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)

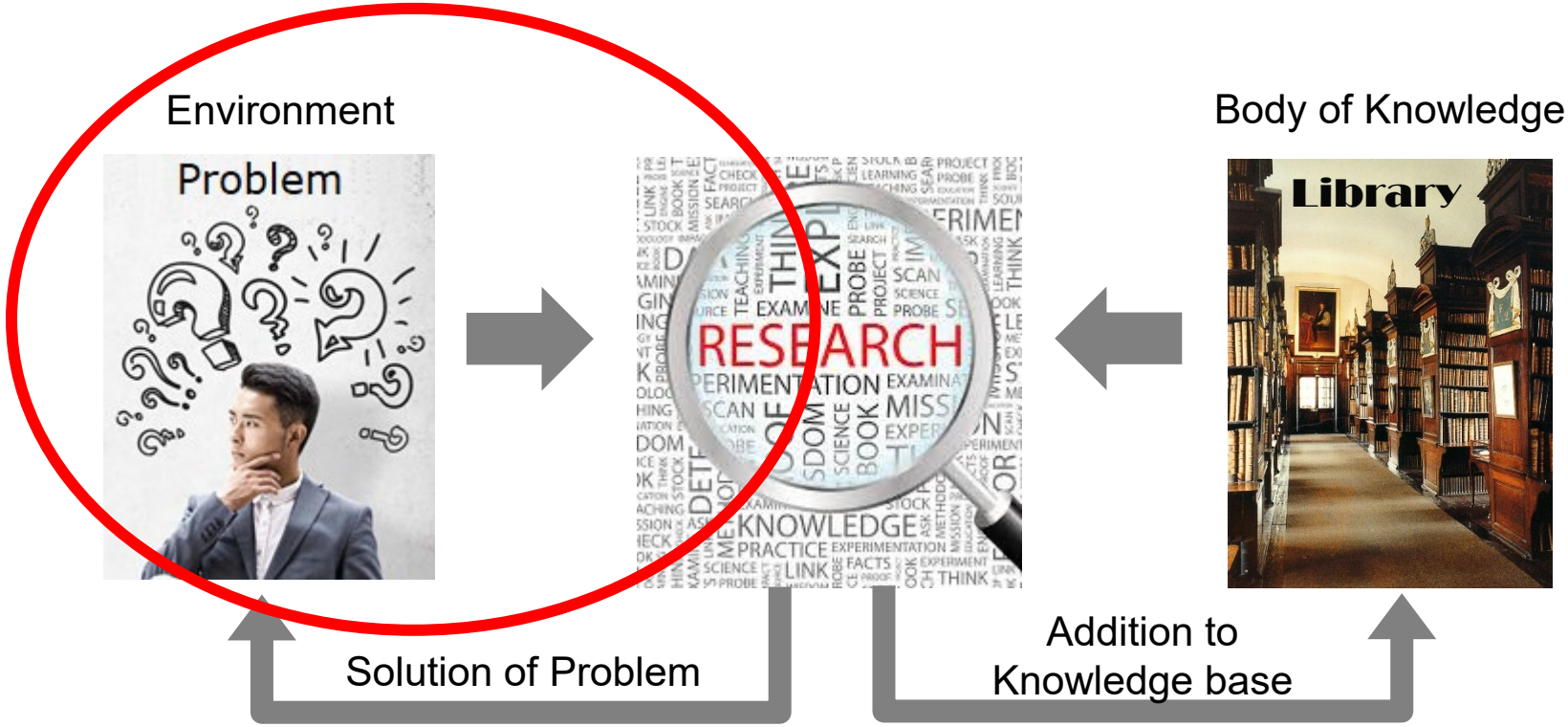
Types of Evidence – Appropriate Use of Reseach Method

- 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

(Hofstee 2006, pp. 146ff)

Data support Relevance

- With data you analyse your environment (application domain)



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)

