# 7. Evidence: Data Collection and Analysis

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# *Evidence*

- In an academic work you need to convince readers that your point of view is correct.

- The only way to do this is to offer credible *evidence*, clearly substantiating the point you are trying to make.

- Evidence is needed whenever you make an assertion or claim that is not self-evidently true to the average reader in your field.

- Evidence is the foundation of any academic argument. Without evidence you don't have an argument in academic terms – all you have is an opinion.

(Hofstee 2006, pp. 146ff)

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2

# Types of Evidence – Appropriate Use of Reseach Method

- Your concrete research usually is made up of different types of evidence

- Your *research method* determines what type of evidence you will mainly rely on.

- Evidence from Knowledge Base
  - quotes from literature

- **Data** collected from Environment
  - Quantitative vs. Qualitative
  - Primary vs secondary

Environment

Problem

RESEARCH

Knowledge Base

Library

(Hofstee 2006, pp. 146ff)

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3

# *Data support Relevance*

- With data you analyse your environment (application domain)

Environment

Body of Knowledge



Solution of Problem

Addition to
Knowledge base

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4

# Evidence is based on Data and Analysis

■ Your research *provides you with relevant facts or data* that you can *analyse and use as evidence* to prove your thesis statement (resp. answer your research question)

■ If you want your readers to accept or even consider your argument, you need

♦ the **data** to substantiate your point and

♦ provide **analysis** and argumentation that gives meaning to the data

(Hofstee 2006, pp. 146ff)

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5

# *Primary Sources*

- Primary sources are the *thing* that you are investigating. They have not been analysed or interpreted by someone else.

- Types of data collection – examples:
  - Measuring (e.g. process performance, performance of an algorithm)
  - Looking into company records (e.g. databases, event logs)
  - Data from sensors
  - Setting up an experiment
  - Observations
  - Interviewing people
  - Questionnaires
  - Workshops, focus groups

- Primary data is considered stronger than secondary data.

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6

# *Secondary Sources*

- Secondary sources pertain to what you are investigating, but are based on primary data that someone else has interpreted or analysed.

- Examples:
  - ♦ Studies, surveys and statistics
  - ♦ Measurements published in literature

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7

# Research Strategies, Choices and Philosophy



(De Villiers 2005)

