes no sense

- Most important is the understanding gained and reported
  - Proper analysis
  - Conceptualisation

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# References

Brereton P, Kitchenham BA, Budgen D, Turner M and Khalil M, 2007. Lessons from applying the systematic literature review process within the software engineering domain, Journal of Systems and Software, 80, 571–583

Dybå T and Dingsøyr T, 2008.Empirical Studies of Agile Software Development: A Systematic Review, Information and Software Technology, 50, 833-859

Dybå T, Dingsøyr T and Hanssen GK, 2007. Applying systematic reviews to diverse study types: An experience report. Proc. of Symposium on Empirical Software Engineering and Measurement.

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