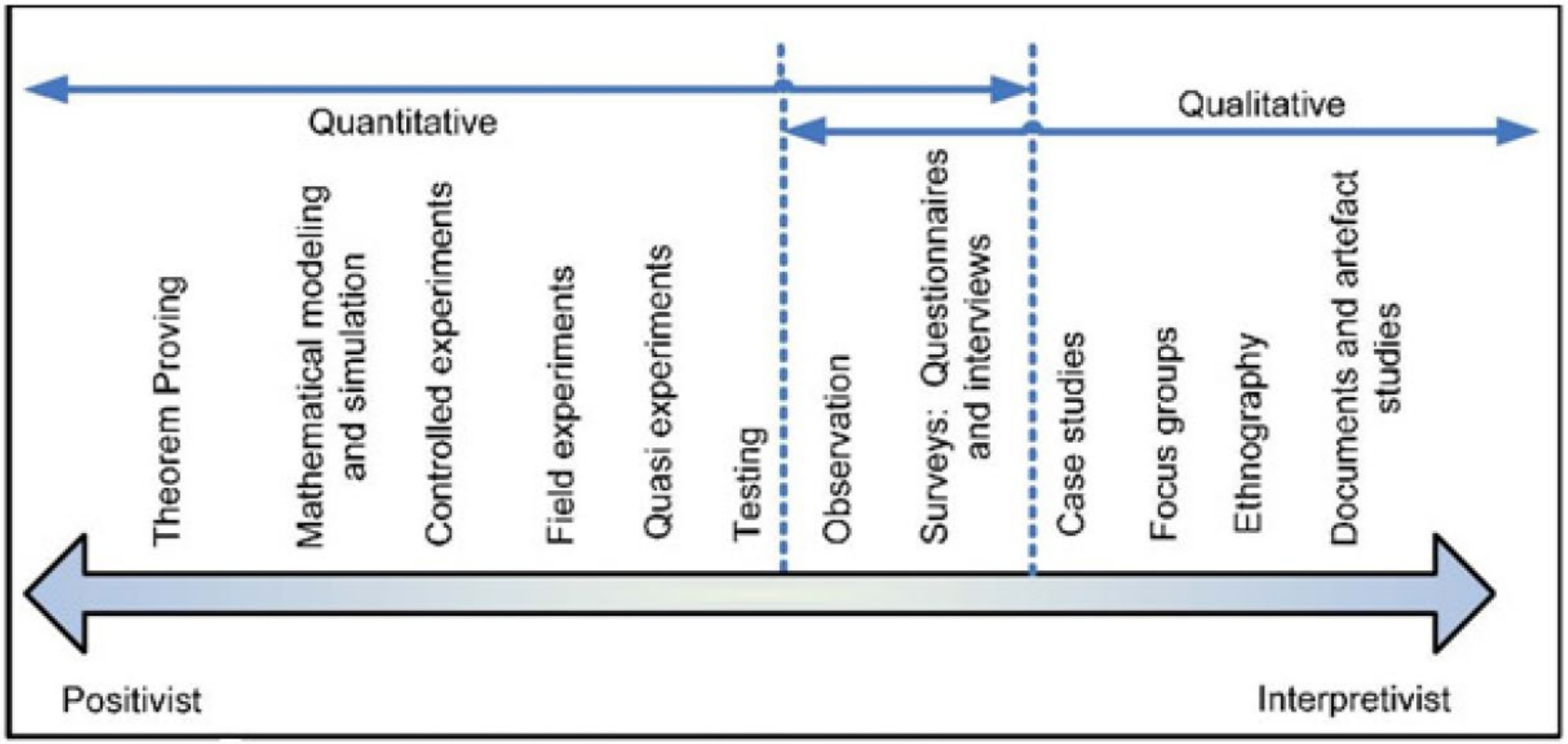
Primary Sources

- 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.