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8
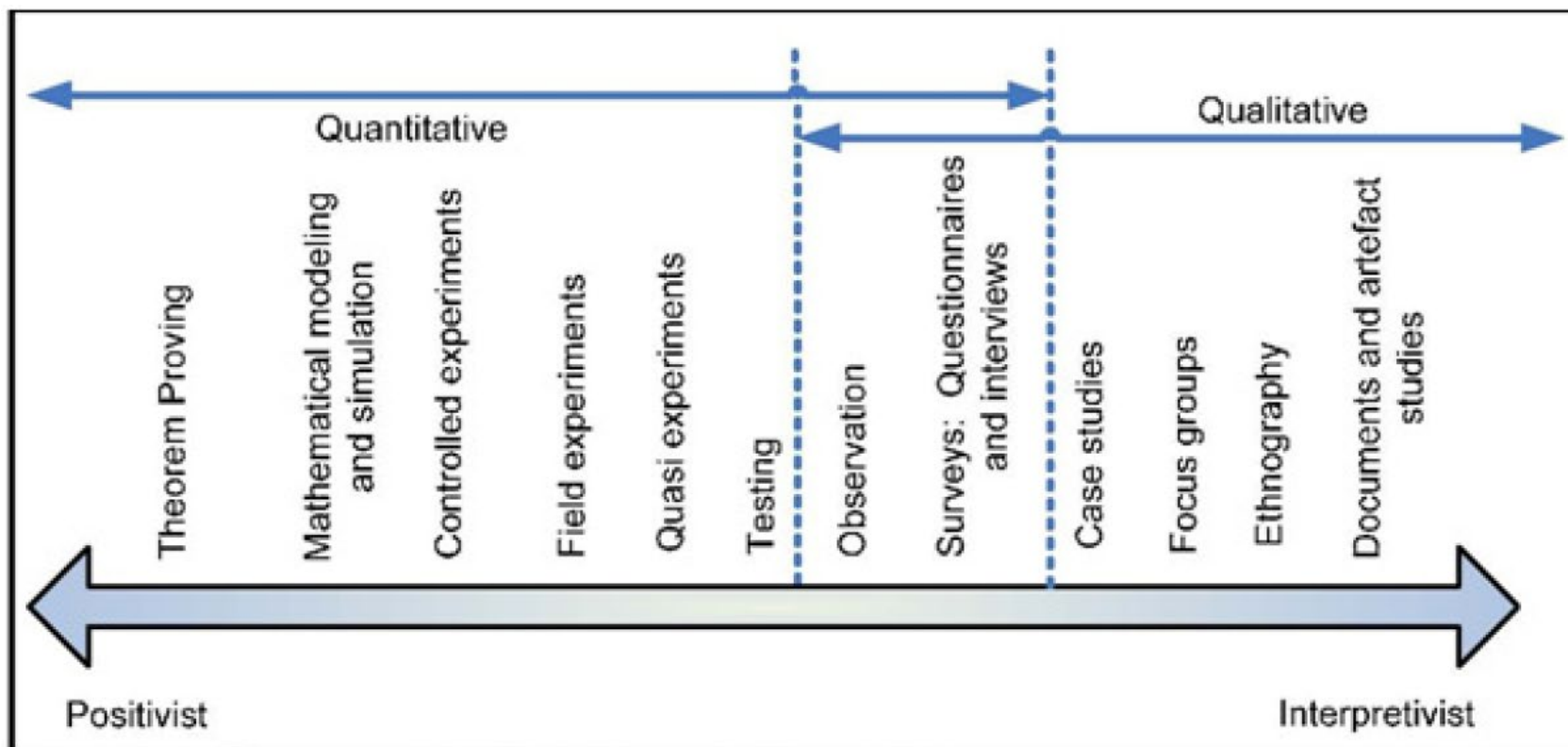
# Quantitative vs. Qualitative

- **Quantitative research:**
  - ♦ focuses on verifying hypotheses (deductive) or finding patterns (inductive) using typically *large amounts of data*

- **Qualitative research:**
  - ♦ focuses on understanding the important characteristics of typically *small samples of data*

- **Example**: investigate users' response to an interface
  - ♦ quantitative approach: collect ratings, verify user acceptance, sensor data, test results,
  - ♦ qualitative approach: understand *why* users interact with the interface in certain ways

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9

# Research Choices



(Saunders et al. 2009)

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10
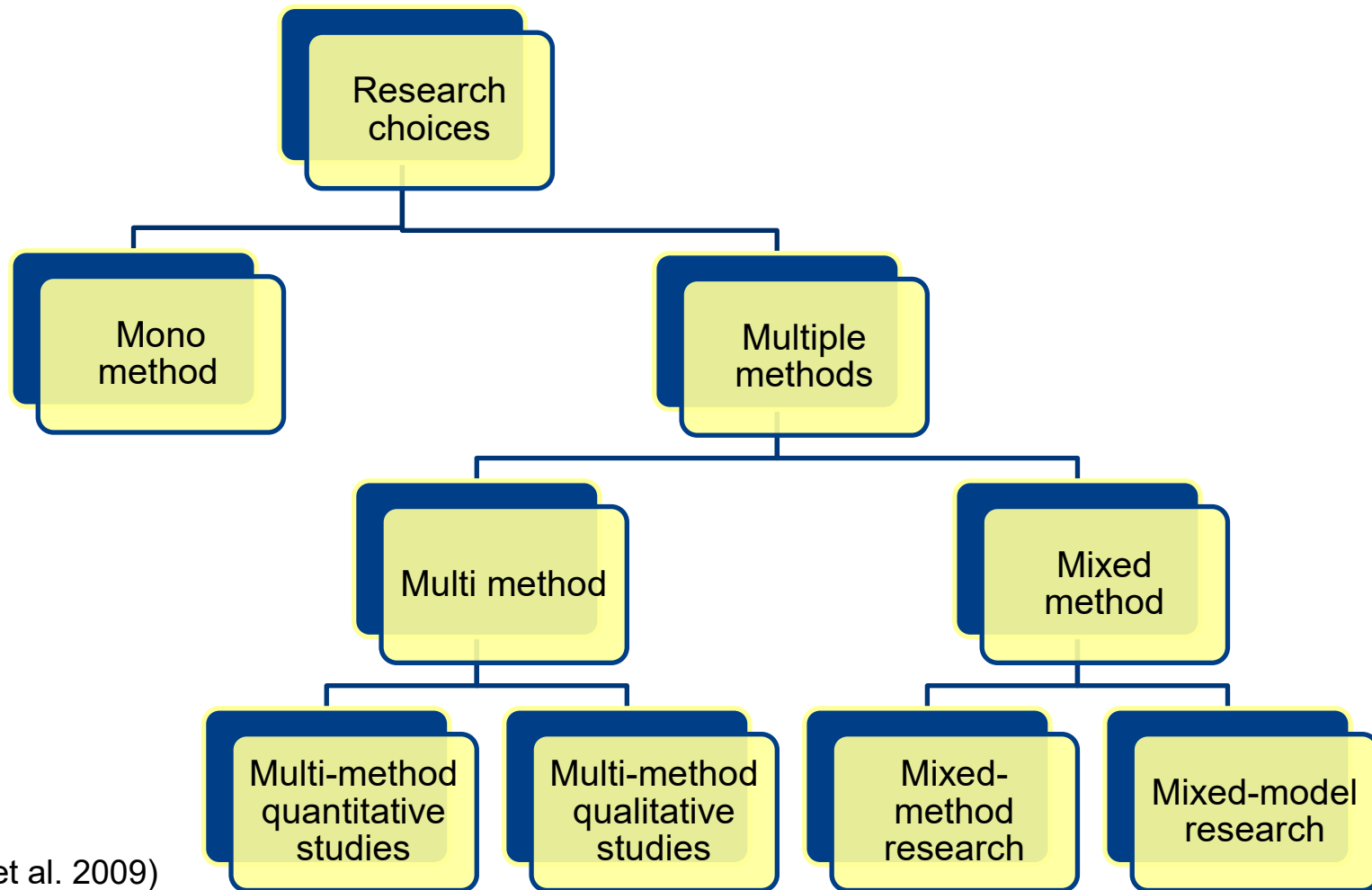
# *Evidence Depends on the Quality of Data and the Appropriate Use of it*

■ All data and facts can be used as evidence for something, and they can be used effectively or ineffectively.

■ After you have established what type of evidence is appropriate to your dissertation, it is up to you to make sure that the evidence you present is both

♦ of **sufficient quality** and

♦ **used appropriately**

(Hofstee 2006, pp. 146ff)

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11

# Sufficient Data Quality

■ «Of sufficient quality» means that …

… the data is realiable,

… there is enough of it,

… it pertains directly to your point, and

… it is current

(i.e. it must not have been superseded by later evidence that has established the earlier work to be inapplicable or flawed)

(Hofstee 2006, pp. 146ff)

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12

# The quality of your data will determine the quality of your dissertation ..

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13

# Evidence in Design Science Research

In Design research evidence from data is particularly used for problem understanding and artefact evaluation
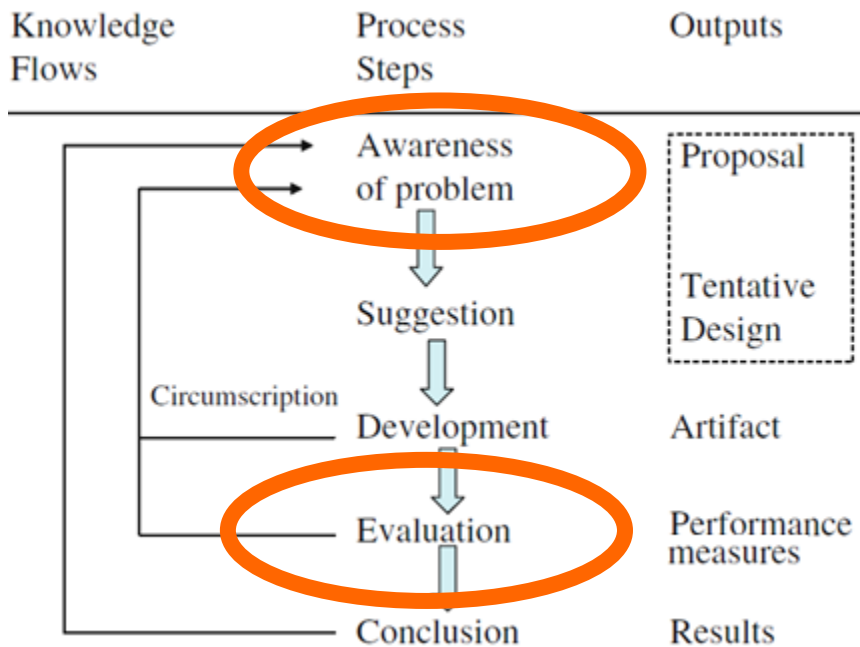