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

Research Strategies, Choices and Philosophy



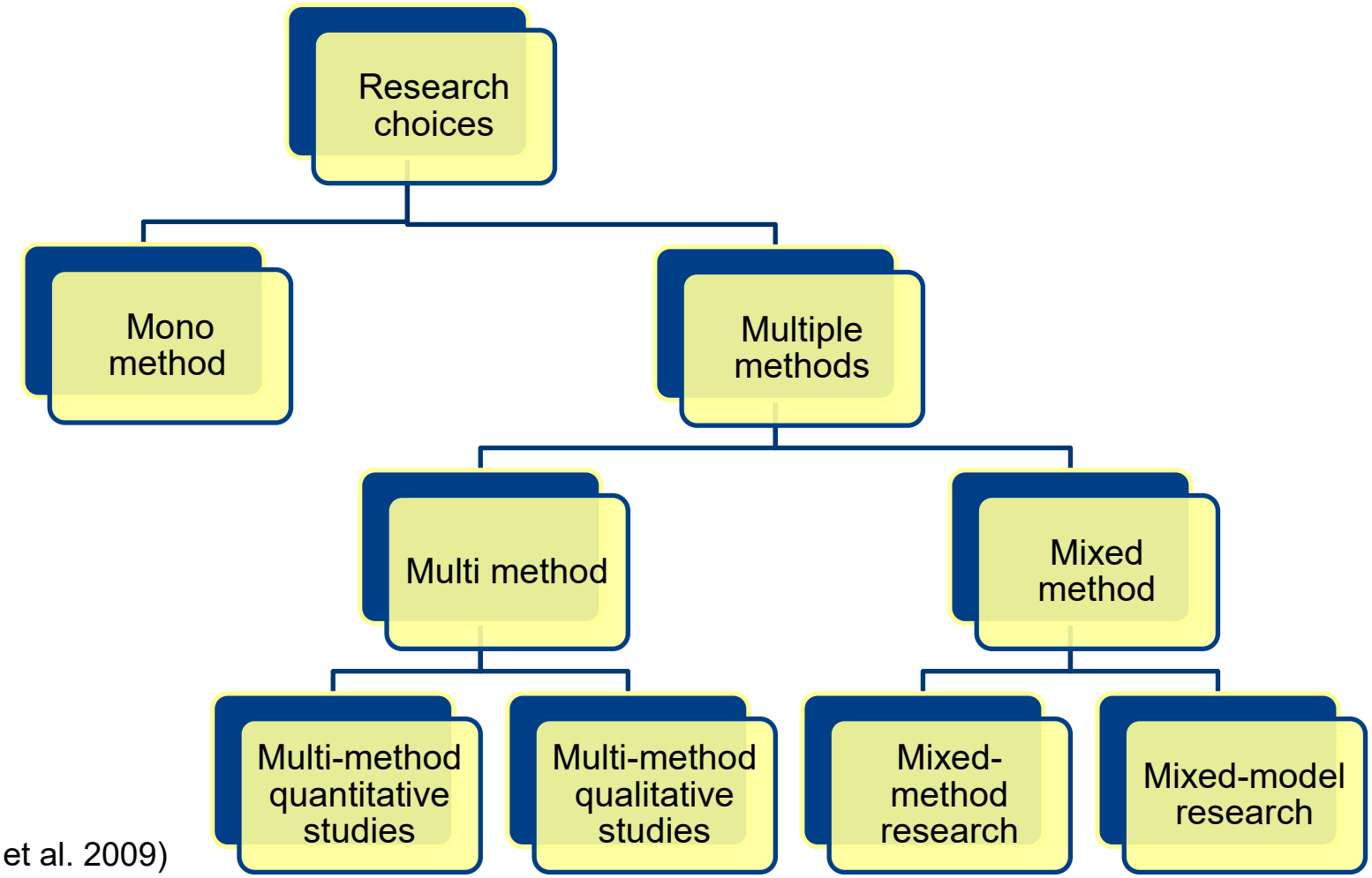
(De Villiers 2005)

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

Research Choices



(Saunders et al. 2009)

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)

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

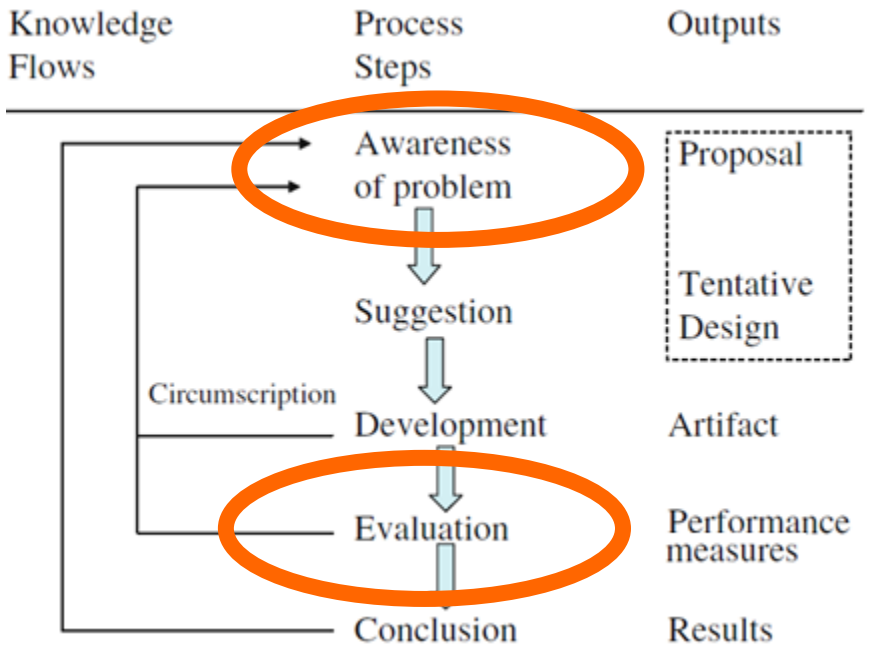
    (i.e. it must not have been superseded by later evidence that has established the earlier work to be inapplicable or flawed)

(Hofstee 2006, pp. 146ff)

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

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)

Sources of Evidence

Collecting Data from Documents and Databases

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

(Yin 2018)

Interviews

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

(Yin 2018)

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

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

Questionnaires:

- Questionnaires are one of the most efficient ways to collect data.
- They contain fixed-response questions about various features of an organization.
- They can be administered to large numbers of people simultaneously.
- They can be analyzed quickly.
- They can be easily be fed back to employees.
- The can have closed questions (analyzed quantitatively) and open questions (qualitative)

Observations

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

(Yin 2018)

Data from Physical Artefacts

Source of Evidence	Strengths	Weaknesses
Physical artifacts Technical devices, tools, instruments, sensors, …	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

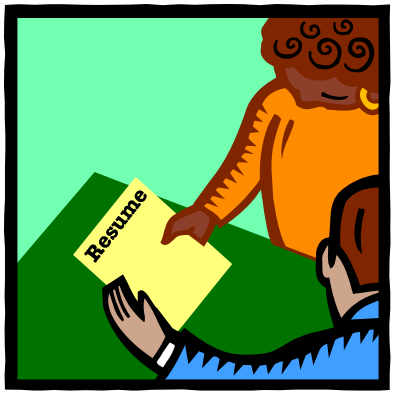
(Yin 2018)

Using these Data Collection Methods

- Each method has advantages and problems. Ideally you want to use a combination of techniques.
- Examples:
  - Questionnaires and surveys are open to self-report biases, such as respondents' tendency to give socially desirable answers rather than honest opinions.
  - Observations are susceptible to observer biases, such as seeing what one wants to see rather than what is actually there.

Use more than one

- Because of the biases inherent in any data-collection method, it is best to use more than one method when collecting diagnostic data.
- The data from the different methods can be compared, and if consistent, it is likely the variables are being validly measured.



Data Analysis

Data Analysis / Coding

- Analysis of data is a process of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information, suggesting conclusions, and supporting decision-making.

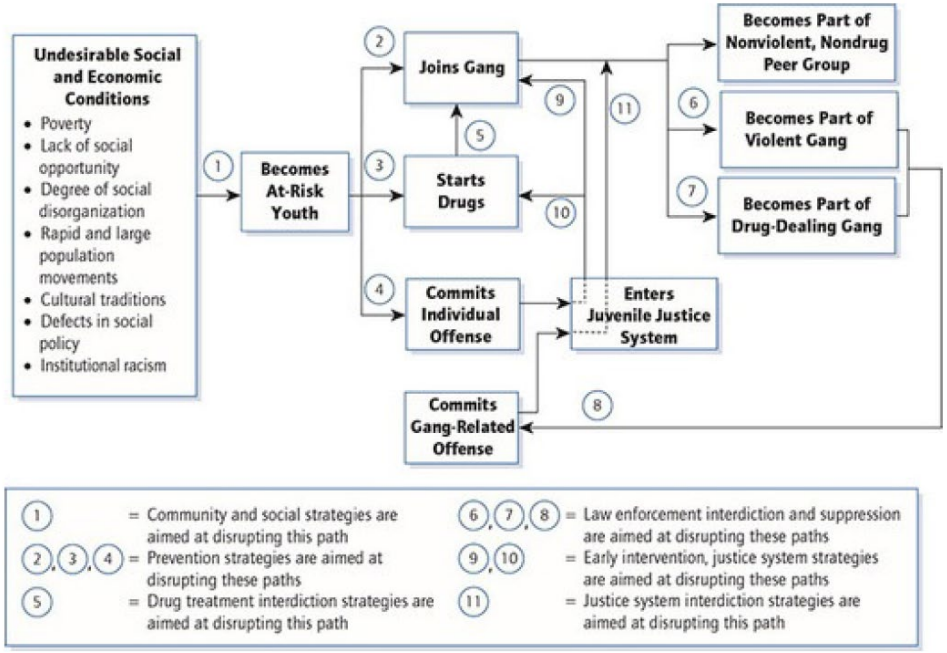
Analytical Techniques for Qualitative Case Studies