**Awareness of the Problem:**
- Based on the collected data, a design researcher designs an artifact that provides utility
- In addition the researcher has to provide evidence that this artifact solves a real problem.

**Evaluation:**
- To provide evidence, it has to be examined whether the artifact meets the requirements.

*(Hevner & Chatterjee 2010, p. 110/122)*

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14

# *Sources of Evidence*

# Collecting Data from Documents and Databases

| Source of Evidence | Strengths | Weaknesses |
|---|---|---|
| **Documentation**<br><br>Project reports, emails, meeting minutes, progress reports, … | • Stable—can be reviewed repeatedly<br>• Unobtrusive—not created as a result of the case study<br>• Specific—can contain the exact names, references, and details of an event<br>• Broad—can cover a long span of time, many events, and many settings | • Retrievability—can be difficult to find<br>• Biased selectivity, if collection is incomplete<br>• Reporting bias—reflects (unknown) bias of any given document's author<br>• Access—may be deliberately withheld |
| **Archival records**<br><br>Statistics, finance sheets, budgets, personnel records, … | • *[Same as those for documentation]*<br>• Precise and usually quantitative | • *[Same as those for documentation]*<br>• Accessibility due to privacy reasons |

(Yin 2018)

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16

# *Interview*



- One of the most important sources of evidence for case studies

- Tend to adopt semi-structured designs

- There are many different types of interview styles you need to identify the correct one for your study

- Interviewees can have different levels of engagement in the interview

- Thinking about how to record and process interview data is important

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17

# *Interviews*

| Source of Evidence | Strengths | Weaknesses |
|---|---|---|
| **Interviews** | • Targeted—can focus directly on case study topics<br><br>• Insightful—provides explanations as well as personal views (e.g., perceptions, attitudes, and meanings) | • Bias due to poorly articulated questions<br><br>• Response bias<br><br>• Inaccuracies due to poor recall<br><br>• Reflexivity—e.g., interviewee says what interviewer wants to hear |

(Yin 2018)

# Focus Group – Group Interview



- A focus group is a moderated discussion among 6–12 people who discuss a topic under the direction of a moderator

- The focus group technique is useful as an

  - *exploratory method* when little is known about the phenomenon (e.g. problem understanding, identify needs and requirements)

  - as a *confirmatory method* to test hypotheses or to evaluate a design

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19

# *Observations*

| Source of Evidence | Strengths | Weaknesses |
|---|---|---|
| **Direct observations** | • Immediacy—covers actions in real time<br><br>• Contextual—can cover the case's context | • Time-consuming<br><br>• Selectivity—broad coverage difficult without a team of observers<br><br>• Reflexivity—actions may proceed differently because participants know they are being observed<br><br>• Cost—hours needed by human observers |
| **Participant-observation** | • *[Same as above for direct observations]*<br><br>• Insightful into interpersonal behavior and motives | • *[Same as above for direct observations]*<br><br>• Bias due to participant-observer's manipulation of events |

(Yin 2018)

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20

# *Data from Physical Artefacts*

| Source of Evidence | Strengths | Weaknesses |
|---|---|---|
| **Physical artifacts**<br><br>Technical devices, tools, instruments, sensors, … | • Insightful into cultural features<br><br>• Insightful into technical operations | • Selectivity<br><br>• Availability |

(Yin 2018)

# *Data Analysis*

# *Analytical Techniques for Qualitative Case Studies*

■ **Pattern Matching**

- ♦ Compare the empirical patterns (findings based on your data) to a prior predicted pattern (or several) established before the data collection, e.g. a theory found in literature (confirmation, replication) [*)]

■ **Explanation Building**

- ♦ Building an explanation about "how" or "why" some outcome has occurred; typically takes a narrative form

■ **Time Series Analysis**

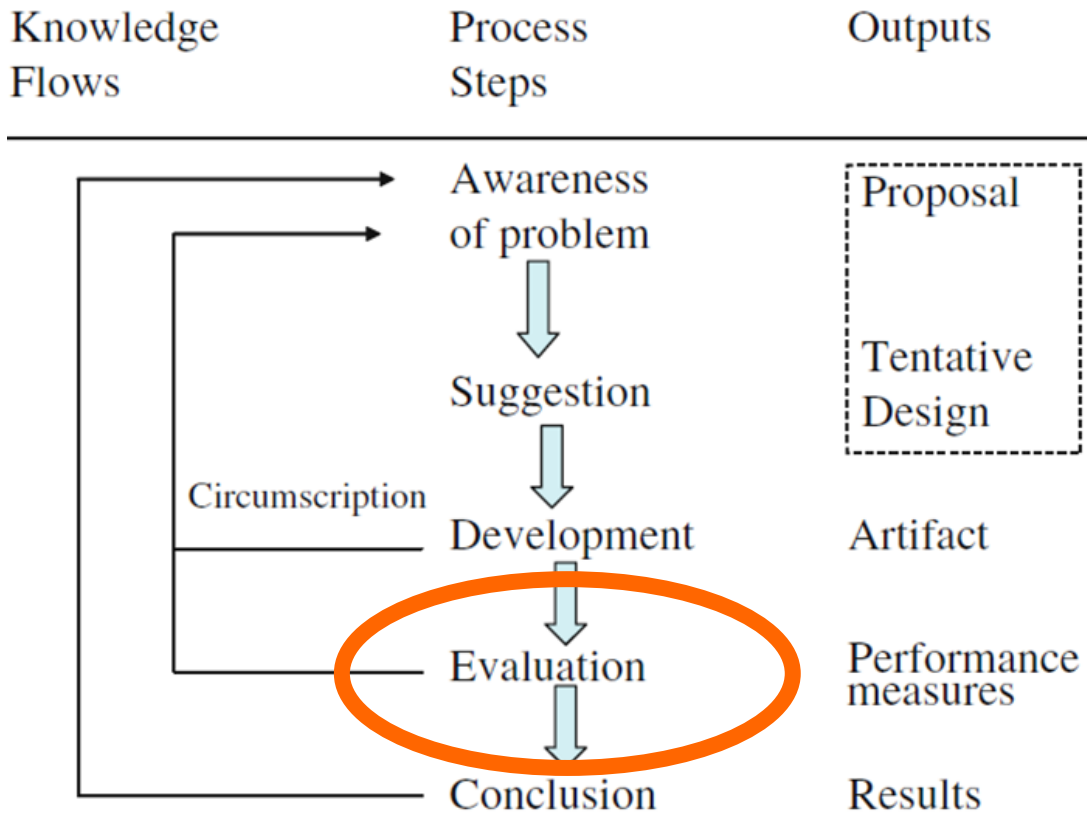- ♦ Track a phenomenon over time to identify how changes take place

■ **Logical Models**

- ♦ Stipulate a complex chain of events tat occurred over an extended period of time in cause-effect-cause-effect patterns; can be represented graphically

[*)] See section 2 – Research contribution

(Yin 2018)

# *Examples of Logical Models*



This logical model from (Yin 2018) shows youth behaviour and possible interventions

- Logical Models are often used in information systems to represent
  - ◆ Behaviour (e.g. process models)
  - ◆ Conceptual Models (e.g. class diagrams)
  - ◆ Interactions (e.g. use case diagrams)
  - ◆ Cause-effect relationships (e.g. state transition diagrams)