- 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 that 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

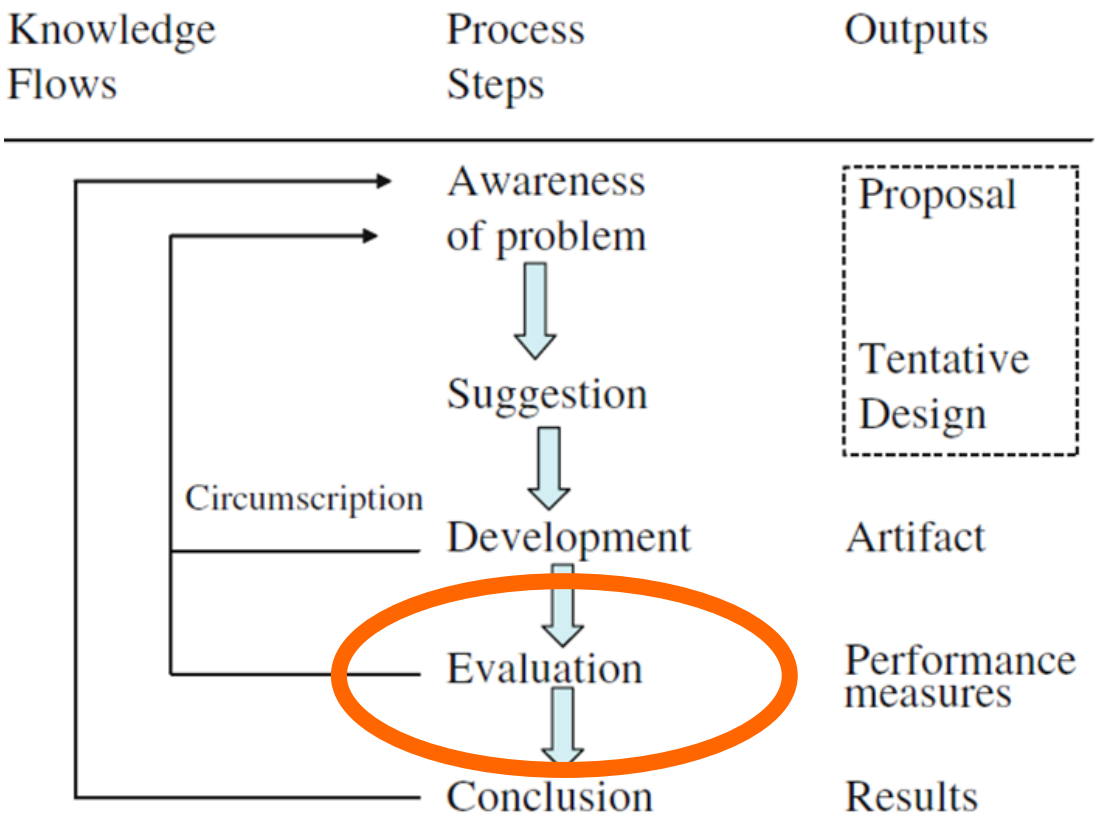


This logical model from (Yin 2018) shows youth behaviour and possible interventions

- 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)