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24

# *Evaluation: Evidence for Design Research*

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# Evaluation in Design Science Research



**Knowledge Flows** | **Process Steps** | **Outputs**

- Awareness of problem → Proposal
- Suggestion → Tentative Design
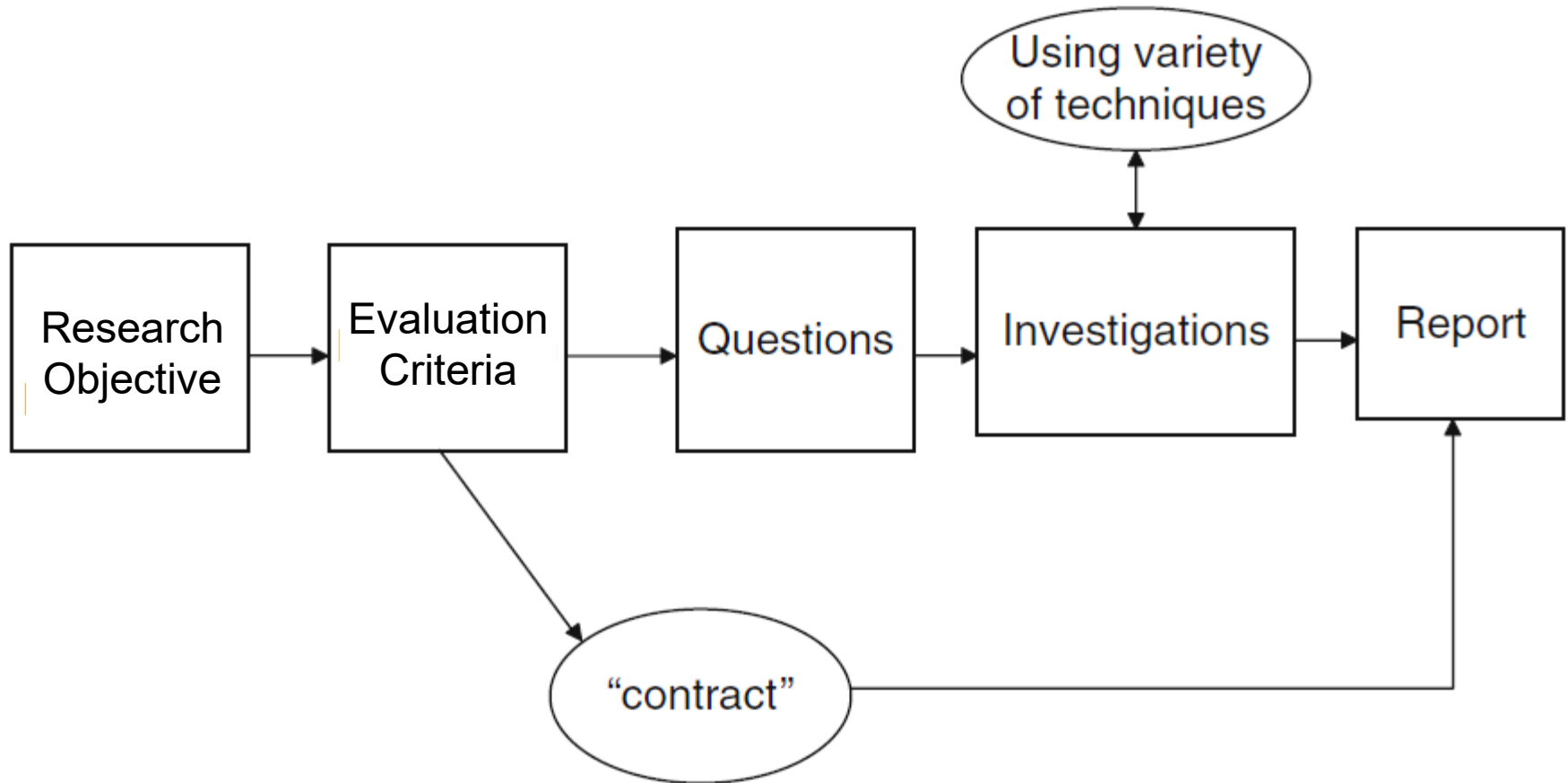- Circumscription
- Development → Artifact
- Evaluation → Performance measures
- Conclusion → Results

- To provide evidence, it has to be examined whether the artifact meets the requirements. This is done in the **evaluation phase**.

- Evidence-based artifact evaluation requires that the artifact is evaluated within the business environment.

- A design science paper with no evaluation is least likely to be accepted for a conference or journal

*(Hevner & Chatterjee 2010, p. 27/122)*

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26

# Structure of an Evaluation Study



Evaluation should be viewed as an exercise in argument, rather than as a demonstration, because any study appears equivocal when subjected to serious scrutiny.

adapted from (Hevner & Chatterjee 2010, p. 112f)

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27

# *What to evaluate in Design Science Research*

- Depending on the artifact, there are different aspects that can be evaluated, for example
  - ♦ performance (of a technical system)
  - ♦ organizational impact

- Depending on what to be evaluated there are different evaluation methods, e.g.

| What to evaluate | Evaluation Methods |
| --- | --- |
| Performance | analytical modeling, simulation, measurement, testing |
| Organisation impact | quantitative surveys, qualitative interviews, focus groups, questionnaires, observation |

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28

# *How to do evaluation?*

Example1: *We develop and introduce a new IT system that supports customer consultants in a bank in recommending financial products reducing effort and making recommendations better*

- ■ How would you make the evaluation?

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29

# *Evaluation Methods (1)*

■ *Measurements / Observational Case Studies*

♦ Study the designed artifact in depth in a real environment.

♦ Observe the use of the artifact to gain understanding of its value and utility.

♦ Measurement is typically used for Performance Evaluation

♦ *Metrics* are criteria for variables to evaluate the performance, e.g.

● efficiency (time required, use of resources, scalability)
● effectiveness (accuracy, quality of results)

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30

# *Evaluation Methods (2)*

Alternative evaluations, if you cannot measure the artefact in a real environment:

♦ *Descriptive* evaluation

- Informed argument uses information from knowledge base to build a convincing argument for artifact's utility.

♦ *Scenarios construction*

- construct detailed scenarios around artifact to demonstrate its utility.

♦ *Experimental* methods

- controlled experiments in which you study the artifact in controlled environment for qualities (e.g., usability).
- *simulation* models: execute the artifact with artificial data and observe dynamic performance behavior and scalability.

♦ *Analytical* techniques

- examine the structure of the artifact for static qualities (e.g., complexity, architecture) or behaviours

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31

# *Critical Evaluation*

- The evaluation should be critical in order to provide evidence

- Even if not applicable in a real scenario, you have to allow and stimulate a critical assessment of your artefact

  ♦ Construction a scenario in which the systems is used and assessed

  ♦ Make a workshop in which the artefact is evaluated be several people (maybe covering different perspective), e.g. focus group

- Be careful with interviews:

  ♦ Often too shallow – interviewee must be very familiar with the artefact

  ♦ Critical setting: Determine weaknesses, not ask for confirmation

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32

# *Using Evidence Appropriately*

- Your use of the evidence must
  - ♦ relate it clearly to the point that you want to make.

- If your evidence has shortcomings, but you still believe it is useful, you must
  - ♦ admit to those shortcomings and
  - ♦ justify why you believe the evidence still supports your point.

- You should present both
  - ♦ evidence that is in favor of your thesis and
  - ♦ evidence that contradicts it.

  (Ignoring contradicting evidence or weaknesses in evidence suggests to readers that you are afraid that your argument would fall apart.)

  (Hofstee 2006, pp. 146ff)

# *Assess Quality of your Evidence*

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35

# *Evidence and Research Methods*

- To provide evidence you have to make sure that

  - ♦ the research method was suitable for your research

  - ♦ You have applied it appropriately and

  - ♦ that the conclusions you drew are valid

- The reader and reviewer of your thesis/paper (in particular your supervisor and the examiners) will check whether you did it adequately

- In the following we provide some sample questions you (or a reviewer) can use as guidelines to check the adequate application of the evidence.

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36

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