Evaluation: Evidence for Design Research

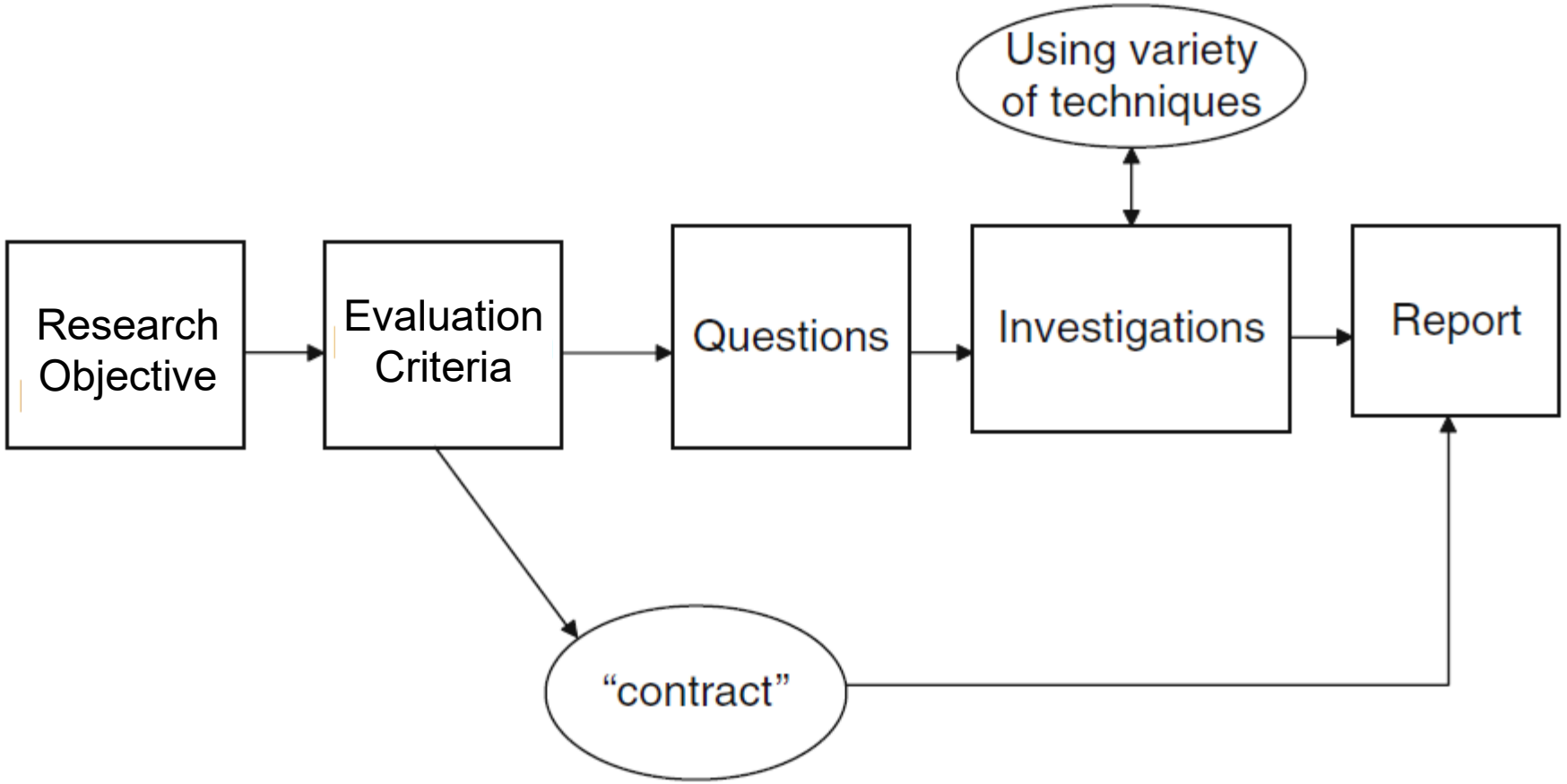
Evaluation in Design Science Research



- 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)

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)

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

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?

Evaluation Methods (1)

Guideline 3

- *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)

Problems with Measurements

Guideline 3

- Putting system into practice is not possible
  - Changing processes or organisation structure required
  - Technical integration of a system is additional effort
- Not enough time to make the measurements
  - Observing effect of an artefact might require weeks or months
- Artefact is not executable (framework, concept)
- Data not available
  - To analyse effect of an artefact it often has to be compared to previous situation for which historic data is missing
- Did we take into account the appropriate data?
- Did the artefact really cause the effect that were measured?

Evaluation Methods (2)

Guideline 3

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

Critical Evaluation

Guideline 3

- 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

Assess Quality of your Evidence

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)

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.

References

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